PDHonline Course E255 (2 PDH)

Thermowells – Basic Selection Criteria

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Thermowells – Basic Selection Criteria

David A. Snyder, PE

Course Content

Choosing the proper thermowell for a given process connection and temperature sensor or thermometer may seem like an easy, straightforward task, but there are several pitfalls and challenges lurking to trap the unwary and uninitiated.

What does a thermowell do, what purpose does it serve? In some applications, thermometers or temperature sensors (such as RTDs or thermocouples) are installed directly into the process without any protection at all. Some examples of this are temperature devices installed directly in HVAC ducts and the thermometer that one puts in a turkey in order to ensure it is cooked thoroughly. There are also applications in which thermocouples are welded directly to the exterior of a pipe to sense the temperature of the fluid flowing through the interior of that pipe.

On the other hand, if the measured process is corrosive, poisonous, hot, or pressurized, a boundary is required between the process and the outside world. A thermowell is a common way to provide this boundary (see sidebar for discussion of protection tubes). Here are some of the advantages that a thermowell provides:

1) Protects the temperature sensor or thermometer from the force of the flowing or agitated fluid. This force could bend or break off the sensor or thermometer, depending on the density and velocity of the fluid.

2) Closes off the process (as previously discussed) such that the temperature sensor or thermometer can be removed and replaced without shutting down the process. To state this differently, you can pull out the temperature sensor or thermometer without getting sprayed by the process fluid.

Protection tubes are typically made of metal, high temperature glass, or ceramic and are used in low-pressure / high temperature applications, such as industrial furnaces. This type of protection will not be discussed further in this document.

The above advantages come with disadvantages, which include:

1) Increased cost to purchase the thermowell.

2) Slower response to temperature changes, compared to a naked sensor, due to the thermal inertia of the thermowell.

3) A thermowell presents some resistance to flow, due to the cross-sectional area of the thermowell, but a well-designed installation can minimize this effect.

The key factors to consider when selecting a thermowell are:

1) Process connection size and type.
2) Process insertion length (U length)
3) Lagging length (T length)
4) Extension length (E length)
5) Sensor length (X length)
6) Interior diameter (bore) for the sensor or thermometer
7) Internal threads for the sensor or thermometer
8) Shape of thermowell (straight, stepped, tapered, built-up)
9) Material of construction

Process Connection Size and Type: The figures below show some typical thermowell process connection types. Notice that the process insertion length U and the sensor length X start at two different places (separated by 0.25") on the right-hand side of the drawings. Examples of common process connections include 1" NPT threaded, 2" raised-face flange (RFF), 3/4" socket-weld, et cetera. The process connection size and type are determined by the nozzle on the tank or vessel or the fitting on the pipe or duct. Figure 1 shows a 1" NPT threaded process connection, Figure 2 shows a 1" socket-weld process connection, and Figure 3 shows a 1" 150# raised-face flanged process connection. Other types of process connections that are available include Weld-In, Van Stone, and Sanitary, which won't be discussed further, but the concepts covered in this document also apply to those types of thermowells.

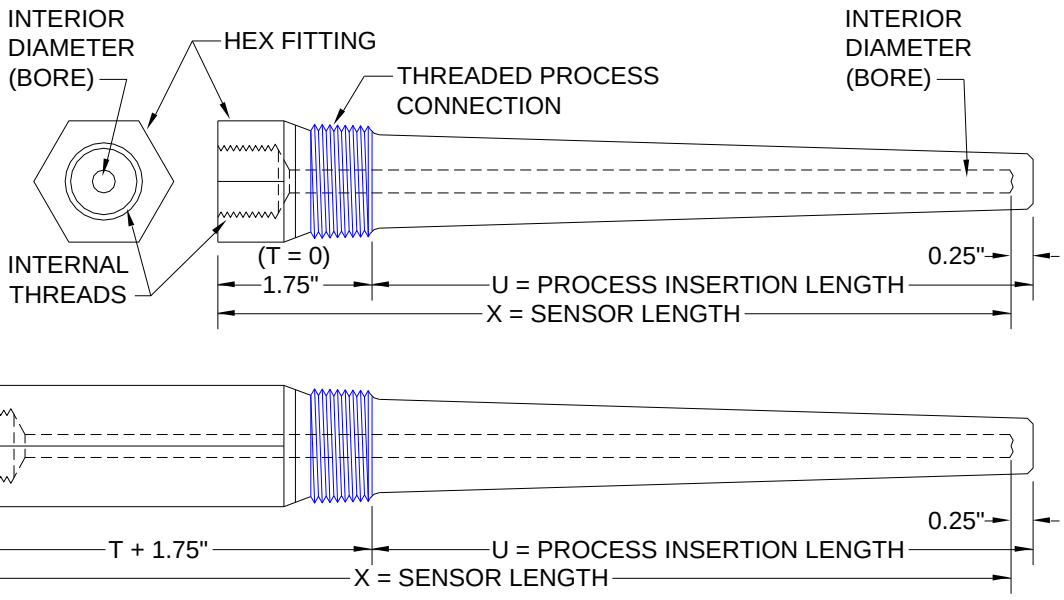


FIGURE 1 - THREADED, TAPERED

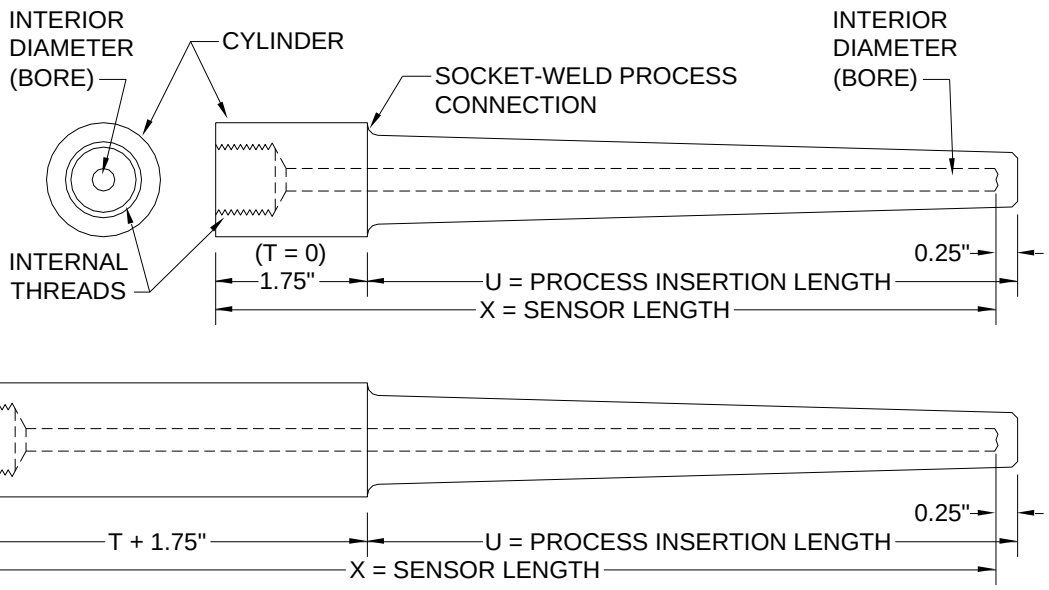


FIGURE 2 - SOCKET-WELD, TAPERED

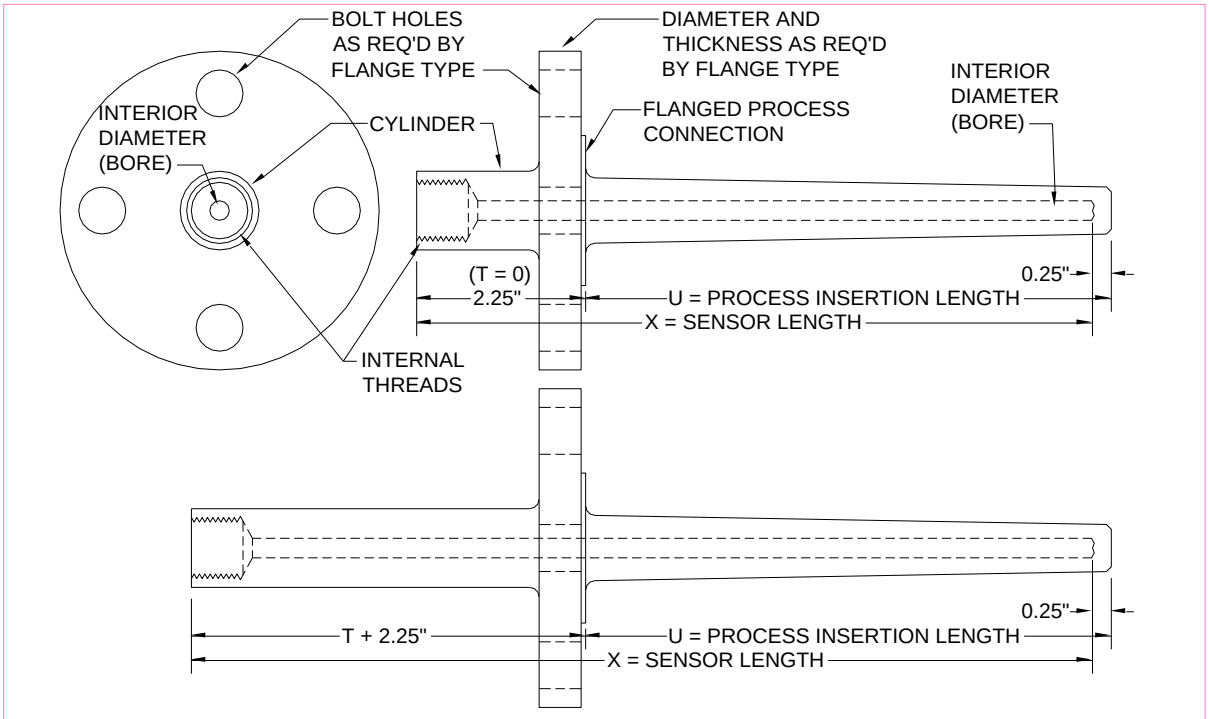


FIGURE 3 - FLANGED, TAPERED

Process Insertion Length (U Length): This is how far the thermowell sticks in to or penetrates the process (vessel, tank, pipe, or duct). On a thermowell catalog cut-sheet (Attachments A through F), this is denoted as the U length. If the process you are measuring happens to be a liquid, then the process insertion length is the portion of the thermowell that is wetted by the process. When selecting the thermowell process insertion length, the depth of the thermowell's mechanical connection to the process must also be taken into account. For example, if we are to install a thermowell into a Schedule 40 12" diameter pipe, we would choose a process insertion length that will put the tip of the thermowell at or near the centerline of the pipe (consider 1/3 the diameter of the pipe to be the absolute minimum process insertion length). Look at Figure 4 and notice that the Thredolet fitting that is welded to the pipe to accommodate the thermowell adds approximately1.3" to the process insertion length (the U length). Measuring from the centerline of the pipe to the top of the Thredolet fitting yields a distance of 7.6875" (7-11/16"), which roughly coincides with a standard U length of 7.5" for threaded thermowells. When the thermowell is screwed in to the Thredolet, however, it will go about 0.68" (this is the thread engagement, see Table 1) into the Thredolet, which explains why the tip of the thermowell goes slightly beyond the centerline of the pipe even though the distance from the centerline of the pipe to the top of the Thredolet is slightly more than 7.5".

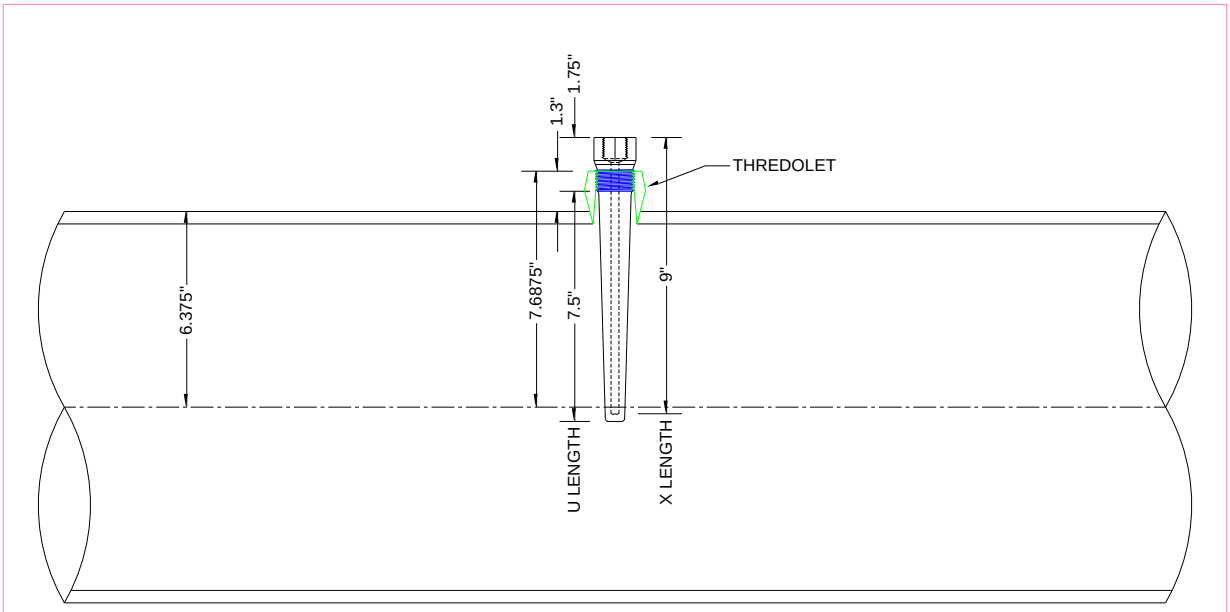


FIGURE 4 - EXAMPLE WITH NO LAGGING

TABLE 1 – APPROXIMATE THREAD ENGAGEMENT DISTANCES FOR NPT-TO-NPT CONNECTIONS				
0.5" NPT	0.53" ENGAGEMENT	----	2" NPT	0.76" ENGAGEMENT
0.75" NPT	0.55" ENGAGEMENT	----	2.5" NPT	1.1" ENGAGEMENT
1" NPT	0.68" ENGAGEMENT	----	3" NPT	1.2" ENGAGEMENT
1.5" NPT	0.72" ENGAGEMENT	----	4" NPT	1.3" ENGAGEMENT

Another type of installation would be a thermowell in the side of a tank or vessel. It is not necessary or even practical to get a thermowell long enough to reach the center of a large tank or vessel. We need to make the process insertion length just long enough to be a reasonable distance, perhaps 6" or so, into the interior of the tank, making sure there are no conflicts with baffles, agitator blades, or other possible physical hazards.

Another type of thermowell is called Limited Space, which usually has a threaded connection. As the name implies, these thermowells have very short process insertion lengths and are intended for applications that have a limited amount of space. This type of thermowell will not be discussed further in this document.

Lagging Length (T Length): This feature is not always used, but it is useful when the pipe has a jacket of insulation around it. See Figure 5, which shows 3" of insulation on the pipe we considered in Figure 4 above. The thermowell in this figure is shown with 3" of lagging to get the sensor insertion point outside of the insulating jacket, so the thermometer or temperature sensor installer doesn't have to dig around in the insulation to find the thermowell. Oftentimes, the thermowell is installed by the piping contractor, since the thermowell is part of the pressure boundary of the pipe. The insulation will typically be installed on the piping after the thermowell is installed. The lagging on the thermowell in Figure 5 will move the sensor connection point to a more convenient location outside of the insulating jacket.

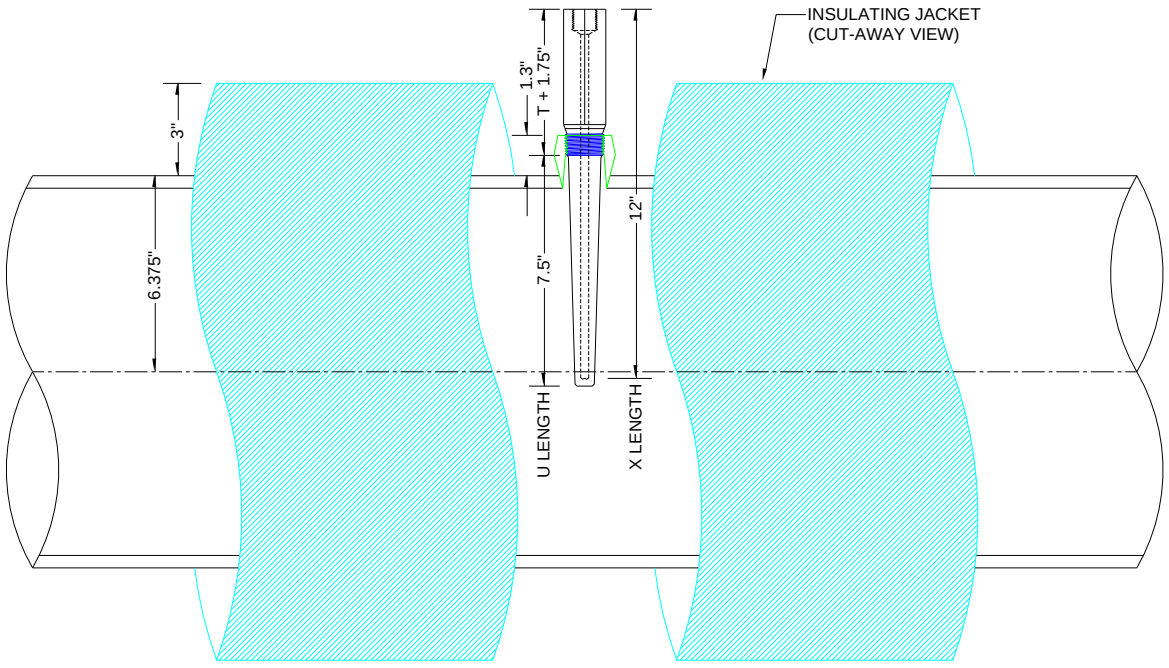


FIGURE 5 - EXAMPLE WITH LAGGING

In contrast to an insulated pipe, when a tank or vessel has an insulating jacket around it and has flanged thermowell connections, the flanged connections are usually extended out beyond the insulating jacket, which adds to the required process insertion length (U length) but does not require any lagging length (T length).

To clarify the location of lagging length T on a threaded thermowell, Figure 6 shows that the lagging length T is defined as being between the wrench allowance and the thread allowance. In other words, the lagging length is not just tacked on to sensor end of the thermowell, it is added between the 0.75" wrench allowance and the 1" thread allowance, both of which add up to give us the 1.75" shown on the thermowell with no lagging in Figure 6. The same definition of lagging location holds true for socket-weld and other types of process connections, although the terms 'wrench allowance' and 'thread allowance' don't apply.

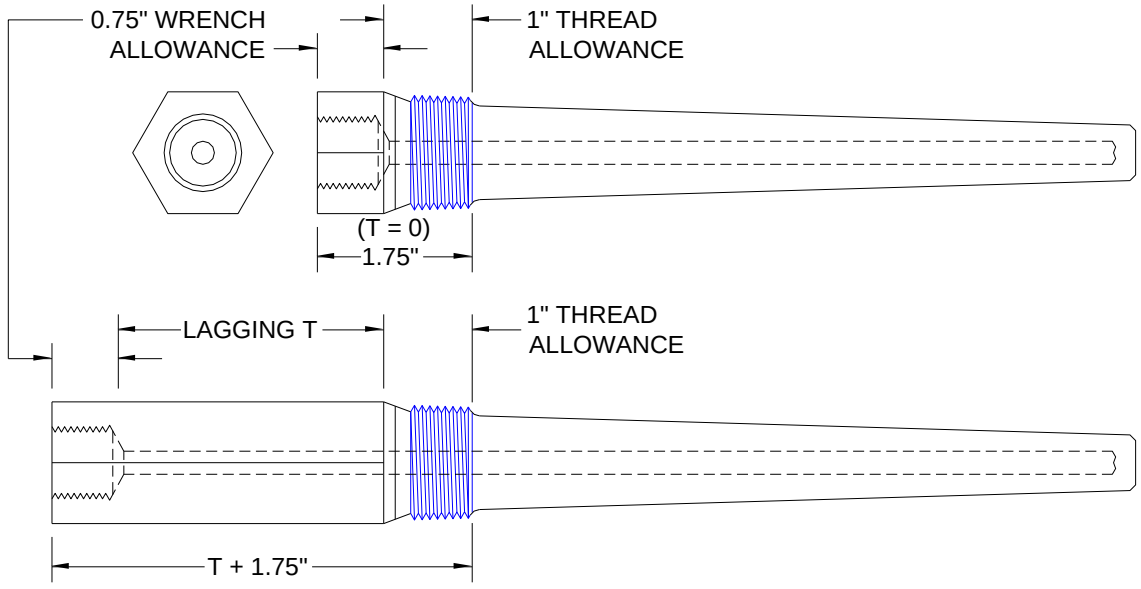


FIGURE 6 - LAGGING LENGTH LOCATION

Extension Length (E Length): This feature is not always used. The extension length (see Figure 7) typically adds 3" or 6" to the sensor length, but can be ordered in other lengths. The extension length moves the connection head of the temperature sensor further away from the process and can also include a union to simplify the installation of a thermocouple or RTD. A nipple-union-nipple connection, as shown in Figure 7, allows both nipples on either side of the union to be screwed tightly to the union without rotating the entire assembly. One of these nipples is connected to the sensor connection head (which would be to the far left, if it were shown on Figure 7) and the other nipple is connected to the thermowell. This feature is useful because it allows the connection head end of the assembly to remain stationary when removing or installing a thermocouple or RTD, so the wires and flexible conduit attached to the connection head do not have to be twisted or disconnected.

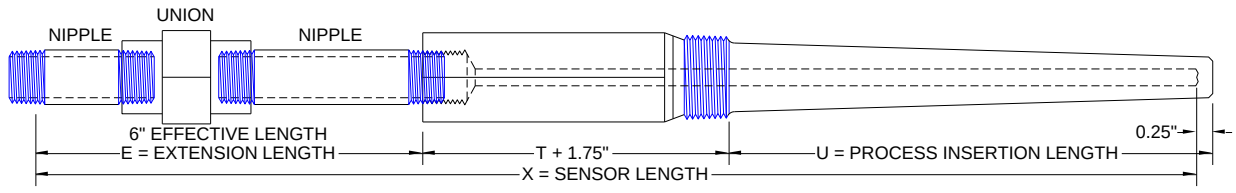


FIGURE 7 - THREADED, TAPERED, WITH 6" EXTENSION

Sensor Length (X Length, Sometimes Called S Length): This is how long a temperature sensor or thermometer bulb needs to be in order for the tip of the sensor or bulb to touch the process end of the bore inside the thermowell. To phrase it differently, the tip of the sensor or bulb needs to be touching the process end of the thermowell in order to get good temperature transfer from the thermowell to the sensor or bulb. If there were a gap between the thermowell and the tip of the sensor or bulb, then the accuracy of the temperature reading would suffer. Very often, RTDs are specified as spring-loaded to ensure that the tip of the RTD is touching the process end of the bore.

In order to determine the sensor length, we need to factor in all of the lengths (Extension [E], Lagging [T], Process Insertion [U]) that are discussed above, plus the distance from the process connection to the beginning of the threads for the temperature sensor or thermometer. The formulas for determining sensor length are simple, but there are two different styles, depending on the type of process connection:

1) Most Types of Process Connections:

   X = E + T + U + 1.75” – 0.25”, which is usually simplified and represented as:

   X = E + T + U + 1.5”

   Take a look at Figure 7, which shows all of the lengths, X, E, T, and U, as well as the 1.75” and 0.25” lengths.

2) Flanged Process Connections:

   X = E + T + U + 2.25” – 0.25”, which is usually simplified and represented as:

   X = E + T + U + 2”

Let’s start with the first formula, in item 1) Most Types of Process Connections above. The 1.75” length is shown in the T = 0 (no lagging) examples in Figures 1 and 2 as the distance from the process connection to the beginning of the threads for the temperature sensor or thermometer.

The 0.25" is shown as the distance from the outside tip of the thermowell to the inside end of the internal bore of the thermowell. The + 1.75" and the – 0.25" are usually combined into a single value of + 1.5".

Let's examine the simplified case shown in Figure 4, where there is no extension length E, no lagging length T, and we are using a threaded process connection. In this case, we have:

X = E + T + U + 1.75" – 0.25"

X = 0" + 0" + U + 1.75" – 0.25".

X = U + 1.5"

X = 7.5" + 1.5"

X = 9"

As can be seen from the cut-sheets (Attachments G and H), this is a standard offering for sensor or thermometer length.

Consider the example in Figure 5, which has no extension length, but a lagging length T = 3" and a threaded process connection. The sensor length would be, as before:

X = E + T + U + 1.75" – 0.25"

X = 0" + T + U + 1.5"

X = 0" + 3" + 7.5" + 1.5" = 12".

As can be seen from the cut-sheets (Attachments G and H), a temperature sensor or thermometer length of 12" is a standard offering.

Now, let's consider an application with a flanged process connection, for which the sensor length formula appears in item 2) Flanged Process Connections on page 8. As can be seen in the T = 0 (no lagging) example in Figure 3, instead of a distance of 1.75" from the process connection to the sensor connection, we now have a distance of 2.25". That means our new sensor length formula is:

X = E + T + U + 2.25" – 0.25", which can be simplified as:

X = E + T + U + 2"

This 2.25" distance for flanged thermowells is 0.5" longer than the 1.75" distance for the other process connection types, but the standard process insertion lengths for flanged thermowells are typically 0.5" shorter than those for other types of process connections, so the resulting sensor length is unaffected. In other words, while a 7.5" process insertion length is standard for other

types of process connections, a 7" process insertion length is standard for flanged process connections.

For this example, we'll have no extension length (E = 0), a lagging length T = 3", a process insertion length U = 7", and a flanged process connection. The sensor length X will be:

X = E + T + U + 2"

X = 0" + 3" + 7" + 2"

X = 12"

This is the same sensor length as the threaded example illustrated in Figure 5, but the process insertion length is 0.5" shorter.

Let's consider one more example for a flanged thermowell, this one with a 13" process insertion length U, a 3" lagging length T, and a 6" extension length E. As we learned above (though we always confirm with the cut-sheets), the sensor length X for this type of process connection is:

X = E + T + U + 2"

X = 6" + 3" + 13" + 2"

X = 24"

As can be seen on the cut-sheets (Attachments G and H), this thermometer or sensor length is a standard offering. Non-standard temperature sensor and thermometer bulb lengths are available, but specifying non-standard devices can sometimes add to the cost and delivery time.

Tables 2 and 3 list the most popular combinations of process insertion length U, lagging length T, extension length E, and resulting sensor length X for the two main types of process connections, namely a) flanged and b) everything else. Some companies will list additional choices for standard lengths.

TABLE 2 -- FLANGED THERMOWELLS			
PROCESS INSERTION LENGTH U (INCHES)	LAGGING LENGTH T (INCHES)	EXTENSION E (INCHES)	SENSOR LENGTH X (INCHES) = E + T + U + 2”
2	0	0	4
2	2	0	6
2	2	3	9
2	2	6	12
---	---	---	---
4	0	0	6
4	3	0	9
4	3	3	12
4	3	6	15
---	---	---	---
7	0	0	9
7	3	0	12
7	3	3	15
7	3	6	18
---	---	---	---
10	0	0	12
10	3	0	15
10	3	3	18
10	3	6	21 (NON-STD.)
---	---	---	---
13	0	0	15
13	3	0	18
13	3	3	21 (NON-STD.)
13	3	6	24
---	---	---	---
16	0	0	18
16	3	0	21 (NON-STD.)
16	3	3	24
16	3	6	27 (NON-STD.)
---	---	---	---
22	0	0	24
22	3	0	27 (NON-STD.)
22	3	3	30 (NON-STD.)
22	3	6	33 (NON-STD.)

Note: Standard lagging lengths are not typically listed on cut-sheets for flanged thermowells.

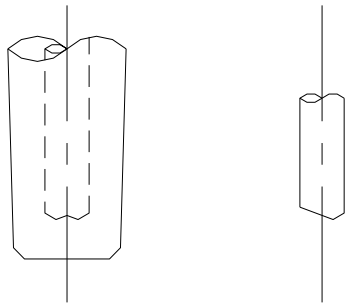
TABLE 3 -- THREADED, SOCKET WELD, AND OTHER TYPES OF THERMOWELLS			
PROCESS INSERTION LENGTH U (INCHES)	LAGGING LENGTH T (INCHES)	EXTENSION E (INCHES)	SENSOR LENGTH X (INCHES) = E + T + U + 1.5”
2.5	0	0	4
2.5	2	0	6
2.5	2	3	9
2.5	2	6	12
---	---	---	---
4.5	0	0	6
4.5	3	0	9
4.5	3	3	12
4.5	3	6	15
---	---	---	---
7.5	0	0	9
7.5	3	0	12
7.5	3	3	15
7.5	3	6	18
---	---	---	---
10.5	0	0	12
10.5	3	0	15
10.5	3	3	18
10.5	3	6	21 (NON-STD.)
---	---	---	---
13.5	0	0	15
13.5	3	0	18
13.5	3	3	21 (NON-STD.)
13.5	3	6	24
---	---	---	---
16.5	0	0	18
16.5	3	0	21 (NON-STD.)
16.5	3	3	24
16.5	3	6	27 (NON-STD.)
---	---	---	---
22.5	0	0	24
22.5	3	0	27 (NON-STD.)
22.5	3	3	30 (NON-STD.)
22.5	3	6	33 (NON-STD.)

Interior Diameter (Bore): This is the diameter or bore of the hole that is drilled in to the solid bar stock of the thermowell raw material to create the cavity for the temperature sensor or thermometer stem to be inserted. The two most popular choices for interior diameter are 0.26" and 0.385".

The 0.26" diameter bore will accommodate a 0.25" (1/4") diameter temperature sensor, such as an RTD. The extra 0.01" (0.005" all around) in the 0.26" diameter bore provides enough room to allow the 0.25" diameter sensor to slide in to the thermowell.

Similarly, the 0.385" diameter bore is intended for a 0.375" (3/8") diameter thermometer stem or bulb. Other interior diameters are available.

The funny-looking W-shape at the process end of the bore inside the thermowell is the result of the 0.26" or 0.385" bore being formed by a gun drill. The deepest part of the gun drill bit is offset from the center of the gun drill such that the deepest part of the bore is about one-half of the radius from the center of the bore. This creates a bore hole that has a raised cone at the center with a V-shaped trough encircling it.



Internal Threads: This is the connection for the temperature sensor or thermometer. It is often 0.5" NPSM female (see Some Pipe Thread Types sidebar), but could be 0.5" NPT female or some other connection type. The 0.5" NPT male connector on the temperature sensor or thermometer will fit both the 0.5" NPSM female connection and the 0.5" NPT female connection, so either internal thread type is acceptable. The temperature sensor or thermometer will slide into the thermowell and then be tightened to this internal thread. If an extension is used, the process end of the extension will be tightened to this internal thread, rather than the temperature sensor or thermometer (see Figure 7).

Some Pipe Thread Types:

NPT, in spite of what many people think, is actually the abbreviation for National Pipe Taper, not National Pipe Thread. There are several different types of American national pipe thread defined in the ASME B1.20.1 standard, including tapered (NPT), straight coupling (NPSC), and straight mechanical (NPSM). If the T in NPT stood for thread, there would be a T in each of the thread standard acronyms.

The tapered threads of male NPT connections have a diameter that gets larger and the tapered threads of female NPT connections have a diameter that gets smaller as the male fitting is screwed in to the female fitting, thus making the connection tighter and tighter.

NPSM is the National Pipe Straight Mechanical thread standard. It is similar to the tapered (NPT) standard (same pitch and thread flank angle), except that the threads are straight, not tapered. That is, the diameter of the threads does not change.

Shape of Thermowell: This is the shape or stem geometry or shank style of the process portion of the thermowell. The four main types are straight (Figure 8), stepped (Figure 9), tapered (Figures 1, 2, and 3), and built-up (not shown).

1) Straight thermowells (Figure 8) have good rigidity and are the simplest shape to fabricate. As the name implies, the outer diameter of the thermowell is the same from the process end of the thermowell to the process connection. Straight thermowells are almost always available with a 0.385" bore, and sometimes with 0.26".

2) Stepped thermowells (Figure 9) have a smaller diameter at the process end than at the process connection. This change in diameter takes place in one step, rather than being smoothly tapered. The small diameter of the process end of this thermowell results in decreased thermal inertia and can therefore respond more quickly to changes in temperature than a straight thermowell. Stepped thermowells are typically available with a 0.26" bore, not 0.385".

3) Tapered thermowells (Figures 1, 2, and 3) also have a smaller diameter at the process end than at the process connection. This change in diameter takes places in a smooth, continuous taper. Due to the smaller diameter of its tapered tip, this type of thermowell can react more quickly to changes in temperature than a straight thermowell and has the added advantage of high rigidity. This type of thermowell is typically used in heavy-duty as well as general-purpose applications. Tapered thermowells are available with a 0.26" or 0.385" bore.

4) Built-up thermowells are used for very long (typically 22" or more) process insertion lengths (U length). They are available with the same process connections and process ends (stem geometry) as the above thermowells, but a length of pipe is welded between the process connection and the process end to give the required process insertion length.

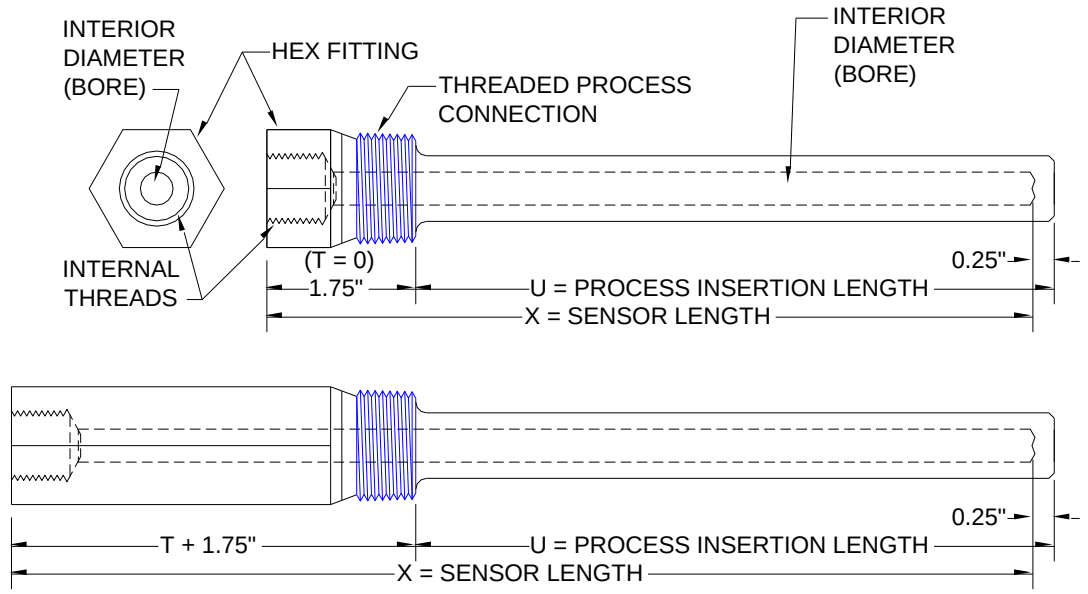


FIGURE 8 - THREADED, STRAIGHT

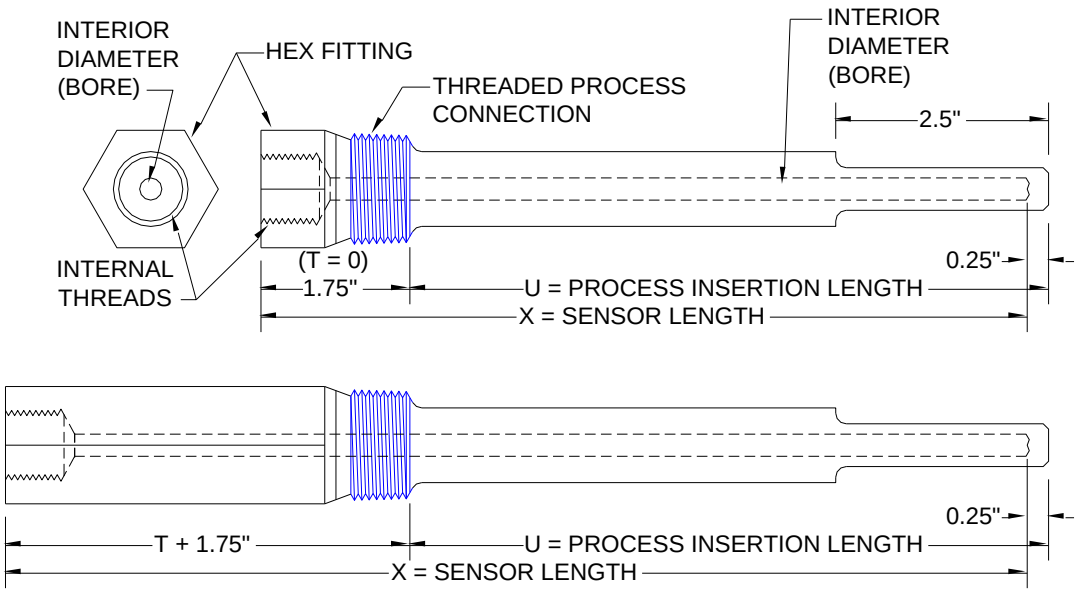


FIGURE 9 - THREADED, STEPPED

Material of Construction: Thermowells can be fabricated from a variety of metals, the most popular of which include brass, carbon steel, 304 stainless steel, and 316 stainless steel. Other material choices include aluminum, monel, Hastelloy C and titanium, to name a few. The choice of material depends on the process medium, thermowell cost, and thermowell delivery time. Two popular all-around choices for material of construction are 304 or 316 stainless steel, since these materials are compatible with a great many processes and thermowells constructed from these materials are readily available.

To determine the best choice for the material of construction of the thermowell, consult the manufacturer's material compatibility or corrosive service guide such as shown in Attachment I. For example, 304 stainless steel is recommended for ethylene glycol and 316 stainless steel is recommended for titanium tetrachloride in this attachment.

Additional Considerations: Fluids flowing past the thermowell will put a bending force on the thermowell. Additionally, fluids traveling transverse or perpendicular to a thermowell will generate a wake of a certain frequency, based on the fluid velocity and diameter of the thermowell. This wake will cause the thermowell to vibrate. Ordinarily, these vibrations are negligible, until the vibrations approach the natural frequency of the thermowell. Each thermowell has a natural or resonant frequency, based on the length of the thermowell and the material from which it is fabricated. The formulas for these frequencies can be used to determine if a particular thermowell is acceptable in a given application (see ASME publication PTC 19.3). Many thermowell manufacturers have tabulated the approximate velocity rating of each of their standard thermocouples, based on assumptions for the maximum process temperature and the type of fluid. Contact your thermowell vendor or search the internet for "thermowell velocity rating" (quotes omitted) for additional information.

In Closing: The information presented in this document is intended to represent the standard offerings from leading thermowell manufacturers. In every case, the specifier should confirm the exact dimensions and standard offerings from the selected manufacturer and model cut-sheet.

ATTACHMENTS FOLLOW AND ARE INCLUDED BY PERMISSION

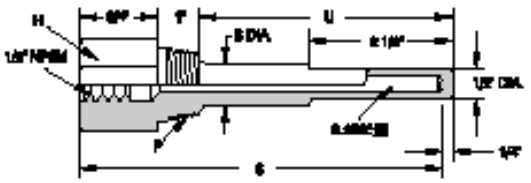
Attachment A

TEMP-PRO Inc. *Thermowell Catalog*

An ISO 9001 CERTIFIED Company

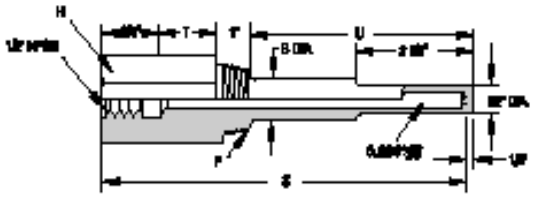
Threaded, Stepped Shank, 1/4" Nominal Bore

Standard



GENERAL INFORMATION					PART #
B	H	S	U	P	
1/2"	1-1/8"	4"	2-1/2"	1/2	50 W 0250 ST 260
1/2"	1-1/8"			3/4	75 W 0250 ST 260
1/2"	1-3/8"			1	10 W 0250 ST 260
5/8"	1-1/8"	6"	4-1/2"	1/2	50 W 0450 RT 260
3/4"	1-1/8"			3/4	75 W 0450 RT 260
7/8"	1-3/8"			1	10 W 0450 RT 260
5/8"	1-1/8"	9"	7-1/2"	1/2	50 W 0750 RT 260
3/4"	1-1/8"			3/4	75 W 0750 RT 260
7/8"	1-3/8"			1	10 W 0750 RT 260
5/8"	1-1/8"	12"	10-1/2"	1/2	50 W 1050 RT 260
3/4"	1-1/8"			3/4	75 W 1050 RT 260
7/8"	1-3/8"			1	10 W 1050 RT 260
5/8"	1-1/8"	15"	13-1/2"	1/2	50 W 1350 RT 260
3/4"	1-1/8"			3/4	75 W 1350 RT 260
7/8"	1-3/8"			1	10 W 1350 RT 260
5/8"	1-1/8"	18"	16-1/2"	1/2	50 W 1650 RT 260
3/4"	1-1/8"			3/4	75 W 1650 RT 260
7/8"	1-3/8"			1	10 W 1650 RT 260
5/8"	1-1/8"	24"	22-1/2"	1/2	50 W 2250 RT 260
3/4"	1-1/8"			3/4	75 W 2250 RT 260
7/8"	1-3/8"			1	10 W 2250 RT 260

With Lagging Extension



GENERAL INFORMATION						PART #
B	H	T	S	U	P	
1/2"	1-1/8"	2"	6"	2-1/2"	1/2	50 W 0250 LST 260
1/2"	1-1/8"	2"			3/4	75 W 0250 LST 260
1/2"	1-3/8"	2"			1	10 W 0250 LST 260
5/8"	1-1/8"	3"	9"	4-1/2"	1/2	50 W 0450 LRT 260
3/4"	1-1/8"	3"			3/4	75 W 0450 LRT 260
7/8"	1-3/8"	3"			1	10 W 0450 LRT 260
5/8"	1-1/8"	3"	12"	7-1/2"	1/2	50 W 0750 LRT 260
3/4"	1-1/8"	3"			3/4	75 W 0750 LRT 260
7/8"	1-3/8"	3"			1	10 W 0750 LRT 260
5/8"	1-1/8"	3"	15"	10-1/2"	1/2	50 W 1050 LRT 260
3/4"	1-1/8"	3"			3/4	75 W 1050 LRT 260
7/8"	1-3/8"	3"			1	10 W 1050 LRT 260
5/8"	1-1/8"	3"	18"	13-1/2"	1/2	50 W 1350 LRT 260
3/4"	1-1/8"	3"			3/4	75 W 1350 LRT 260
7/8"	1-3/8"	3"			1	10 W 1350 LRT 260
5/8"	1-1/8"	3"	24"	19-1/2"	1/2	50 W 1950 LRT 260
3/4"	1-1/8"	3"			3/4	75 W 1950 LRT 260
7/8"	1-3/8"	3"			1	10 W 1950 LRT 260

LEGEND

- U = Shank length below threads
- P = Process connection NPT
- S = Bore depth = instrument element length including its threads
- B = Max Shank Diameter
- H = Hex size across flats
- T = Lagging Extensions

Specify Material Coding At End Of Part #

(See Inside Cover)

AA	-	Brass
B	-	Carbon Steel
C	-	AISI 304
S	-	AISI 316

To order plug and chain, add a suffix to the part number. For brass, add 1. For stainless, add 2.

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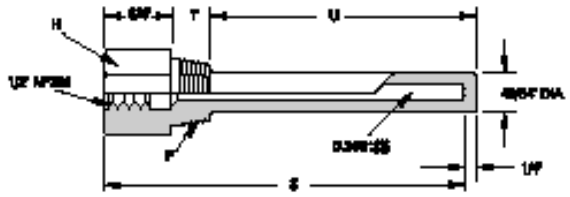
Attachment B

TEMP-PRO Inc. *Thermowell Catalog*

An ISO 9001 CERTIFIED Company

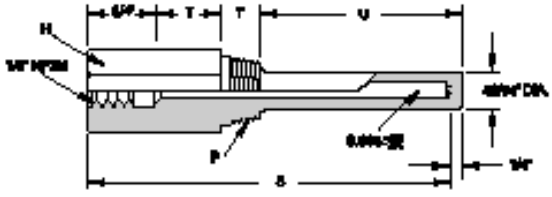
Threaded, Straight Shank, 3/8" Nominal Bore

STANDARD



GENERAL INFORMATION				PART #
H	S	U	P	
1-1/8"	4"	2-1/2"	3/4	75 W 0250 ST 385
1-3/8"			1	10 W 0250 ST 385
1-1/8"	6"	4-1/2"	3/4	75 W 0450 ST 385
1-3/8"			1	10 W 0450 ST 385
1-1/8"	9"	7-1/2"	3/4	75 W 0750 ST 385
1-3/8"			1	10 W 0750 ST 385
1-1/8"	12"	10-1/2"	3/4	75 W 1050 ST 385
1-3/8"			1	10 W 1050 ST 385
1-1/8"	15"	13-1/2"	3/4	75 W 1350 ST 385
1-3/8"			1	10 W 1350 ST 385
1-1/8"	18"	16-1/2"	3/4	75 W 1650 ST 385
1-3/8"			1	10 W 1650 ST 385
1-1/8"	24"	22-1/2"	3/4	75 W 2250 ST 385
1-3/8"			1	10 W 2250 ST 385

WITH LAGGING EXTENSION



GENERAL INFORMATION					PART #
H	T	S	U	P	
1-1/8"	2"	6"	2-1/2"	3/4	75 W 0250 LST 385
1-3/8"	2"			1	10 W 0250 LST 385
1-1/8"	3"	9"	4-1/2"	3/4	75 W 0450 LST 385
1-3/8"	3"			1	10 W 0450 LST 385
1-1/8"	3"	12"	7-1/2"	3/4	75 W 0750 LST 385
1-3/8"	3"			1	10 W 0750 LST 385
1-1/8"	3"	15"	10-1/2"	3/4	75 W 1050 LST 385
1-3/8"	3"			1	10 W 1050 LST 385
1-1/8"	3"	18"	13-1/2"	3/4	75 W 1350 LST 385
1-3/8"	3"			1	10 W 1350 LST 385
1-1/8"	3"	24"	19-1/2"	3/4	75 W 1950 LST 385
1-3/8"	3"			1	10 W 1950 LST 385

LEGEND

- U = Shank length below threads
- P = Process connection NPT
- S = Bore depth = instrument element length including its threads
- H = Hex size across flats
- T = Lagging Extensions

Specify Material Coding At End Of Part #

(See Inside Cover)

- AA - Brass
- B - Carbon Steel
- C - AISI 304
- S - AISI 316

To order plug and chain add a suffix to the part number.
For brass add 1. For stainless add 2.

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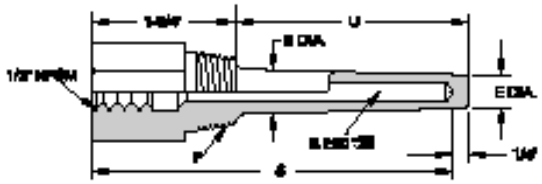
Attachment C

TEMP-PRO Inc. *Thermowell Catalog*

An ISO 9001 CERTIFIED Company

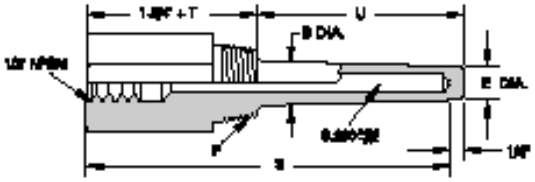
Threaded, Tapered Shank, 1/4" Nominal Bore

STANDARD



GENERAL INFORMATION						PART #
B	E	H	S	U	P	
5/8"	1/2"	1-1/8"	4"	2-1/2"	1/2	50 W 0250 HT 260
7/8"	5/8"	1-1/8"			3/4	75 W 0250 HT 260
1-1/16"	5/8"	1-3/8"			1	10 W 0250 HT 260
5/8"	1/2"	1-1/8"	6"	4-1/2"	1/2	50 W 0450 HT 260
7/8"	5/8"	1-1/8"			3/4	75 W 0450 HT 260
1-1/16"	5/8"	1-3/8"			1	10 W 0450 HT 260
5/8"	1/2"	1-1/8"	9"	7-1/2"	1/2	50 W 0750 HT 260
7/8"	5/8"	1-1/8"			3/4	75 W 0750 HT 260
1-1/16"	5/8"	1-3/8"			1	10 W 0750 HT 260
5/8"	1/2"	1-1/8"	12"	10-1/2"	1/2	50 W 1050 HT 260
7/8"	5/8"	1-1/8"			3/4	75 W 1050 HT 260
1-1/16"	5/8"	1-3/8"			1	10 W 1050 HT 260
5/8"	1/2"	1-1/8"	15"	13-1/2"	1/2	50 W 1350 HT 260
7/8"	5/8"	1-1/8"			3/4	75 W 1350 HT 260
1-1/16"	5/8"	1-3/8"			1	10 W 1350 HT 260
5/8"	1/2"	1-1/8"	18"	16-1/2"	1/2	50 W 1650 HT 260
7/8"	5/8"	1-1/8"			3/4	75 W 1650 HT 260
1-1/16"	5/8"	1-3/8"			1	10 W 1650 HT 260
5/8"	1/2"	1-1/8"	24"	22-1/2"	1/2	50 W 2250 HT 260
7/8"	5/8"	1-1/8"			3/4	75 W 2250 HT 260
1-1/16"	5/8"	1-3/8"			1	10 W 2250 HT 260

WITH LAGGING EXTENSION



GENERAL INFORMATION							PART #
B	E	H	T	S	U	P	
5/8"	1/2"	1-1/8"	2"	6"	2-1/2"	1/2	50 W 0250 LHT 260
7/8"	5/8"	1-1/8"	2"			3/4	75 W 0250 LHT 260
1-1/16"	5/8"	1-3/8"	2"			1	10 W 0250 LHT 260
5/8"	1/2"	1-1/8"	3"	9"	4-1/2"	1/2	50 W 0450 LHT 260
7/8"	5/8"	1-1/8"	3"			3/4	75 W 0450 LHT 260
1-1/16"	5/8"	1-3/8"	3"			1	10 W 0450 LHT 260
5/8"	1/2"	1-1/8"	3"	12"	7-1/2"	1/2	50 W 0750 LHT 260
7/8"	5/8"	1-1/8"	3"			3/4	75 W 0750 LHT 260
1-1/16"	5/8"	1-3/8"	3"			1	10 W 0750 LHT 260
5/8"	1/2"	1-1/8"	3"	15"	10-1/2"	1/2	50 W 1050 LHT 260
7/8"	5/8"	1-1/8"	3"			3/4	75 W 1050 LHT 260
1-1/16"	5/8"	1-3/8"	3"			1	10 W 1050 LHT 260
5/8"	1/2"	1-1/8"	3"	18"	13-1/2"	1/2	50 W 1350 LHT 260
7/8"	5/8"	1-1/8"	3"			3/4	75 W 1350 LHT 260
1-1/16"	5/8"	1-3/8"	3"			1	10 W 1350 LHT 260
5/8"	1/2"	1-1/8"	3"	24"	19-1/2"	1/2	50 W 1950 LHT 260
7/8"	5/8"	1-1/8"	3"			3/4	75 W 1950 LHT 260
1-1/16"	5/8"	1-3/8"	3"			1	10 W 1950 LHT 260

Specify Material Coding At End Of Part #

(See Inside Cover)

- AA - Brass
- B - Carbon Steel
- C - AISI 304
- S - AISI 316

LEGEND

- U = Shank length below threads
- P = Process connection NPT
- S = Bore depth = instrument element length including its threads
- B = Max Shank Diameter
- H = Hex size across flats
- T = Lagging Extensions

To order plug and chain add a suffix to the part number.
For brass, add 1. For stainless, add 2.

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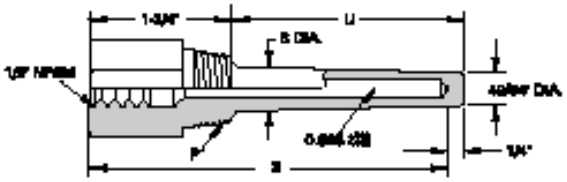
Attachment D

TEMP-PRO Inc. *Thermowell Catalog*

An ISO 9001 CERTIFIED Company

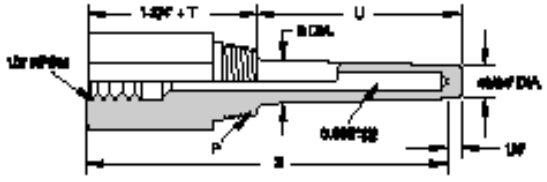
Threaded, Tapered Shank, 3/8" Nominal Bore

STANDARD



GENERAL INFORMATION					PART #
B	H	S	U	P	
7/8"	1-1/8"	4"	2-1/2"	3/4	75 W 0250 HT 385
1-1/16"	1-3/8"			1	10 W 0250 HT 385
7/8"	1-1/8"	6"	4-1/2"	3/4	75 W 0450 HT 385
1-1/16"	1-3/8"			1	10 W 0450 HT 385
7/8"	1-1/8"	9"	7-1/2"	3/4	75 W 0750 HT 385
1-1/16"	1-3/8"			1	10 W 0750 HT 385
7/8"	1-1/8"	12"	10-1/2"	3/4	75 W 1050 HT 385
1-1/16"	1-3/8"			1	10 W 1050 HT 385
7/8"	1-1/8"	15"	13-1/2"	3/4	75 W 1350 HT 385
1-1/16"	1-3/8"			1	10 W 1350 HT 385
7/8"	1-1/8"	18"	16-1/2"	3/4	75 W 1650 HT 385
1-1/16"	1-3/8"			1	10 W 1650 HT 385
7/8"	1-1/8"	24"	22-1/2"	3/4	75 W 2250 HT 385
1-1/16"	1-3/8"			1	10 W 2250 HT 385

WITH LAGGING EXTENSION



GENERAL INFORMATION						PART #
B	H	T	S	U	P	
7/8"	1-1/8"	2"	6"	2-1/2"	3/4	75 W 0250 LHT 385
1-1/16"	1-3/8"	2"			1	10 W 0250 LHT 385
7/8"	1-1/8"	3"	9"	4-1/2"	3/4	75 W 0450 LHT 385
1-1/16"	1-3/8"	3"			1	10 W 0450 LHT 385
7/8"	1-1/8"	3"	12"	7-1/2"	3/4	75 W 0750 LHT 385
1-1/16"	1-3/8"	3"			1	10 W 0750 LHT 385
7/8"	1-1/8"	3"	15"	10-1/2"	3/4	75 W 1050 LHT 385
1-1/16"	1-3/8"	3"			1	10 W 1050 LHT 385
7/8"	1-1/8"	3"	18"	13-1/2"	3/4	75 W 1350 LHT 385
1-1/16"	1-3/8"	3"			1	10 W 1350 LHT 385
7/8"	1-1/8"	3"	24"	19-1/2"	3/4	75 W 1950 LHT 385
1-1/16"	1-3/8"	3"			1	10 W 1950 LHT 385

LEGEND

- U = Shank length below threads
- P = Process connection NPT
- S = Bore depth = instrument element length including its threads
- B = Max Shank Diameter
- H = Hex size across flats
- T = Lagging Extensions

Specify Material Coding At End Of Part #

(See Inside Cover)

- AA - Brass
- B - Carbon Steel
- C - AISI 304
- S - AISI 316

To order plug and chain add a suffix to the part number.
For brass, add 1. For stainless, add 2.

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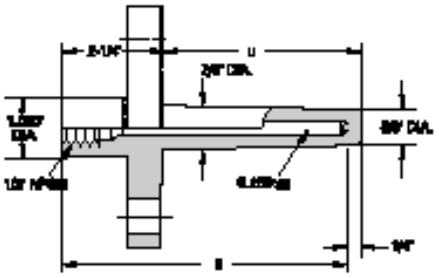
Attachment E

TEMP-PRO Inc. *Thermowell Catalog*

An ISO 9001 CERTIFIED Company

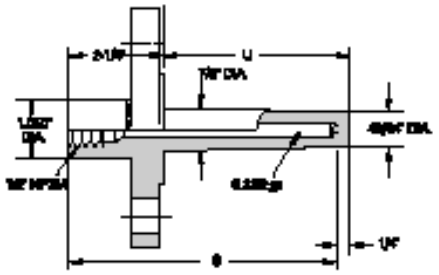
Raised Face, Flanged, Tapered Shank

1/4" NOMINAL BORE



GENERAL INFORMATION			PART #
S	U	FLANGE SIZE	
4"	2"	1"	10 W 0200 HF 260
		1-1/2"	15 W 0200 HF 260
		2"	20 W 0200 HF 260
6"	4"	1"	10 W 0400 HF 260
		1-1/2"	15 W 0400 HF 260
		2"	20 W 0400 HF 260
9"	7"	1"	10 W 0700 HF 260
		1-1/2"	15 W 0700 HF 260
		2"	20 W 0700 HF 260
12"	10"	1"	10 W 1000 HF 260
		1-1/2"	15 W 1000 HF 260
		2"	20 W 1000 HF 260
15"	13"	1"	10 W 1300 HF 260
		1-1/2"	15 W 1300 HF 260
		2"	20 W 1300 HF 260
18"	16"	1"	10 W 1600 HF 260
		1-1/2"	15 W 1600 HF 260
		2"	20 W 1600 HF 260
24"	22"	1"	10 W 2200 HF 260
		1-1/2"	15 W 2200 HF 260
		2"	20 W 2200 HF 260

3/8" NOMINAL BORE



GENERAL INFORMATION			PART #
S	U	FLANGE SIZE	
4"	2"	1"	10 W 0200 HF 385
		1-1/2"	15 W 0200 HF 385
		2"	20 W0200 HF 385
6"	4"	1"	10 W 0400 HF 385
		1-1/2"	15 W 0400 HF 385
		2"	20 W 0400 HF 385
9"	7"	1"	10 W 0700 HF 385
		1-1/2"	15 W 0700 HF 385
		2"	20 W 0700 HF 385
12"	10"	1"	10 W 1000 HF 385
		1-1/2"	15 W 1000 HF 385
		2"	20 W 1000 HF 385
15"	13"	1"	10 W 1300 HF 385
		1-1/2"	15 W 1300 HF 385
		2"	20 W 1300 HF 385
18"	16"	1"	10 W 1600 HF 385
		1-1/2"	15 W 1600 HF 385
		2"	20 W 1600 HF 385
24"	22"	1"	10 W 2200 HF 385
		1-1/2"	15 W 2200 HF 385
		2"	20 W 2200 HF 385

LEGEND

U = Shank length below flange face

S = Bore depth = instrument element length including its threads

1. See inside cover to compose part number.

2. To order plug and chain add a suffix to the part number. For brass add 1. For stainless, add 2.

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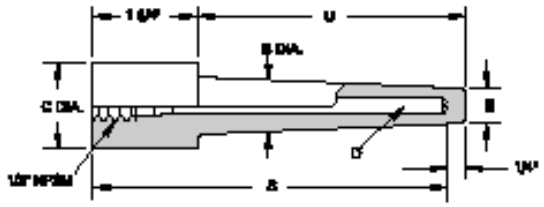
Attachment F

TEMP-PRO Inc. *Thermowell Catalog*

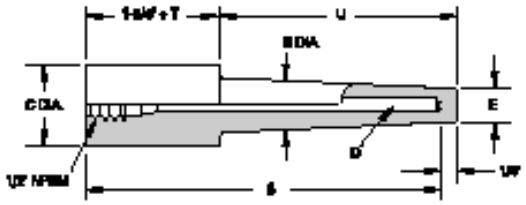
An ISO 9001 CERTIFIED Company

Socket-Weld, Tapered Shank, 3/4" & 1" Pipe Sizes, 1/4" & 3/8" Nominal Bore

STANDARD



WITH LAGGING EXTENSION



GENERAL INFORMATION			PART #	PART #
S	U	P	.260 BORE	.385 BORE
4"	2-1/2"	3/4	75 W 0250 HS 260	75 W 0250 HS 385
		1	10 W 0250 HS 260	10 W 0250 HS 385
6"	4-1/2"	3/4	75 W 0450 HS 260	75 W 0450 HS 385
		1	10 W 0450 HS 260	10 W 0450 HS 385
9"	7-1/2"	3/4	75 W 0750 HS 260	75 W 0750 HS 385
		1	10 W 0750 HS 260	10 W 0750 HS 385
12"	10-1/2"	3/4	75 W 1050 HS 260	75 W 1050 HS 385
		1	10 W 1050 HS 260	10 W 1050 HS 385
15"	13-1/2"	3/4	75 W 1350 HS 260	75 W 1350 HS 385
		1	10 W 1350 HS 260	10 W 1350 HS 385
18"	16-1/2"	3/4	75 W 1650 HS 260	75 W 1650 HS 385
		1	10 W 1650 HS 260	10 W 1650 HS 385
24"	22-1/2"	3/4	75 W 2250 HS 260	75 W 2250 HS 385
		1	10 W 2250 HS 260	10 W 2250 HS 385

GENERAL INFORMATION				PART #	PART #
T	S	U	P	.260 BORE	.385 BORE
2"	6"	2-1/2"	3/4	75 W 0250 LHS 260	75 W 0250 LHS 385
2"			1	10 W 0250 LHS 260	10 W 0250 LHS 385
3"	9"	4-1/2"	3/4	75 W 0450 LHS 260	75 W 0450 LHS 385
3"			1	10 W 0450 LHS 260	10 W 0450 LHS 385
3"	12"	7-1/2"	3/4	75 W 0750 LHS 260	75 W 0750 LHS 385
3"			1	10 W 0750 LHS 260	10 W 0750 LHS 385
3"	15"	10-1/2"	3/4	75 W 1050 LHS 260	75 W 1050 LHS 385
3"			1	10 W 1050 LHS 260	10 W 1050 LHS 385
3"	18"	13-1/2"	3/4	75 W 1350 LHS 260	75 W 1350 LHS 385
3"			1	10 W 1350 LHS 260	10 W 1350 LHS 385
3"	24"	19-1/2"	3/4	75 W 1950 LHS 260	75 W 1950 LHS 385
3"			1	10 W 1950 LHS 260	10 W 1950 LHS 385

GENERAL INFORMATION				
P	B	C	BORE DIA. D	E
3/4	25/32	1.05	.260	5/8
			.385	49/64
1	1-1/32	1.315	.260	5/8
			.385	49/64

LEGEND

- U = Shank length below threads
- P = Process connection NPT
- S = Bore depth = instrument element length including its threads
- B = Max Shank Diameter
- H = Hex size across flats
- T = Lagging Extensions

Specify Material Coding At End Of Part #

(See Inside Cover)

- AA - Brass
- B - Carbon Steel
- C - AISI 304
- S - AISI 316

To order plug and chain add a suffix to the part number.
For brass, add 1. For stainless, add 2.

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Attachment G

ASHCROFT

Bimetal Thermometers
Series EI, ASME B40.3
Grade A (±1% of span)

- *Hermetically sealed*
- *External adjustment*
- *Maxivision® dial*
- *±1% full-span accuracy (ASME B40.3 Grade A)*
- *All-welded stainless steel construction*
- *Silicone on the coil provides vibration dampening and superior time response*
- *Heavy-duty glass standard; plastic or shatterproof glass optional*
- *Limited five-year warranty*

This series has a hermetic seal and an external adjustment in the rear of the case. As with other Ashcroft® industrial bimetal thermometers, it has a Maxivision® dial which eliminates parallax by placing the pointer on the same plane as the graduations. The connection locations are rear, lower, and Everyangle™.

The hermetic seal prevents entry of moisture into the casing, thus minimizing the possibility of icing or fogging inside the case. The window stays clear, and with the Maxivision dial, precise readings are certain.

SELECTION TABLE

Case Size		Style Code	Stem				Stem Lengths Available		Temperature Range					
Dial	Code		Connection	Code	Location	Code	"S" Length (inches)	Code	°F* Fahrenheit	°/Div.	Fig. Inter.	°C Celsius	°/Div.	Fig. Inter.
2"	20	EI	Plain	40	Rear	R			–80/120	2	20	–50/50	1	10
			Pointed Plain	50	Rear	R	2½	025	–20/120††			–20/120	2	20
			¼ NPT	60	Rear	R	4	040	30/130††	1	10	0/50††	1	5
3"	30		½ NPT Union	42	Everyangle	E	6	060	0/200	2	20	0/100	1	10
			½ NPT	60			9	090	0/250		50	10/150	2	20
			½ NPT	60	Rear	R	12	120	50/300			0/200		
					Lower	L	15	150	50/400	5		0/300	5	50
5"	50		½ NPT Union	42	Everyangle	E	18	180	50/550			50/450**†		
			½ NPT	60			24	240	200/700†			100/500**†		
			½ NPT	60	Rear	R			100/800†	10	100			
					Lower	L			200/1000**†					

*Dual scale ranges available for all standard °F ranges (3" and 5" case only)
**Satisfactory for continuous service up to 800°F or 425°C. Can be used for intermittent service from 800 to 1000°F, or 425 to 500°C. Use Ashcroft Duratemp® thermometers for ranges above and below those listed above.
†Minimum stem length for these ranges is 4".
††Minimum stem length for lower connection and Everyangle is 4".

Thermowells must be used on all pressure or velocity applications, to protect the stem of thermometer from corrosion and physical damage, and to facilitate removal of the thermometer without disturbing the process. Maximum ambient temperature is 200°F (95°C).

Overtemperature Limits	
Top of Range °F	Maximum Overtemperature
up to 250	100% of span
250/550	50% of span
550/1000	800°F **

TO ORDER THIS EI SERIES BIMETAL THERMOMETER:

Select: 30 EI 60 R 040 0/250°F XNH

1. Case Size: 3" Code 30
2. Style: Code EI
3. Stem Conn: ½ NPT Code 60
4. Stem Location: Rear Code R
5. Stem Length: 4" Code 040
6. Range: Code 0/250°F
7. Options: Stainless Steel Tag (see Page 210)

Consult factory for guidance in product selection
Phone (203) 385-0217, Fax (203) 385-0602 or
visit our web site at www.ashcroft.com

MADE IN U.S.A.

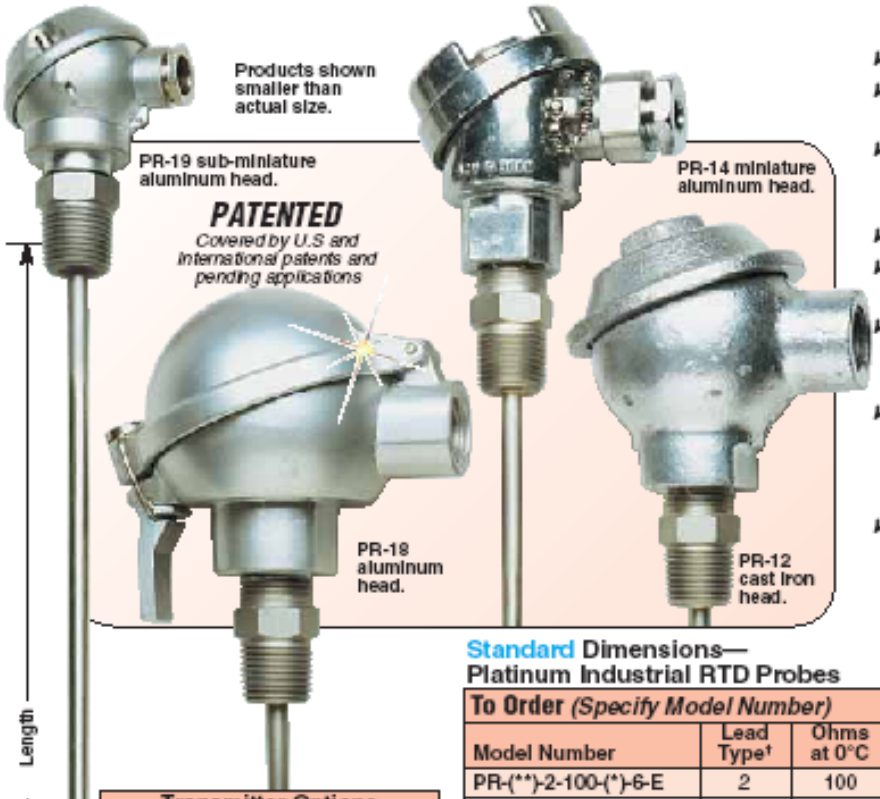
Attachment H

Platinum RTD Probes

Industrial Fixed Length Design

Standard and Metric Dimensions

PR-Series Starts at $90



- Rugged Design
- Offers Variety of Protection Heads
- ½ NPT Mounting Threads and Screw-Type Terminal Block
- Fixed Length
- 304 SS Sheath Connected to 304 SS Hex Fitting
- Standard 3-Wire Configuration, 2 and 4-Wire Also Available
- 100 Ω Wire-Wound Class "A" DIN Platinum 3-Wire Standard (2- and 4-Wire Available)
- Optional 4 to 20 mA Transmitters Can be Conveniently Installed in Some Protection Heads

Standard Dimensions— Platinum Industrial RTD Probes

MOST POPULAR MODELS HIGHLIGHTED!

To Order *(Specify Model Number)*					
Model Number	Lead Type†	Ohms at 0°C	Sheath Length	¼" O.D. Price	⅛ or 3/16" O.D. Price
PR-(**)-2-100-(*)-6-E	2	100	6"	$90	$94
PR-(**)-2-100-(*)-9-E	2	100	9"	90	94
PR-(**)-2-100-(*)-12-E	2	100	12"	90	94
PR-(**)-2-100-(*)-18-E	2	100	18"	93	97
PR-(**)-2-100-(*)-24-E	2	100	24"	99	100

** Specify: 1/8, 3/16 or 1/4 for probe diameter in inches. Other lengths readily available*
*** Specify protection head style: 12 = cast iron; 14 = miniature aluminum; 18 = aluminum; 19 = subminiature aluminum.*
Ordering Example: PR-12-2-100-1/14-6-E, industrial RTD probe with cast iron head, 3-wire configuration (style 2), 100 Ω, Class "A" DIN platinum element, ¼" diameter, 6" length, European curve (α = 0.00385), $90.
† For other lead types please see page C-13.

Metric Dimensions - Platinum Industrial RTD Probes

To Order *(Specify Model Number)*					
Model Number	Lead Type†	Ohms at 0°C	Sheath Length	6 mm O.D. Price	3 or 4.5 mm O.D. Price
PR-(**)-2-100-(*)-150-E	2	100	150 mm	$90	$94
PR-(**)-2-100-(*)-225-E	2	100	225 mm	90	94
PR-(**)-2-100-(*)-300-E	2	100	300 mm	90	94
PR-(**)-2-100-(*)-450-E	2	100	450 mm	93	97
PR-(**)-2-100-(*)-600-E	2	100	600 mm	94	100

** Specify: M30, M45 or M60 for probe diameter in millimeters. Other lengths readily available*
*** Specify protection head style: 12 = cast iron; 14 = miniature aluminum; 18 = aluminum; 19 = subminiature aluminum.*
† For other lead types please see page C-13.
Ordering Example: PR-12-2-100-M60-150-E, industrial RTD probe with cast iron head, 3-wire configuration (style 2), 100 Ω, Class "A" DIN platinum element, 6 mm diameter, 150 mm length, European curve (α = 0.00385), $90.

Transmitter Options		
Model No.	Description	Page
TX94A	Mini transmitter	N-12
TX94	Ultra-low profile	N-14
TX904	Field rangeable	N-15

Note: See Section N for transmitter range codes.
Ordering Example: PR-18-2-100-1/4-12-E-TX904, fixed length 100 Ω, Class "A" DIN Platinum RTD with snap-locking aluminum head and TX904-2 transmitter, $70 + 173 = $243.

Use RTD Extension Wire, e.g., EXTT-3CU Series. Please see page C-50.

Connection Heads		
Model No.	Description	Code
PR-12	Cast iron	12
PR-14	Mini aluminum	14
PR-18	Aluminum hinge top	18
PR-19	Sub-mini aluminum	19

To Order, Call 1-800-82-66342 or 1-800-TC-OMEGA or Shop Online at *omega.com*

Attachment I
CORROSIVE SERVICE GUIDE TO MATERIALS

CORRODENT	TEMP °F.	CONC. %	RECOM. MATERIAL
Acetic Acid	212	ALL	Monel
Acetic Anhydride	300		Nickel
Acetone	212	ALL	304 SS
Acetylene	400		304 SS
Alcohols	212	ALL	304 SS
Alum (Potassium or Sodium)	300	ALL	Hast. C
Aluminum Chloride	212	ALL	Hast. B
Aluminum Sulfate	212	ALL	316 SS
Ammonia, Dry	212	ALL	304, 316 SS
Ammonium Hydroxide (Ammonia, Aqua)	212	ALL	304, 316 SS
Ammonium Chloride	300	50%	Monel
Ammonium Nitrate	300	ALL	304 SS
Ammonium Sulfate	212	ALL	316 SS
Amyl Acetate	300	ALL	304 SS
Aniline	75		Monel
Asphalt	250		304 SS
Atmosphere (Industrial and Marine)			304 SS
Barium Compounds		SEE CALCIUM	
Beer	70		304 SS
Benzene (Benzol)	212		Steel
Benzoic Acid	212	ALL	316 SS
Bleaching Powder	70	15%	Monel
Borax	212	ALL	Brass
Bordeaux Mixture	200		304 SS
Boric Acid	400	ALL	316 SS
Bromine	125	DRY	Monel
Butane	400	ALL	Steel
Butyl Alcohol		SEE ALCOHOLS	
Butyric Acid	212		Hast. C
Calcium Bisulphite	75	ALL	Hast. C
Calcium Chloride	212	ALL	Hast. C
Calcium Hydroxide	300	20%	Hast. C
Calcium Hypochlorite		SEE BLEACHING POWDER	
Carbolic Acid		SEE PHENOL	
Carbon Dioxide, Dry	800	ALL	Brass
Carbonated Water	212	ALL	304 SS
Carbonated Beverages	212		304 SS
Carbon Disulfide	200		304 SS
Carbon Tetrachloride	125	ALL	Monel
Chlorine, Dry	100		Monel
Chlorine, Moist	100	ALL	Monel
Chloroacetic Acid	212	ALL	Monel
Chloroform, Dry	212		Monel
Chromic Acid	300	ALL	Hast. C
Cider	300	ALL	304 SS
Citric Acid	212	ALL	Hast. C
Copper (II) Chloride	212	ALL	Hast. C
Copper (II) Nitrate	300	ALL	316 SS
Copper (II) Sulfate	300	ALL	316 SS

CORRODENT	TEMP °F.	CONC. %	RECOM. MATERIAL
Copper Plating Solution (Cyanide)	180		304 SS
Copper Plating Solution (Acid)	75		304 SS
Corn Oil	200		304 SS
Creosote	200	ALL	304 SS
Crude Oil	300		Monel
Ethyl Acetate		SEE LACQUERS AND THINNERS	
Ethyl Chloride, Dry	500		Steel
Ethanol		SEE ALCOHOLS	
Ethylene Glycol (Uninhibited)	212	ALL	304 SS
Ethylene Oxide	75		Steel
Fatty Acids	500	ALL	316 SS
Ferric Chloride	75	ALL	Hast. C
Ferric Sulfate	300	ALL	304 SS
Formaldehyde	212	40%	316 SS
Formic Acid	300	ALL	316 SS
Freon	300		Steel
Flourine, Anhydrous	100		304 SS
Furfural	450		316 SS
Gasoline	300		Steel
Glucose	300		304 SS
Glue ph 6-8	300	ALL	304 SS
Glycerine	212	ALL	Brass
Hydrobromic Acid	212	ALL	Hast. C
Hydrochloric Acid (37-38%)	225	ALL	Hast. B
Hydrogen Chloride, Dry	500		304 SS
Hydrocyanic Acid	212	ALL	304 SS
Hydroflouric Acid	212	60%	Monel
Hydrogen Flouride, Dry	175		Steel
Hydrofluogilicic Acid	212	40%	Monel
Hydrogen Peroxide	125	10-100%	304 SS
Kerosene	300	ALL	Steel
Lacquers and Thinners	300	ALL	304 SS
Lactic Acid	300	ALL	316 SS
Lime	212	ALL	316 SS
Linseed Oil	75		Steel
Magnesium Chloride	212	50%	Nickel
Magnesium Hydroxide (or Oxide)	75	ALL	304 SS
Magnesium Sulfate	212	40%	304 SS
Mecuric Chloride	75	10%	Hast. C
Mercury	700	100%	Steel
Methylene Chloride	212	ALL	304 SS
Methyl Chloride, Dry	75		Steel
Milk, fresh or sour	180		304 SS
Molasses		SEE GLUCOSE	
Natural Gas	70		304 SS
Nitric Acid	75	ALL	304 SS
Nitric Acid	110	ALL	316 SS
Oxygen	75	ALL	Steel

CORRODENT	TEMP °F.	CONC. %	RECOM. MATERIAL
Oleic Acid		SEE FATTY ACIDS	
Oxalic Acid	212	ALL	Monel
Photographic Bleaching	100	ALL	304 SS
Palmitic Acid		SEE FATTY ACIDS	
Phosphoric Acid	212	ALL	316 SS
Phenol	212	ALL	316 SS
Potassium Compounds		SEE SODIUM COMPOUNDS	
Propane	300		Steel
Rosin	700	100%	316 SS
Sea Water	75		Monel
Soap and Detergents	212	ALL	304 SS
Sodium Bicarbonate	212	20%	316 SS
Sodium Bisulphite	212	20%	304 SS
Sodium Bisulphate	212	20%	304 SS
Sodium Carbinate	212	40%	316 SS
Sodium Chloride	300	30%	Monel
Sodium Chromate	212	ALL	316 SS
Salt or Brine		SEE SODIUM CHLORIDE	
Sodium Cyanide	212	ALL	304 SS
Sodium Hydroxide	212	30%	316 SS
Sodium Hypochlorite	75	10%	Hast. C
Sodium Nitrate	212	40%	304 SS
Sodium Nitrite	75	20%	316 SS
Sodium Phosphate	212	10%	Steel
Sodium Silicate	212	10%	Steel
Sodium Sulfate	212	30%	316 SS
Sodium Sulfide	212	10%	316 SS
Sodium Sulfite	212	30%	304 SS
Sodium Thiosulfate	212	ALL	304 SS
Steam			304 SS
Stearic Acid		SEE FATTY ACIDS	
Sugar Solutions		SEE GLUCOSE	
Sulfur	500		304 SS
Sulfur Chloride	75	DRY	316 SS
Sulfur Dioxide	500	DRY	316 SS
Sulfur Trioxide	500	DRY	316 SS
Sulfuric Acid	212	10%	316 SS
Sulfuric Acid	212	10-90%	Hast. B
Sulfuric Acid	212	90-100%	316 SS
Sulfuric Acid, Fuming	175		Alloy 20
Sulfurous Acid	75	20%	316 SS
Titanium Tetrachloride	75	ALL	316 SS
Tannic Acid	75	40%	Hast. B
Toluene	75		Steel
Trichloroacetic Acid	75	ALL	Hast. B
Trichlorethylene	300	DRY	Monel
Turpentine	75		316 SS
Varnish	150		Steel
Zinc Chloride	212	ALL	Hast. B
Zinc Sulfate	212	ALL	316 SS

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