Bristol

Bristol® Thermometer Systems

Class 3 - Gas Filled

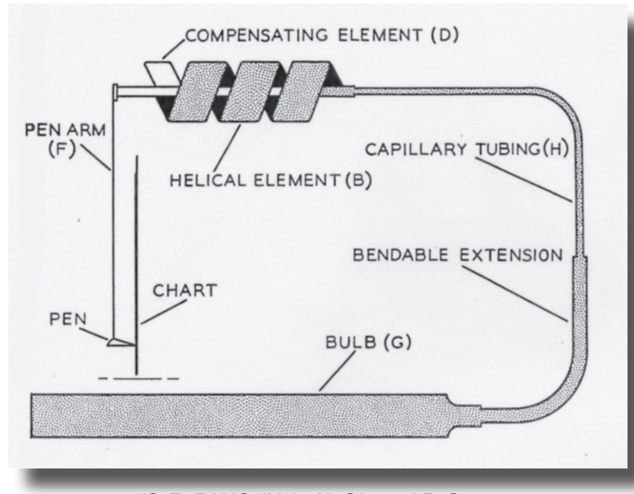
Characteristics of Class 3 Thermometers

The chief characteristics of Class 3 systems are:

- Uniformly-graduated scale
- Larger bulb than Class 1

Temperature range between -350°F and +1000°F (-212 and +538°C). Usually specified for applications where maximum temperature is 500°F or more.

- Minumum recommended temperature-span, 200°F (110°C). Class 1, is better for short spans' or partial ranges.
- Response-time is slightly better than for Class 1
- Bulb elevation does not affect reading



(S.P. DWG #3658) Class 3B Gas-Filled Thermometer System

Principle of Operation

A Class 3 thermometer is gas-filled and measures temperature as a function of pressure. This is in accordance with "Charles' Law": if the volume of a given weight of gas is kept constant, the absolute pressure will vary directly as the absolute temperature. Expressed mathemathically: PV = RT or Pi/Pa = Ti/Tg, where R is a constant; Pi and Pa are the initial and final absolute pressures; and TI and Ts, the initial and final absolute temperatures.

At constant volume, the absolute pressure of a given quantity of gas changes about 1/460 for each change of 1°F in temperature.

No gas or mixture of gases follows this pressure-temperature relationship exactly, because Charles' Law implies a perfect gas. However, the magnitude of the departure of common gases from the ideal scale is too slight to be considered in industrial thermometer applications. A nitrogen system, for example, at 1000°F actual temperature would indicate a temperature of 999.75°F. At lower temperatures, the departure will be proportionately less.

How a Class 3 Thermometer Works

Figure 1 is a simplified sketch of a Class 3 System. The system is filled with gas under pressure. When the temperature increases at the bulb, the pressure increases in the system causing the helical element to unwind slightly. This motion positions the pen or pointer on a chart or scale graduated in temperature units.

Ambient Temperature Compensation

Temperature changes at the helical element or along the tubing will also affect the pressure in the system. Such ambient-temperature errors in a gas-filled system are smaller than in a liquid-filled system, but must be considered in designing and specifying a Class 3 System.

Temperature changes around the measuring element have two effects: first, the volume of the measuring element is changed; second, the elastic modulus of the element changes with temperature.

Because the volume of the measuring element is less than 1% of the bulb-volume, this error is insignificant, due to volume change in systems designed to meter spans of 300°F or more. Also, except in unusual applications, case temperatures seldom vary more than ±50%. For this change, the volume error incurred is less than 0.2%.

However, a change of 50°F in ambient temperature will cause the elastic modulus to change slightly more than 1%. When translated into pressure, this results in an error of 4% for a measured span of 200°F. This error decreases proportionately as the measured span increases.

Fortunately, both of these errors can be minimized by inserting a bimetallic compensating-strip between the element and the pen. The strip is designed so that its motion is equal, ‘ but opposite, to the motion of the measuring-element.

This compensation is perfect for only one temperature (T_b) of the bulb. Therefore, the error will increase as the bulb temperature departs from T_b. However, by properly designing the compensator, and calibrating the system at mid-scale, the errors at the extremes will be less than ±1% for ±50°F ambient change.

Thermometers with this kind of compensation are called “Class 3B” or “Case-Compensated Class 3”.

Errors due to ambient-changes along the capillary depend on the volume of the capillary relative to the bulb-volume and the temperature range. To keep these errors within 1% of full scale, for ambient-temperature changes of ±50°F, Class 3B systems are furnished with 9/16 inch diameter bulbs.

Range Span	Capillary Length	Bulb Size
200° F to 1000° F	1 to 25 ft	9/16” x 8.0”
Standard bulb materials: 316 stainless steel		

Permissible capillary lengths

Thermometric Gases

Nitrogen is used as filling mediums for thermometer systems.

However, except for special applications, pure nitrogen is usually employed, because it is:

- Chemically inert, and will not react under ordinary conditions with metals or other chemicals.
- Non-toxic and non-inflammable. In case of leakage, it is harmless.
- Economical for commercial use.

Temperature Ranges

Theoretically, a perfect gas could measure temperatures down to absolute zero (-459.69°F). However, all the known gases condense at a critical temperature considerable above absolute zero (nitrogen, -232.8°F; hydrogen, -399.8°F). The practical lower limit of a Class 3 thermometer is some temperature above the critical.

Gas-filled systems are furnished for measuring temperatures from -350°F to +1000°F. Ranges extending below -60°F and above 800°F, however, require special calibrating equipment, and are more difficult to calibrate, consequently, such ranges usually entail an extra calibrating charge.

Gas-filled systems are sometimes furnished for special applications to measure spans as low as 100°F. However, 200°F is considered the minimum practical span, and this span only for temperatures up to 400°F. Above 400°F the measured span should never be less than 400°F. For spans less than the above limits, the element motion is insufficient to satisfactorily operate controls or other secondary mechanisms.

All Bristol Class 3 thermometer systems are furnished with the same pressure element, regardless of the temperature range. This is a 3/8-inch flat, four-turn helical trumpet-netal element.

These elements will stand a maximum pressure of

810 psig, and are rated to deflect thru 23 angular degrees with a pressure-change of 300 psig.

The pressures developed in the system depend on the temperature range to be measured. These pressures are calculated as a function of the measured span; i.e., minimum and maximum bulb-temperatures to permit the maximum deflection of the measuring-element up to 23 angular degrees, without exceeding a maximum system-pressure of 810 psi. The shorter the span, the higher the.initial pressure (pressure at the minimum measured-temperature) will be.

For spans less than 300°F, the initial pressure is too high to use a 300 psi pressure-change and still remain within a maximum system-pressure of 810 psi. For example, to measure a range of 400 to 600°F, a span of 200°F, the pressure at 400°F will be 610 psi; at 600°F, 810 psi. The pressure-change, therefore, is only 200 psi between minimum and maximum bulb-temperatures. Consequently, the measuring element deflects only 2/3 the rated 23°, and its motion must be multiplied 3:2 to move the pen across the chart-scale. The resulting torque available at the pen is therefore slightly less than 1/2 of what it would be with no multiplication between the element and the pen.

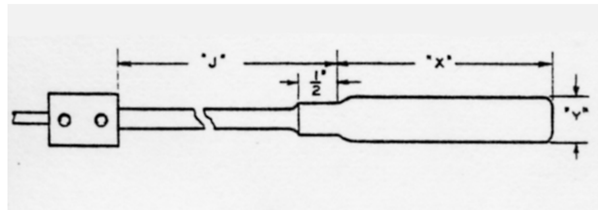
Class 3 Bulbs, Wells, and Fittings

Bulbs and Well Materials

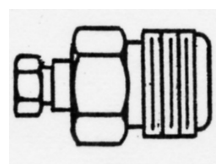
For temperatures 450°F and higher, if a well is required, bulb and well should be of similar material. For example: stainless steel bulb in a stainless steel well.

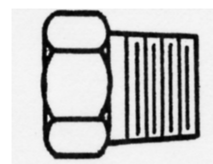
For temperatures 500°F and higher, always specify stainless steel bulbs in preference to copper. Otherwise, at these elevated tenperatures, copper will oxidize and will permit the gas filling-medium to diffuse through it.

Special bulbs can be manufactured for specific applications in a large variety of shapes, dimensions, or materials. However, it is desirable to avoid special shapes or materials because they.are expensive. Such bulbs are generally completely hand-made, and must be used under actual operating conditions to determine their effectiveness.

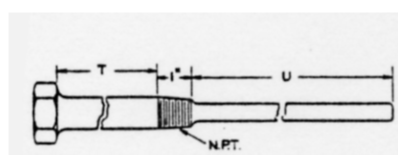


Bulbs		
"Y"	"X"	Specification Number
		Stainless
9/16"	8"	SA-3029-J-080





Adjustable Fittings SAMA Type	Bushings (For use with adj. filltings. Not required with wells.)	
Part No.	Part No.	N.P.T.
Stainless Steel	Stainless Steel	
A6323	A6333	3/4"



SAMA Standard Wells	
T	Part No.
	316 Stainless Steel
0	A70204-"U"
3	A70205-"U"

How to Specify

First determine the bulb size required from Figure 2. In Figure 5 find the specification number for the bulb size selected and the material required. Insert 10 inch or 30 inch “J” dimension in the specification number. For example: If a plain stainless steel bulb with a 30 inch extension and a 40 foot capillary length is required, a 9/16” diameter bulb should be selected and the specification number will be SA50214-50-065.

When adjustable fittings are required, specify the appropriate fitting part number from Figure 5. A standard fitting furnished with the bulb is adjustable along the bulb extension, but is not removable. Removable fittings can be furnished as a special item for use with capillary averaging bulbs, as shown in Figure 4.

A bushing must be specified with the same standard adjustable fitting, unless the bulb is to be installed in a well. The standard fittings in Figure 5 are designed to fit SAMA standard wells. If the bulb is to be used with wells other than SAMA standard, a special bushing will be necessary as required to fit the well.

Where the system is to be furnished with a well, the bushing is omitted and the appropriate well part number is selected from Figure 5. Wells should be specified with a “U” dimension of at least 2 inches longer than the “X” dimension of the bulb.

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