ENGINEERING STANDARD

FOR

TEMPERATURE INSTRUMENTS

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1. SCOPE

This Standard represents the minimum and general Engineering requirements for different types of temperature measurement and control instruments, which are used widely in oil, gas and petrochemical industries.

Temperature instruments will be discussed in this standard within nine different sections, which are as follow:

1) General.
2) Filled System and Bimetallic Dial Thermometers.
3) Resistance Type Temperature Measurement.
4) Thermocouples.
5) Thermowells and Pockets of Thermometers.
6) Temperature Transmitters.
7) Temperature Indicating, Recording and Controlling Instruments.
8) Radiation-type pyrometers
9) Optical pyrometers

For custody transfer temperature measurement reference to be made to chapter 7 of API'S manual of petroleum measurement standards.

2. REFERENCES

Throughout this Standard the following standards and codes are referred to. The editions of these standards and codes that are in effect at the time of publication of this standard shall, to the extent specified herein, form a part of this Standard. The applicability of changes in standards and codes that occur after the date of this standard shall be mutually agreed upon by the company and the vendor:

API (AMERICAN PETROLEUM INSTITUTE)

RP-550, Part I, Section 3: "Temperature"
RP-550, Part III, "Fired Heaters and Inert Gas Generators"
Manual of Petroleum Measurement Standards Chapter 7: "Temperature Determination"

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

"STP 470 B Manual on use of Thermocouples in Temperature Measurement"

ANSI (AMERICAN NATIONAL STANDARD INSTITUTE)

"B16.5 Pipe Flanges and Flanged Fittings"
"ISA/MC 96.1 Temperature Measurement Thermocouples"

ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

CSD-1 "Code for Boilers (Control and Safety Devices)"
PTC 19.3 "Performance Test Code-Temperature Measurement"
PVHO-1 "Code for Unfired Pressure Vessels"

IEC (INTERNATIONAL ELECTROTECHNICAL COMMISSION)

"79 Electrical Apparatus for Explosive Gas Atmospheres"
"529 Classification of Degrees of Protection Provided by Enclosures"

BSI (BRITISH STANDARD INSTITUTION)

BS 1560	"Specification for Steel Pipe Flanges (Nominal Sizes ½ in. to 24 in.) for Petroleum Industry"
BS 1827	"Reference Tables for Ni/Cr, Thermocouples"
BS 1904 = IEC 751	"Specification for Industrial Platinum Resistance Thermometer Sensors"
BS 2765	"Specification for Dimensions of Temperature Detecting Elements and Corresponding Pockets"
BS 6175	"Temperature Transmitters with Electrical Output"

IPS (IRANIAN PETROLEUM STANDARD)

IPS-E-GN-100	"Units"
IPS-C-EL-272	"Wires and Cables"
IPS-E-IN-190	"Transmission Systems"
IPS-M-IN-120	"Material Standard for Temperature Instruments"
IPS-C-IN-120	"Construction and Installation Standard for Temperature Instruments"

3. UNITS

International system of units (SI) in accordance with IPS-E-GN-100 shall be used. Except for the temperatures, which shall be in degrees celcius instead of kelvin, and for pipes & fittings threads, which shall be in inches of NPT.

4. GENERAL

4.1 Mercury-in-steel thermometers shall be used for transmission, local indication, local recording or local control of temp.

4.2 Bimetallic dial thermometers shall be used when local indication is required, and when errors in indication in excess of 1% of the span are acceptable.

Note:

They are not recommended for areas with salt laden or corrosive atmosphere.

4.3 Mercury-in-glass thermometers shall be used for test measurements.

4.4 Thermall-filled system thermometers shall be normally used for local temp. indication, and on pneumatic control systems where control over narrow span is required. See Table 3 on page 26.

4.5 Thermocouples or resistance thermometers are the preferred means of temp. measurement for centralized control and for multipoint indication or recording.

4.6 The choice between resistance thermometers and thermocouples shall be made taking the following points into consideration:

a) Where accuracy of measurement greater than that obtainable with a thermocouple is required, a resistance thermometer shall be used.

b) Resistance thermometers shall not be used where high frequency vibration is present, e.g. in high velocity steam or gas streams.

c) Resistance thermometers will be considered, when differential temp. measurement is required over a narrow span and for temp. measurements which require a high speed of response. (See Figs. 20 and 21).

d) Resistance thermometers shall be used, when mean temp. measurement is required over a zone.

e) Resistance thermometers shall be used where, condensation within a protective pocket would preclude the use of thermocouples, (e.g. low temp. applications).

Should it be absolutely necessary to use thermocouples for sub-zero temp. Special precautions shall be taken in order to eliminate short circuiting of the thermocouple wires, such as thermocouples with protective sheath.

4.7 Where precise control is not essential, self-acting temp. controllers may be used.

4.8 Temp. switches, locally mounted, shall be the filled system bulb type or bimetallic element. They shall meet the electrical classification and shall have mercury or micro switches. Removable thermowells shall be furnished.

Temp. switches mounted in the control room or on a local panel may be thermocouple actuated. These shall have cold-junction compensation.

5. FILLED SYSTEM AND BIMETALLIC DIAL THERMOMETERS

5.1 The filled system thermometer is designed to provide an indication or record of temp. at some distance from the point of measurement. The sensitive or measuring element (bulb) contains a gas, vapor or liquid which changes in physical characteristics with temp. This change is communicated through a capillary to bourdon tube, bellows or diaphragm. The bourdon (or bellows or diaphragm) respond to the signal from the bulb to provide a motion related in some definite way to the bulb temp.

5.2 Vapor filled systems are preferred for narrow span or cross ambient temp., liquid and Gas filled system is preferred for wide span and elevated temp. (see Table 3 & 4, Fig. 31).

5.3 Generally capillary tubing is required to transmit the temp. bulb signal to the instrument case. The capillary runs from the bulb the instrument activating mechanism. The transmitted signal is in the form of a pressure which represents the instantaneous temp. sensed by the bulb. It shall be required to restrict separation of the bulb from the actuating mechanism to a certain limit as described in table 3. Capillary tubing shall be supplied with adequate protection against corrosion and accidental mechanical damage. All filled system with remote bulb shall be adequately compensated (case and/or capillary.)

Capillary tubing shall be supported throughout its length.

5.4 Case compensation is accomplished by bi-metallic spring "d" rotates pressure spring "c" in an opposite direction so as to counteract for thermal expansion of the liquid in the spring due to ambient temperature changes. (See Fig. 34)

5.5 Case and capillary compensation is accomplished by means of an auxiliary spiral and capillary tubing. The compensating capillary extends parallel to the measuring capillary to terminate at the bulb of the measuring system. The measuring and compensating spirals are interconnected so as to expand in opposite directions. Therefore, a change in temperature within the instrument case or along the capillary tubing will affect both actuating spirals by the same amount, and therefore the measurement will be responsive only to the measuring spiral. (See Fig. 35)

A different approach is used by one instrument manufacturer to compensate for ambient temperature conditions. The system consists of the usual bulb, capillary and spring components. Compensation is obtained by using a special alloy "filler wire" extending through the bore of the capillary tubing. The filler wire has a coefficient of expansion so related to that of the tubing and the liquid that fills the system so that expansion and contraction of the mercury is exactly counteracted by the difference in expansion of the capillary tubing and its filler wire.

5.6 Nominal immersion length shall be selected to allow complete immersion of the bulb in the measured fluid. To obtain best results immersion length should be at least 75 mm for water, 100 mm for oils and for gases.

It is recommended that an additional 20-50 mm immersion be used in order to nullify the effect of heat conduction through metal in the well neck.

Generally this system shall not be used for more than 550°C.

5.7 The error due to the effect of the head of liquid if the detecting element and gage are at different levels, to be taken into account in calibration.

5.8 Bimetallic temp. indicating thermometers shall be dial type, hermetically sealed, heavy-duty with stainless steel socket, straight stem or angle pattern to suit the application.

Ranges shall be selected so that normal operating temp. indication is approximately mid-scale.

5.9 Where lines shall be subject to vibration or may be run in inaccessible locations, the use of filled system dial type indicating distance thermometers shall be considered, armoured capillary tubing supported throughout its length shall be used for connecting the bulbs to the indicators.

5.10 Normally bimetallic thermometers used up to 400°C.

5.11 If non-insertion length of stem exceeds 300 mm (12 in.), it is advisable to use a stem support.

6. RESISTANCE TYPE TEMPERATURE MEASUREMENT

6.1 Application

Resistance-type temperature measurement can provide more accurate measurement of temperature than is possible with thermocouple installations. Accordingly, resistance units are used in many installations where their greater accuracy is warranted, such as in low-differential temperature measurement. To obtain the greater accuracy and sensitivity inherent in a resistance system and to minimize thermal lag, it is important that optimum thermowell dimensions (for the particular resistance element) be employed to maintain good contact between the resistance bulb and the well. For this reason, wells for resistance bulbs frequently are provided with the resistance bulbs as matched units.

Resistance-type temperature measurement can be used in the ranges of -270 to 980°C (extreme), and 250 to 800°C (practical). See Table 1.

6.2 Resistance Temperature Detector's

Resistance temperature detectors (RTDs) operate on the principle of change in electrical resistance on the detector wire as a function of temperature. Two types of detector wires are generally used in resistance elements, nickel for ranges up to (315°C) and platinum for ranges up to (800°C). A third type, copper, is used in large motor windings up to (150°C). (pt 100 is preferred). (See Table 1).

Resistance temperature elements are available in many configurations, with the most common type being a tip-sensitive construction(see Figs. 13 through 24). Even though most resistance elements used in the petroleum industry are mounted in a thermowell, the elements shall be used bare when very fast (5-6 second) response times are required.

The use of transmitters, multiplexers, and micro processors, is applicable to resistance temperature devices. Precautions and practices encountered using thermocouples also apply to resistance temperature devices with two exceptions:

1) Ordinary copper wire is used to connect the readout device to the sensor. The most commonly used configuration provides one wire connection to one end and a two-wire connection to the other end of the sensor. This compensates for resistance and temperature change in the lead wire.

2) The reading is absolute. Elements are available conforming to one of two curves, European R = 0.00385 ohms/ohm/degree Celsius, or American R=0.00392 ohms/ohm/degree celsius. Both curves are based on a sensing element resistance of 100 ohms at 0 degree Celsius. Reference to be made to Table No. 1 of BS 1904.

6.3 Thermistor

A thermistor is a semiconductor exhibiting a large (usually negative) temperature coefficient of resistance. They are very sensitive, permitting full-scale ranges of less than 1°F. The upper operating temperature is determined by physical changes in the semiconductor material and is typically (93°C to 398°C) 200°F to 750°F.

Applications have been in thermal conductivity analyzers and laboratory measurements, but industrial applications are increasing.

6.4 Extension Wires

Individual extension wires (usually three) from the resistance element may terminate in a connection head or in a quick disconnect fitting or extend directly to the measuring unit. Generally, a connection head is employed and the wires are frequently run in a three-wire cable to the board-mounted resistance temperature measuring instrument. The wire normally used is minimally 0.75 mm^2, (18 AWG) stranded copper.

Where multiple installations of resistance elements are used, the wires can be run to a field terminal strip. A multiconductor cable is then used to bring the signals into the control panel. The wire in the multiconductor cable (may be 0.75 mm^2 18 AWG), however, for long distances, a check should be made with the manufacturer on allowable wire resistance.

Generally, no problem exists up to 1.6 Kilometers. Special attention needs to be directed at maintaining a minimal number of junctions or terminations in the extension wire.

6.5 To compensate for changes in ambient temp., resistance thermometers shall be connected to measuring Inst. by either a three or four wire system. (see Fig. 13 through 24).

6.6 To measure the same temperature for two different purposes a dual element resistance thermometer shall be used.

6.7 The use of converters with resistance bulbs are more common both for pneumatic and electronic systems. Such converters allow the use of standard transmission signals and offer more flexibility in the use of receiver equipment.

6.8 The converter where it is applicable shall be mounted in the control center.

6.9 All terminal enclosures shall have suitable protection for area classification and weather proof condition.

6.10 For more details regarding cable and wiring reference to be made to IPS-E-IN-190 "Transmission Systems".

7. THERMOCOUPLES

7.1 A thermocouple is two dissimilar thermoelements so joined as to produce a thermal emf when the measuring and reference junctions are at different temperatures.

7.2 Thermoelement is one of the two dissimilar electrical conductors comprising a thermocouple.

7.3 Measuring junction is that junction of a thermocouple which is subjected to the temperature to be measured.

7.4 Reference junction is that junction of a thermocouple which is at a known temperature or which is automatically compensated for its temperature.

7.5 Normally the thermocouple element is terminated at the connection head. However, the reference junction is not ordinarily located in the connection head but is transferred to the instrument by the use of thermocouple extension wire.

7.6 Extension wire is a pair of wires having such temperature-emf characteristics relative to the thermocouple with which the wires are intended to be used that, when properly connected to the thermocouple, the reference junction is transferred to the other end of the wires.

7.7 The signal from any thermocouple used in conjunction with a shut-down system shall not be connected to any other device.

7.8 When a thermocouple is used for automatic control, a duplicate thermocouple shall be provided in the same pocket. The second thermocouple shall be connected to a precision indicating instrument.

7.9 When two or more thermocouples are located in the same pocket they must be separately and permanently identified regarding their functions e.g. TRC or TI.

7.10 To measure the same temp. for two different purposes, a duplex thermocouple should be used. When two or more thermocouples are used to measure the same temp., they shall be located in the same pocket. When this is not possible and a single thermocouple must be used for two measurements, e.g. skin thermocouples, care shall be taken to avoid significant interaction between instruments connected to the same thermocouple. Such cases shall be referred to the user to ensure there is an adequate impedance on the measuring equipment to avoid interference or measurement errors.

7.11 For temperatures ranges and materials of different kinds of thermocouples see table 5, additional information on applications may be found in ASTM-STP 470 B.

7.12 All thermocouples shall be calibrated according to the latest edition of the appropriate British or USA Standards. ISA recommended practice ANSI/MC 96.1 or the specific National Bureau of standards tables may be used for reference (corresponding British Standards Institution tables BS 1827 are also acceptable).

Accuracy shall be within the limits of error as specified in above mentioned standards.

7.13 Thermocouples shall be manufactured from bare wire with ceramic insulators (see Fig. 1 & 2) but consideration may be given to the use of metal sheathed mineral insulated couples for special applications e.g. locations subjected to extreme vibration.

7.14 The junction of thermocouples shall be in contact with the thermowell to minimize the transfer lag, except where earth currents affect the measurements.

Where grounded thermocouple is used, the earth connection interferences and suitability of monitors and receiving instruments shall be considered.

7.15 All thermocouple positive leads to the terminating points shall be sleeved and marked +. They shall also be color coded in accordance with ISA-ANSI/MC96.1 (latest edition) to identify the metals used (see tables 6, 7 & 8).

7.16 Thermocouple leads shall be either mineral isolated, cupronickel covered, PVC sheathed or PVC insulated and served overall. In special cases where the ambient temperature surrounding the leads dictates asbestos insulated and served overall wire be used.

7.17 Thermocouple leads (extension wires), except mineral insulated type, shall be run in conduit or trunking and connected to the thermocouple head by a 1 m. min. length flexible conduit. Mineral insulated cable may be run in trays or trunking. Alternatively, multicore cable with single strand wire and PVC sheathing is acceptable in specified locations, but is subject to the approval of the user. Sheathing for under ground cables if applicable shall be in accordance with the requirements of IPS-C-EL-272 "wires & cables". (For more details, see IPS-E-IN-190 "Transmission Systems")

7.18 Trunking and conduit must be of adequate size and provided with ample inspection covers, etc., to facilitate maintenance and sealing where necessary. The following conditions shall be considered:

a) Conduits should normally be sized to carry the total required leads plus two.

b) The complete installation shall be weather and dust-proof, thermocouples and thermocouple extension wires are solid drawn conductors, normally 0.75 mm^2 in size and shall meet the application requirements according to the practice of ISA-ANSI/MC96-1.

7.19 On furnaces applications, leads from thermocouples shall be brought out clear from the furnace to reduce the possibility of fire damage. For these locations mineral insulated extension leads, shall be used (refer to: API-RP550, part III). (see Fig. 32).

7.20 The immersion length is the distance from the free end of the temp. sensing element or well to the point of immersion in the medium, the temp. of which is being measured.

In order to obtain optimum accuracy and response time the immersion length for a thermocouple installation shall be at least ten times the outside diameter of the thermocouple sheath, this value shall be increased where space permits. With flowing liquids, six diameters immersion may be used if the pipe and the external portion of protecting tube are well insulated. (see Fig. 12).

7.21 Skin thermocouples shall be installed on selected furnace tubes where coking or carbon blockage may occure or where operating temp. are close to tube design max. temp. and also where required to provide measurement for operational safe guards. (Refer to: API-RP-550, part III) (see Fig. 33).

7.22 Where magnesium-oxide insulated element grounded hot junction shall be used, sheath diameter shall be 7 mm (¼ in.) size and wire gage shall be approximately 16 gage (1.3 mm^2).

7.23 Single and twin thermocouple should fit 6 mm bore pockets.

7.24 Where type k-thermocouple operate on temp. services above 800°C, and hydrogen diffusion to the thermocouple material may be expected, magnesium-oxide insulated thermocouples with inconel protective sheathing should be used, or a titanium getter wire shall be specified in addition to the normal execution, for absorption of the traces of hydrogen.

7.25 With regard to deterioration (drift) of type k, thermocouples, at very high temp., such as in hydrocracking furnaces, consideration should be given to the use of type B-thermocouple, provided these are used only for furnace coil balancing.

7.26 All thermocouples used for furnace coil balancing shall be from the same batch and be calibrated/certified for the specified operating temp., in addition to the standard identification. The thermocouple shall be provided with batch and certificate number.

Note:

Thermocouples used for furnace coil balancing shall be provided with warning plates having black letters on a red background and shall be fixed by means of screws.

8. THERMOWELLS AND POCKETS FOR TEMP. DETECTING ELEMENTS

8.1 Unless otherwise agreed, temp. detecting elements, and the bulb of the dial thermometers, shall be installed in thermometer pockets. (see Figs. 5, 6, 7 & 8).

8.2 Screwed pockets shall be used for all normal duties, i.e. in services with design metal temp. less than (538°C), or where the press-to-temp. design conditions would not require an ANSI class 900 or greater flange. They shall be constructed in accordance with BS-2765 Standard.

8.3 For corrosive duties, including hydrogen, or in services with design metal temp. of 538°C or above, or where the press-temp. design conditions requires an ANSI class 900 or greater flange, flanged pockets shall be used. They shall fit 40 mm (1.5").

Flanges to BS-1560 or ANSI-BI6.5. These pockets shall be constructed in accordance with BS-2765 standard.

8.4 Generally the internal diameter of pockets for resistance thermometer and thermocouples shall be 10 mm. (3/8"), (see BS-2765).

For mercury-in-steel systems, a diameter of 13 mm (½ in) is preferred.

8.5 Proprietary pockets supplied with instruments should meet the requirements of this standard.

8.6 Thermocouple and resistance thermometer pocket assemblies shall be provided with weather proof terminal heads certified for the appropriate area classification and the heads shall be orientated so as to prevent ingress of water (IP-65 according to IEC-529), and shall be with standard extension of 20 mm (¾ in.) nipple & union. (see Fig. 3, 4, 10 & 11).

8.7 In case where thermocouple pockets are installed in erosive catalyst systems they should be fitted with lubricated plug cocks between the well and the thermocouple to be sheared and the well sealed in the event of pocket failure. The length of extension (U-Dimension) shall not be more than 600 mm. (see Fig. 10).

8.8 Thermocouple assemblies heads shall be furnished with grounding terminal, except where averaging or differential are required (see Figs. 29.1 & 29.2)

8.9 Thermowells and thermometer pockets shall be installed in the vertical position wherever possible.

8.10 In services involving erosion, corrosion or high temp. where the standard thermowell is not suitable, consideration shall be given to alternative materials or method of temperature measurement.

8.11 Thermowell for normal services shall be of stainless steel, machined from a solid bar, and screwed to fit into a boss tapped (one inch NPT) thread, internal thread shall be ½" NPT.

8.12 Thermowells inserted in furnace tubes or headers shall meet the specifications of the furnace designer and shall conform to the tube or header plug design. (Refer to: API-RP-550, part III)

8.13 All thermowells in process piping and pressure vessels shall have connections per piping specification. Thermowells installed in process piping or process pressure vessels in other than steam services shall meet the requirements of the latest edition of the ASME code for unfired pressure vessels.

For steam service all thermowells shall meet the requirements of the latest edition of the ASME code for boilers.

8.14 For every thermocouple inserted into a vessel or pipe, consideration shall be given to the installation of a thermometer pocket or thermowell located adjacent to it for checking purposes. This does not apply to high temp. furnace flue gas streams and may be deleted in high temp. furnace oil streams when adequate temp. points are otherwise available. However every controlling temp. point shall have an adjacent check well. Such thermometer pockets, or thermowells, shall be provided with suitable thermometers, or thermocouples & lead to a potentiometer temp. indicator, when considered essential.

8.15 On small lines where adequate immersion cannot be obtained by the thermowell inserted perpendicular to the line, the well shall be inserted at 90 degrees bend in the line. Alternatively a short section of the line may be enlarged to accommodate the thermowell, but this method should only be used when normal methods are impracticable. (see Fig. 30.1 & 30.2).

8.16 Tapered thermowells are recommended for high velocity lines, i.e. more than 21 m/sec. (70 feet per sec.) to overcome the mechanical stresses due to vibration, the max. immersion length shall be 150 mm (6 in.), for pipes of 300 mm (12 in.) and above. (see ASME-PTC 19.3).

8.17 When process required rapid temp. response, thermowells for temp. controllers, shall be constructed with wall thickness as thin as operating conditions will permit.

9. TEMPERATURE TRANSMISSION

9.1 In pneumatic systems where measured temperature in the control center is required pneumatic transmitters shall be used. These transmitters shall be located as close as possible to the detection elements.

9.2 Consideration shall be taken to use temperature transmitters when it is not practicable to use very long T/C or RTD extension wires. See 5.4 and IPS-E-IN-190 "Transmission Systems".

9.3 4-20 mA is the preferred signal type for analogue transmitters in 2-wire system.

9.4 For digital systems such as D.C.S. where transmission is mandatory, the smart (intelligent) transmitters shall be the preferred type of temperature transmission.

9.5 In electrical transmitters normally one of the following design philosophy is utilized:

a) silicon strain gage;
b) force balance;
c) resonant wire.

Note:

Motion balance is not recommended for this type of transmitters, due to wear and tear problem.

9.6 The connection of electrical transmitters to the control center shall be via zener safety barriers where transmission from hazardous areas are required and intrinsically safe transmitter is used.

9.7 All temperature devices capable of transmitting a pneumatic 0.2-1.0 barg or electrical 4-20 mA signal linear with and directly proportional to temperature, shall be suitable for outdoor installation under tropical conditions and/or hazardous locations, as indicated in data sheets.

9.8 When transmitters are used for control, a duplicate measurement from a separate sensor, e.g. thermocouple, shall be provided.

9.9 Millivolt and resistance-to-current converters are preferably mounted in the control center. Locally mounted converters shall not be used except by agreement with the user.

10. TEMPERATURE INDICATING, RECORDING AND CONTROLLING INSTRUMENTS

10.1 Control modes for process temp. control shall normally be adjustable for proportional (gain) reset and derivative action.

10.2 Potentiometer and wheatstone Bridge Instruments, used for temp. measurements, shall be of the high-speed and self balancing type and shall be provided with an integral and suitable constant power supply unit to eliminate the use of dry cells.

10.3 Recording potentiometers and wheatstone Bridge Instruments shall not carry more than four pen records unless otherwise specified previously by the user,in individual data sheets.

10.4 For multipoint temperature indicators when the No. of points required are less than about 48, preference should be given to selection by interlock push-button switches or non locking toggle switches with spring return to neutral, for larger No. of points switch banks and telephone type dial selection should be used.

10.5 When two or more ranges are used on one instrument positive means of range identification shall be provided.

10.6 When temperatures are recorded on 300 mm wide strip charts each temp. mark shall be a plus sign with alternate points identified by the appropriate numeral.

10.7 When temp. controlled by an indicating controllers are recorded on a multipoint recorder, each record of controlled variable shall be readily identifiable from other recorded values.

10.8 Thermocouple and resistance bulb circuits operating high temp. alarms shall have upscale burn-out feature and vice-versa for low temp. alarms.

10.9 All thermocouple actuated control systems shall contain "burn out" protection. The design shall enable this feature to be switched in or out.

10.10 Thermocouple multipoint temp. recorders shall have cold junction compensation and constant voltage source, unicolour numbered print wheels with printing time cycle of max. 15 sec. per point max. cycle time for print out of all points shall not exceed two minutes.

They shall be furnished with high-impedance amplifiers to allow parallel operation with the temp. indicator. Normally 33% of the points shall be reserved as spares. Time for full scale travel of print wheel shall not exceed the interval between prints.

10.11 V/I transducers shall be used for control point measurement. Each transducer shall have its own integral power supply. The receiving Inst. shall be electronic type static inverters shall be considered for critical loops.

10.12 Electropneumatic transducers shall be calibrated for specified range of input signal. The primary element may be a resistance bulb, thermocouple, or any millivolt source.

When thermocouple input is specified, cold junction compensation, upscale drive (max. signal output) and amplifier burnout output signal shall be compatible with receivers and controllers. These transmitters shall be mounted in relay racks on rear of panel.

10.13 Multi-Pen recorders on furnaces outlets shall have a narrow span for normal operation and a wide range for starting-up.

11. RADIATION-TYPE PYROMETERS

11.1 Radiation-type pyrometers are special instruments with limited use in refineries or synthetic fuel plants. The normal range of use falls between (-30°C to 3900°C) -20°F to 7000°F. They are nonlinear in output and have an accuracy of about 2 percent. There is no easy way to calibrate the units. They detect high temperatures and offer the advantage of fast response and noncontact measurement.

11.2 The radiation-type pyrometer measures the temperature of an object without requiring physical contact. The ability to accomplish this is based on the fact that every object emits radiant energy and the intensity of this radiation is a function of its temperature. Most applications use infrared radiation as the measurement source; however, ultraviolet is also used in some instances.

11.3 If the radiation pyrometer is to measure absolute temperature, the effective emissivity (the emissivity of the target material in the spectral range of the radiation pyrometer) must be determined. This can be determined indirectly by applying the radiation laws of physics or experimentally by characterizing the material at a known temperature. Such target nonuniformities as significant temperature changes in the material, the nonhomogeneous nature of some materials, or a basic product change all represent cases in which an absolute change in effective emissivity is exhibited.

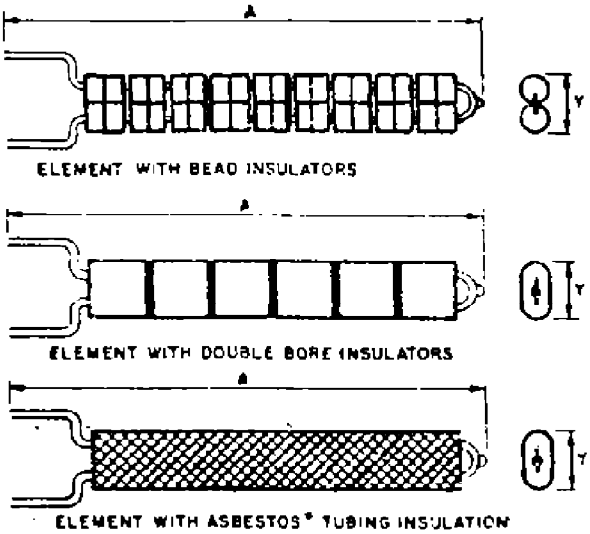
11.4 In industrial temperature measurement using a properly designed industrial instrument, background radiation effects are not a detrimental factor as long as the infrared field of view is aimed exclusively on the target area. The reflection from the background area should be minimized to reduce spurious effects of radiant energy from sources other than the target.

Infrared instruments are designed to minimize these background conditions, but energy overlays in the electromagnetic spectrum can not be completely eliminated without impairing the accuracy and performance of the instrument.

11.5 Most radiation-type pyrometers used in refinery applications are in the high-temperature range. Since they are somewhat special in application, it is recommended that the user work closely with the manufacturer.

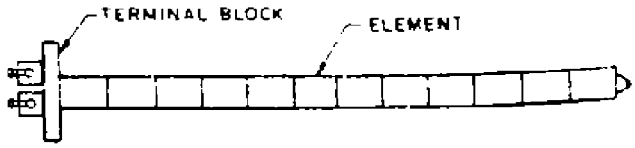
12. OPTICAL PYROMETERS

Optical pyrometers are radiation-type pyrometers that operate within the visible spectrum. They usually rely on the human eye comparing a filtered view of the target with an internal reference. The subject surface must be hot enough to give off visible radiation, typically above 760°C (1400°F). Error may be introduced if the target surface reflects radiation from other hotter surfaces or if the path is partially obstructed by absorbing materials such as fumes, smoke, or glass.



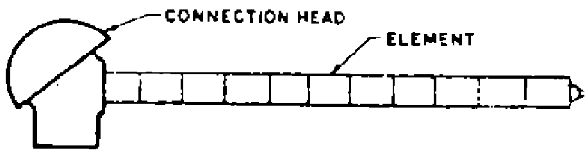
THERMOCOUPLE ELEMENTS

Fig. 1



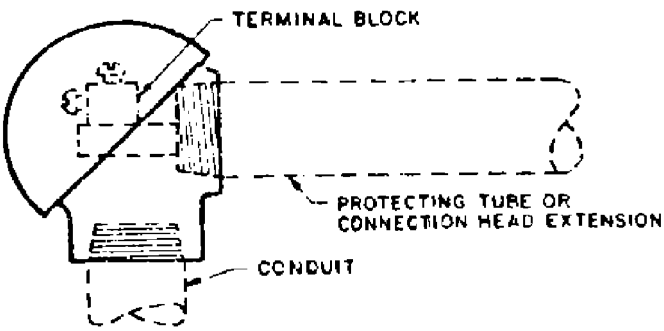
THERMOCOUPLE ELEMENT WITH TERMINAL BLOCK

Fig. 2



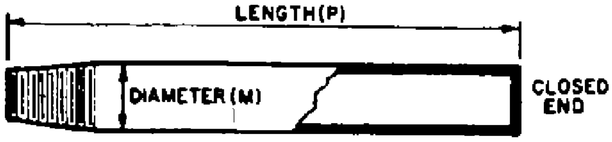
THERMOCOUPLE ELEMENT WITH CONNECTION HEAD

Fig. 3



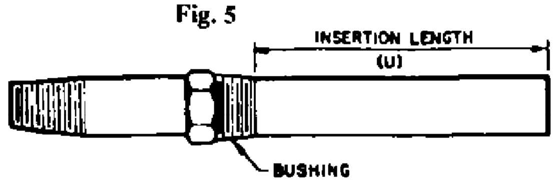
CONNECTION HEAD

Fig. 4



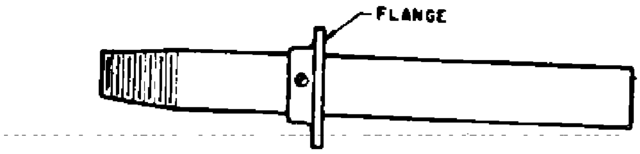
PROTECTING TUBE

Fig. 5



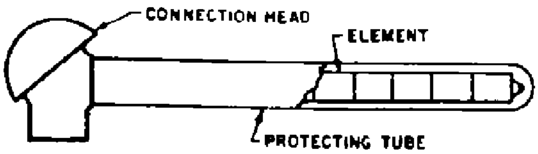
PROTECTING TUBE WITH MOUNTING BUSHING

Fig. 6



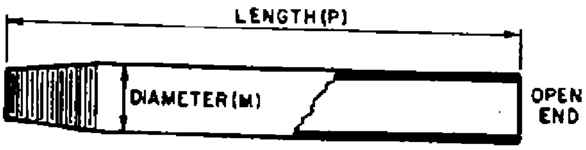
PROTECTING TUBE WITH MOUNTING FLANGE

Fig. 7



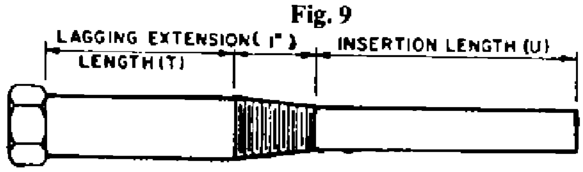
THERMOCOUPLE ELEMENT WITH PROTECTING TUBE AND CONNECTION HEAD

Fig. 8



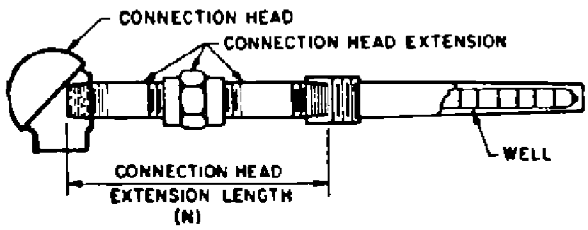
OPEN END PROTECTING TUBE

Fig. 9



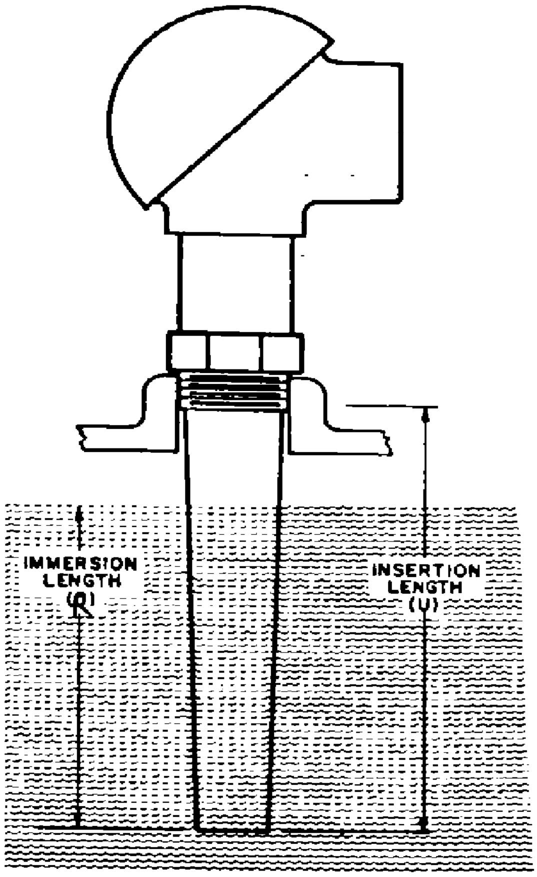
WELL

Fig. 10



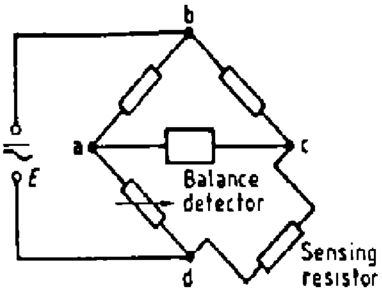
THERMOCOUPLE ASSEMBLY WITH THERMOWELL

Fig. 11



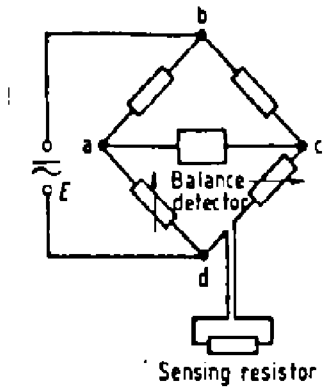
IMMERSION AND INSERTION LENGTHS FOR THERMOCOUPLE ASSEMBLY WITH THERMOWELL

Fig. 12



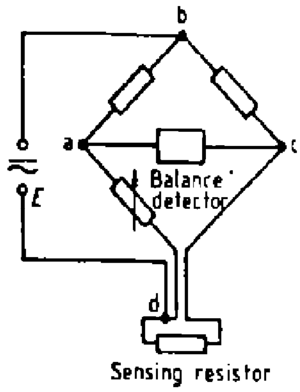
BASIC BRIDGE CIRCUIT

Fig. 13



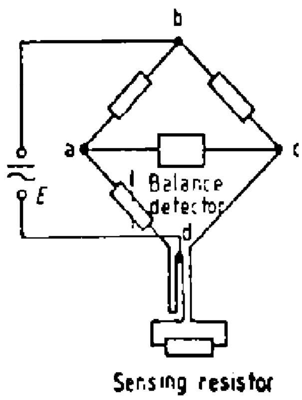
CIRCUIT FOR 2-WIRE SYSTEM

Fig. 14



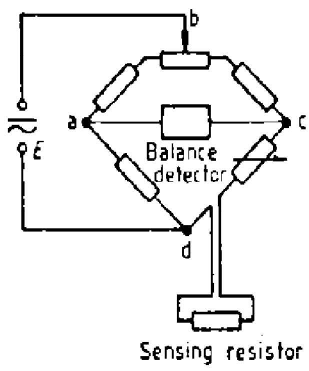
CIRCUIT FOR 3-WIRE SYSTEM

Fig. 15



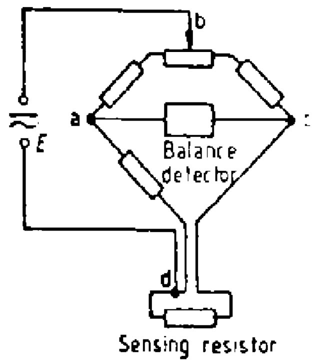
CIRCUIT FOR 4-WIRE COMPENSATED SYSTEM

Fig. 16



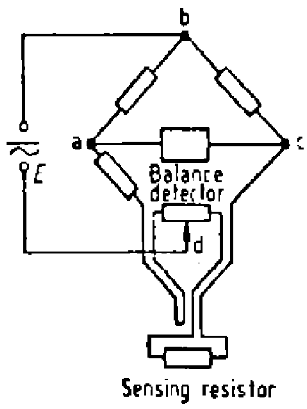
BRIDGE (2-WIRE SYSTEM)

Fig. 17



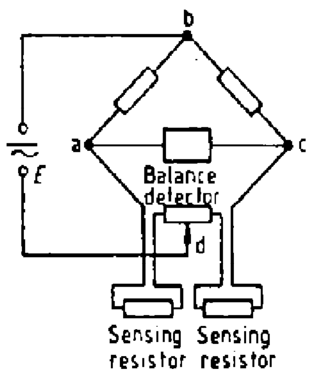
BRIDGE (SIMPLE 3-WIRE SYSTEM)

Fig. 18



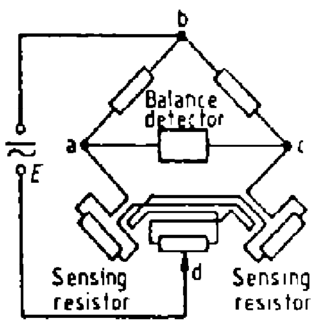
BRIDGE (4-WIRE-COMPENSATED SYSTEM)

Fig. 19



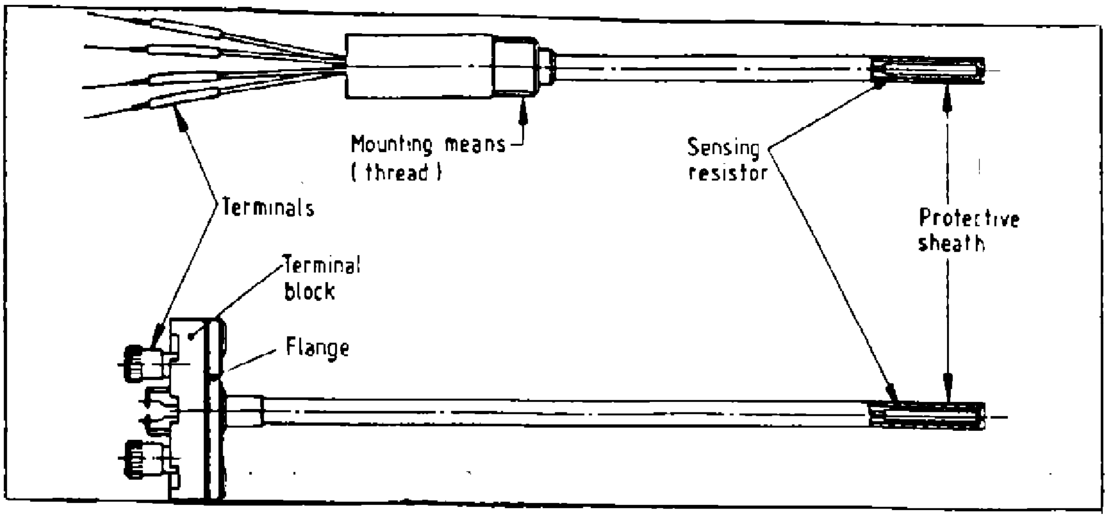
DIFFERENTIAL SYSTEM

Fig. 20



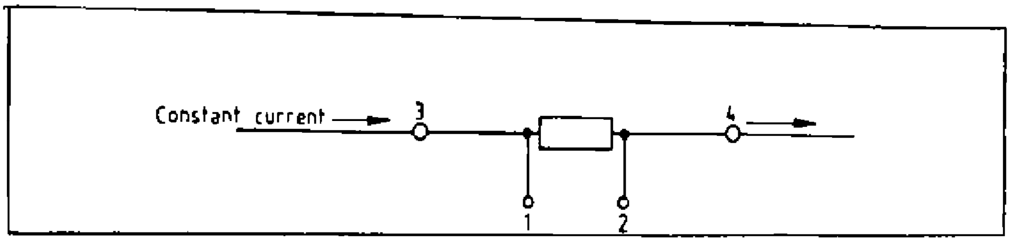
DIFFERENTIAL SYSTEM WITH FULL CONDUCTOR RESISTANCE COMPENSATION

Fig. 21



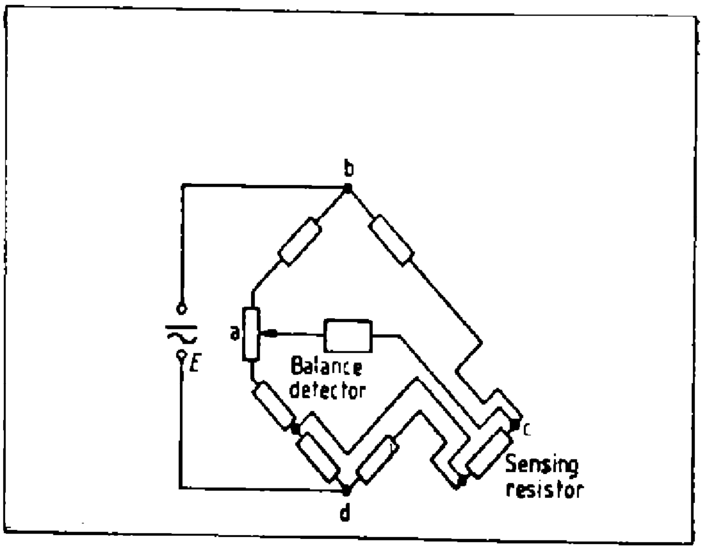
TYPICAL CONSTRUCTION OF RESISTANCE THERMOMETER SENSOR

Fig. 22



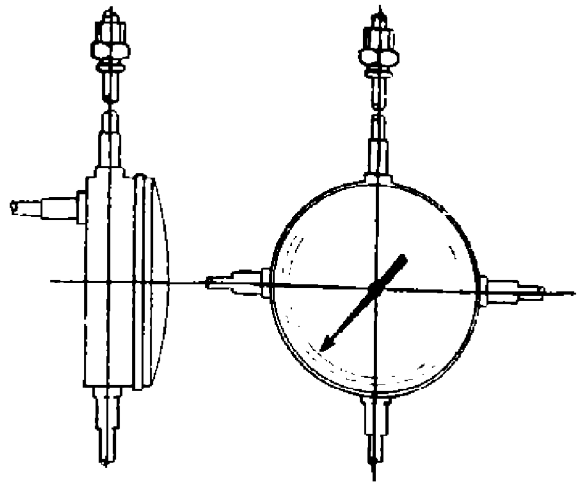
FOUR-TERMINAL SENSING

Fig. 23



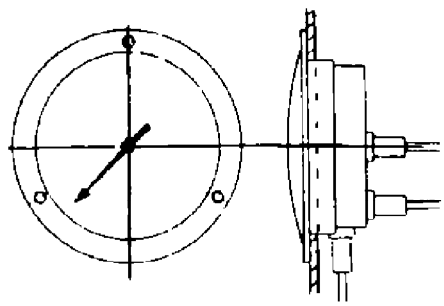
KELVIN DOUBLE BRIDGE (MODIFIED)

Fig. 24

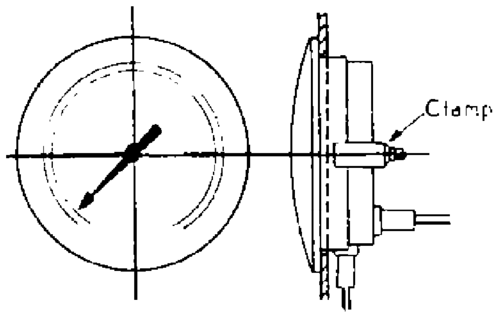


RIGID STEM MOUNTING (BACK, BOTTOM, SIDE OR TOP CAPILLARY ENTRY)

Fig. 25



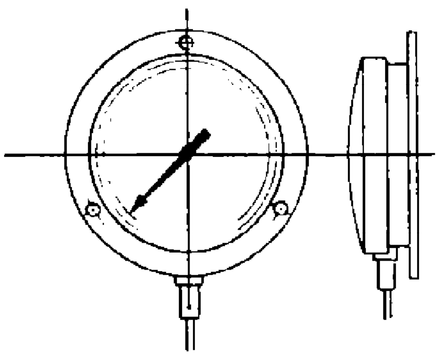
(a) With flange fixing and back or bottom capillary entry



(b) With clamp fixing and back or bottom capillary entry

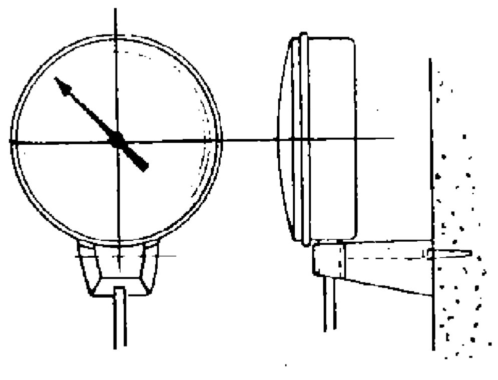
FLUSH MOUNTINGS

Fig. 26



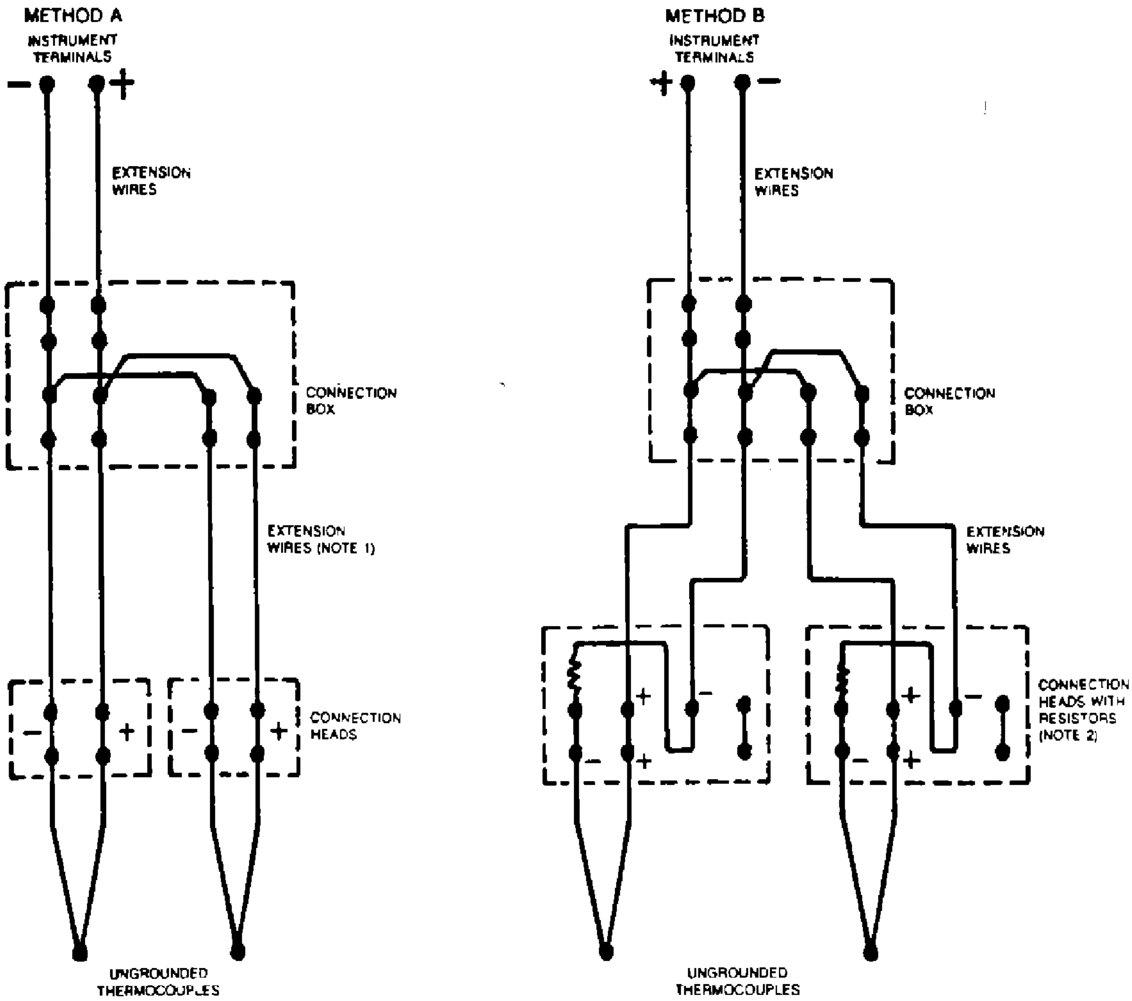
SURFACE MOUNTING WITH BOTTOM CAPILLARY ENTRY

Fig. 27



BRACKET MOUNTING WITH BOTTOM CAPILLARY ENTRY

Fig. 28



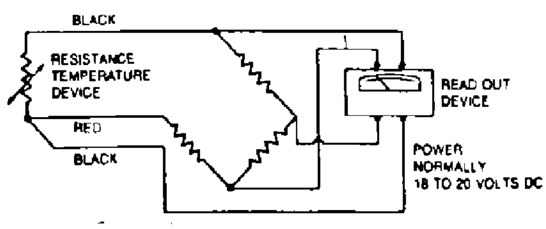
Notes:

1) Duplex extension wires to be of equal resistance-same lengths.

2) Connection head with 1500-ohm resistor-permits use of different lengths of extension wires.

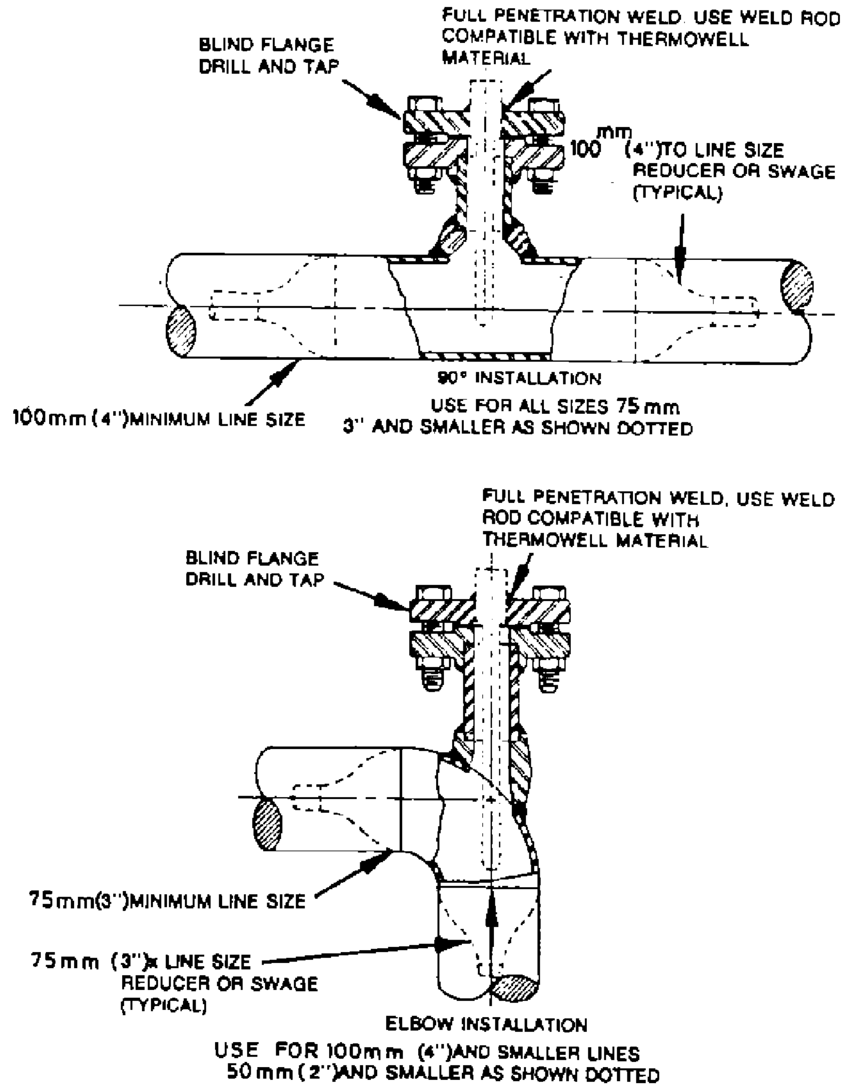
AVERAGE TEMPERATURE MEASUREMENT WITH THERMOCOUPLES

Fig. 29.1



TEMPERATURE DIFFERENCE MEASUREMENT WITH RTD

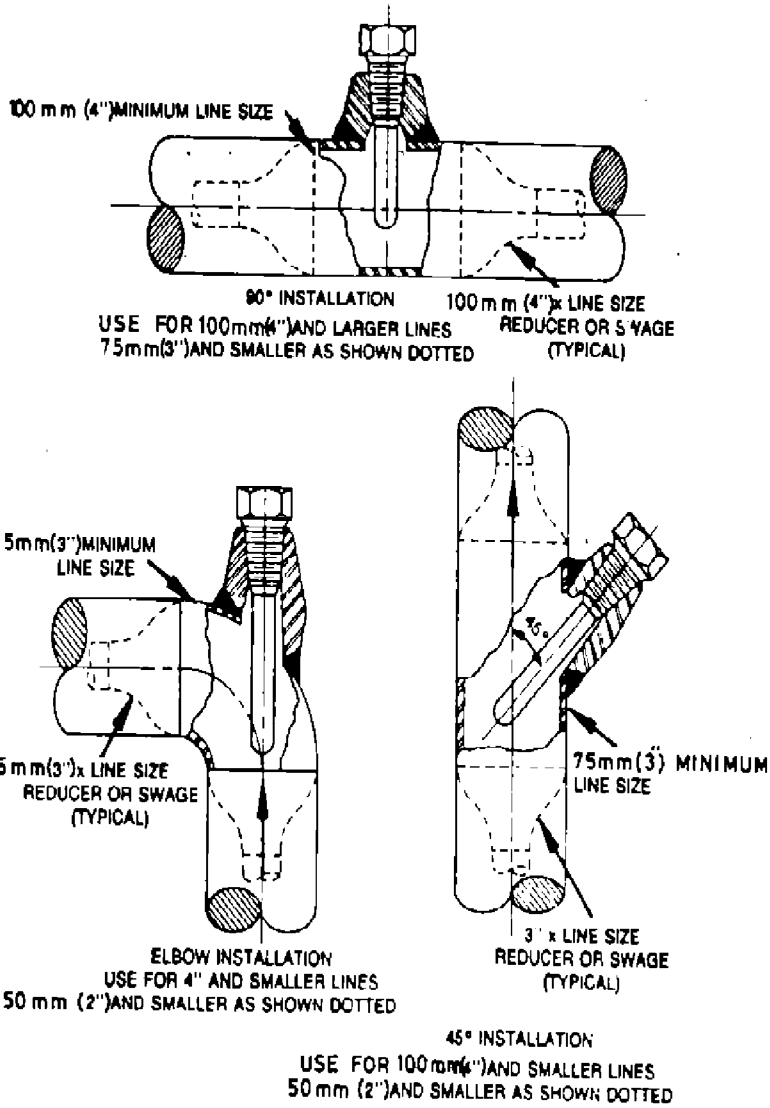
Fig. 29.2



NOTE: Material used for thermowell installation should comply with piping specification material and rating.

TYPICAL FLANGED THERMOWELL INSTALLATION

Fig. 30.1



TYPICAL SCREWED THERMOWELL INSTALLATION

Fig. 30.2

TABLE 1
OPERATING TEMPERATURE OF RESISTANCE THERMOMETER SENSING RESISTORS

SENSING RESISTOR	NORMAL MINIMUM OPERATING TEMPERATURE	NORMAL MAXIMUM OPERATING TEMPERATURE	SPECIAL MAXIMUM TEMPERATURE
	°C	°C	°C
METALLIC SENSING RESISTOR			
Copper	-100	+100	+150
Nickel	-60	+180	+350
Platinum	-200	+600	+850
SEMICONDUCTOR SENSING RESISTORS			
Mixed metal oxides	-100	+200	+600
Silicon	-160	+160	+200

NOTE 1 :

Satisfactory measurement at temperatures above the normal maximum is possible only when special constructions and carefully controlled environments for the sensing resistors are used.

NOTE 2 :

Platinum resistance thermometer sensing resistores of special construction can be used to measure temperature down to -259°C (14 k). Below -200°C, sensors have to be individually calibrated.

NOTE 3 :

Copper resistance thermometer sensing resistors of special construction can be used to measure temperature down to -200°C.

TABLE 2
APPROXIMATE RELATIONSHIP BETWEEN RESISTANCE RATIO AND TEMPERATURE FOR METALLIC SENSING RESISTORS

TEMPERATURE	RESISTANCE RATIO R_t / R_o		
	Platinum*	Nickel	Copper
°C			
-200	0.18	-	-
-100	0.60	-	0.57
-60	0.76	0.70	0.74
-50	0.80	0.74	0.79
0	1.00	1.00	1.00
50	1.19	1.29	1.21
100	1.38	1.62	1.43
150	1.57	1.99	1.65
180	1.68	2.23	-
200	1.76	-	-
250	1.94	-	-
300	2.12	-	-
350	2.30	-	-
400	2.47	-	-
500	2.81	-	-
600	3.14	-	-
700	3.45	-	-
800	3.76	-	-
850	3.90	-	-

***See BS 1904.**
NOTE.
Some thermometer sensors use padding resistors to bring the resistanceof the sensor within specified limits. Generally, they are used in series with the sensing resistor, but in some types of nickel thermometers both series and shunt padding resistors are used to enable the thermometer sensor to match an exponential resistance/temperature curve.

TABLE 3
APPLICATION DATA FOR FILLED MEASUREMENT SYSTEMS

System Type (Note 1) and SAMA Class (Note 2)	Temperature Limits		Span				Limits of Overrange		Maximum Tubing Length (Note 3)		Bulb Size				63% Time Constant (Note 4)
			Minimum		Maximum						Maximum		Minimum		
	C	F	C	F	C	F	C	F	meters	feet	inches	mm	inches	mm	seconds
Vapor pressure (Note 5)															
II-A, C, and D	-225-315	-425-660	40	70	220	400	28	50	45	150	6 × 5/8	152 × 16	2 × 3/8	51 × 9	-
			Note 6				Note 7								
II-B	-224-315	-425-660	40	70	220	400	50 or 100	120 or 212	45	150	6 × 5/8	152 × 16	2 × 3/8	51 × 9	-
			Note 6												
Gas pressure															
III-B	-270-760	-450-1400	110	200	550	1000	760	1400	30	100	10 × 7/8	254 × 21	6 × 5/8	152 × 16	2-8
			Note 8				Note 9								Note 10
Mercury expansion															
V-A	-38-650	-38-1200	55	100	550	1000	200% of span		30	100	6 × 5/8	152 × 16	3 × ½	76 × 13	2-6
			Note 8												Note 10
V-B	-38-650	-38-1200	55	100	315	600	200% of span		15	50	6 × 5/8	152 × 16	3 × ½	76 × 13	2-6
															Note 10
Expansion liquid															
I-A	-185-315	-300-600	22	40	315	600	100% of span		30	100	6 × 3/8	152 × 9	3 × ¼	76 × 6	6
I-B	-185-315	-300-600	22	40	315	600	100% of span		6	20	6 × 3/8	152 × 9	3 × ¼	76 × 6	6

Notes:

1) Relative costs for vapor pressure, gas pressure, mercury expansion, and expansion liquid are low, medium-low, medium-high, and high, respectively.

2) Scientific Apparatus Manufacturer's Association.

3) Longer lengths possible, but unwieldy bulb sizes or poor ambient temperature compensation usually result.

4) Time for temperature to reach 63 percent recovery constant of a step change for bulbs immersed in well-agitated liquid baths. Short tubing lengths and minimum bulb diameters are required to obtain these minimum figures.

5) Scale for vapor pressure is nonuniform. The other three systems are uniform. Uniform motion or output with temperature may be accomplished for certain vapor pressure ranges by mechanical means.

6) Standard spans as narrow as 10°C (20°F) are possible under certain application conditions, particularly very low temperatures. Minimum temperature of -225°C (-425°F) is possible with special construction.

7) Above top scale temperature.

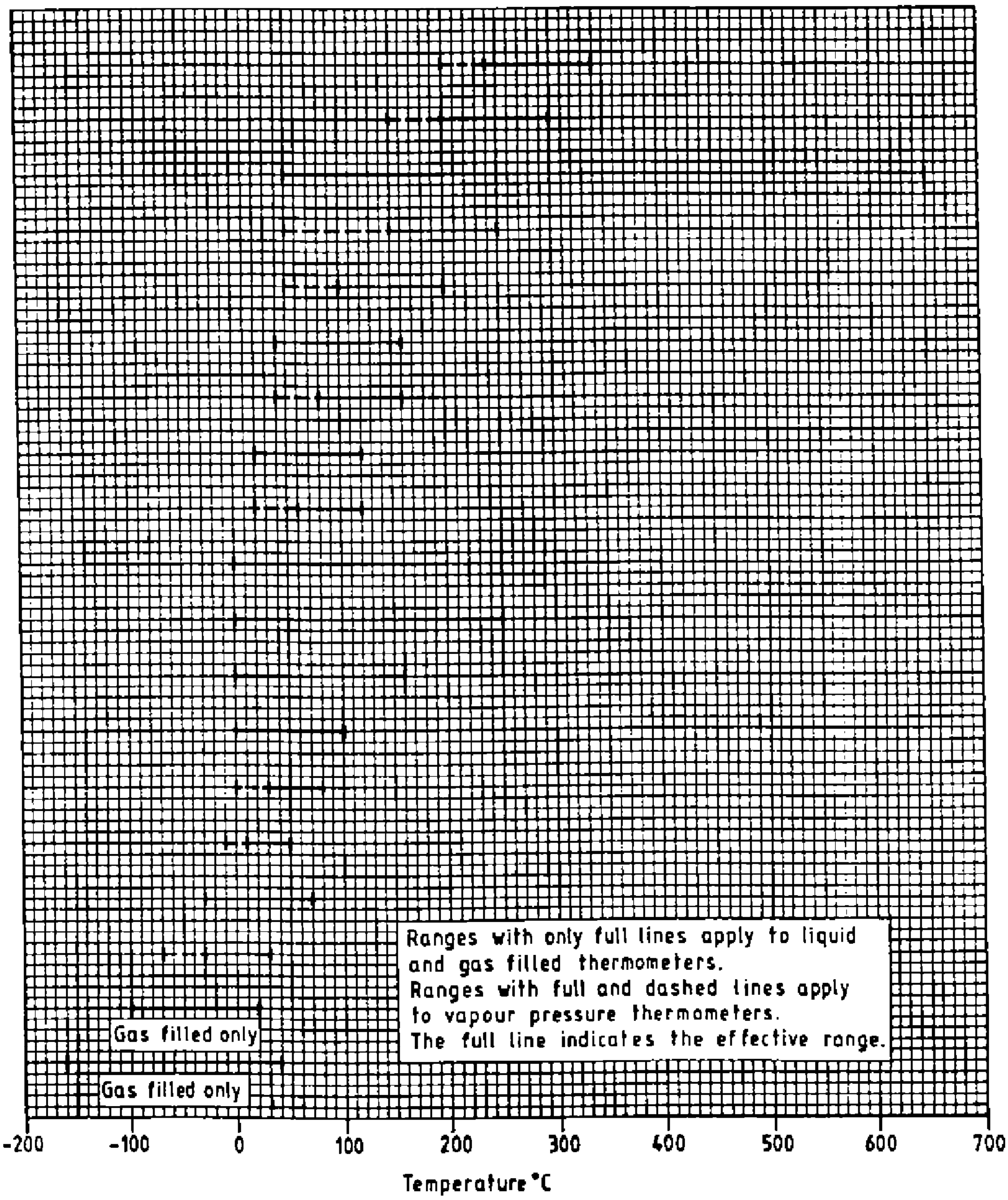
8) Minimum gas and mercury system span for force balance pneumatic transmitters is 50°C (90°F).

9) Reduce to 122°C (250°F) for narrowest spans.

10) Lowest value generally attainable only with force balance pneumatic transmitters. These instruments have bulbs as small as 6 × 3/8 inches (gas systems) and 3 × 3/8 inches (mercury systems).

TABLE 4
CLASSES OF THERMAL SYSTEMS IN GENERAL USE

CLASS	DESCRIPTION
CLASS I-A	LIQUID-FILLED; UNIFORM SCALE; FULLY COMPENSATED.
CLASS I-B	LIQUID-FILLED; UNIFORM SCALE; CASE COMPENSATED ONLY.
CLASS II-A	VAPOR PRESSURE; INCREASING SCALE; WITH MEASURED TEMPERATURE ABOVE CASE AND TUBING TEMPERATURE.
CLASS II-B	VAPOR PRESSURE; INCREASING SCALE; WITH MEASURED TEMPERATURE BELOW CASE AND TUBING TEMPERATURE.
CLASS II-C	VAPOR PRESSURE; INCREASING SCALE; WITH MEASURED TEMPERATURE ABOVE AND BELOW CASE AND TUBING TEMPERATURE.
CLASS II-D	VAPOR PRESSURE; INCREASING SCALE; ABOVE, AT, AND BELOW CASE AND TUBING TEMPERATURE.
CLASS III-A	GAS-FILLED; UNIFORM SCALE; FULLY COMPENSATED.
CLASS III-B	GAS-FILLED; UNIFORM SCALE; CASE COMPENSATED ONLY.
CLASS V-A	MERCURY-FILLED; UNIFORM SCALE; FULLY COMPENSATED.
CLASS V-B	MERCURY-FILLED; UNIFORM SCALE; CASE COMPENSATED ONLY.



TEMPERATURE RANGES FOR FILLED SYSTEM THERMOMETERS

Fig. 31

TABLE 5
THERMOCOUPLE TYPE LETTER DESIGNATIONS

TYPE	NOMINAL TEMPERATURE RANGE	MATERIAL IDENTIFICATION (POSITIVE MATERIAL IN CAPS)
B	0 TO 1820°C	PLATINUM-30 PERCENT RHODIUM VERSUS PLATINUM-6 PERCENT RHODIUM
E	-270 TO 1000°C	NICKEL-10 PERCENT CHROMIUM VERSUS COPPER-NICKEL
J	-210 TO 760°C	IRON VERSUS COPPER-NICKEL
K	-270 TO 1372°C	NICKEL-10 PERCENT CHROMIUM VERSUS NICKEL-5 PERCENT (ALUMINUM, SILICON)
R	-50 TO 1768°C	PLATINUM-13 PERCENT RHODIUM VERSUS PLATINUM
S	-50 TO 1768°C	PLATINUM-10 PERCENT RHODIUM VERSUS PLATINUM
T	-270 TO 400°C	COPPER-VERSUS COPPER-NICKEL

TABLE 6
COLOR CODE-DUPLEX INSULATED THERMOCOUPLE WIRE

THERMOCOUPLE			COLOR of INSULATION		
Type	Positive	Negative	Overall *	Positive *	Negative
E	EP	EN	Brown	Purple	Red
J	JP	JN	Brown	White	Red
K	KP	KN	Brown	Yellow	Red
T	TP	TN	Brown	Blue	Red

*** A tracer color of the positive wire code color may be used in the overall braid.**

TABLE 7
COLOR CODE-SINGLE CONDUCTOR INSULATED THERMOCOUPLE EXTENSION WIRE

EXTENSION WIRE TYPE			COLOR of INSULATION	
Type	Positive	Negative	Positive	Negative *
B	BPX	BNX	Gray	Red-Gray Trace
E	EPX	ENX	Purple	Red-Purple Trace
J	JPX	JNX	White	Red-White Trace
K	KPX	KNX	Yellow	Red-Yellow Trace
R or S	SPX	SNX	Black	Red-Black Trace
T	TPX	TNX	Blue	Red-Blue Trace

*** The color identified as a trace may be applied as a tracer, braid, or by any other readily identifiable means.**

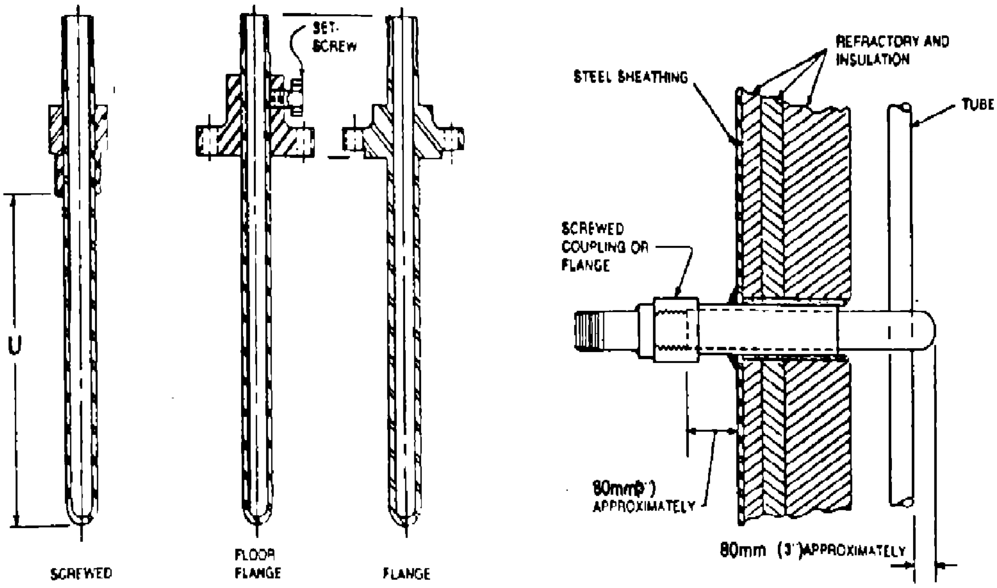
Note of Caution:

In the procurement of random lengths of single conductor insulated extension wire, it must be recognized that such wire is commercially combined in matching pairs to conform to established temperature-EMF curves. Therefore, it is imperative that all single conductor insulated extension wire be procured in pairs, at the same time, and from the same source.

TABLE 8
COLOR CODE-DUPLEX INSULATED THERMOCOUPLE EXTENSION WIRE

EXTENSION WIRE TYPE			COLOR of INSULATION		
Type	Positive	Negative	Overall	Positive	Negative *
B	BPX	BNX	Gray	Gray	Red
E	EPX	ENX	Purple	Purple	Red
J	JPX	JNX	Black	White	Red
K	KPX	KNX	Yellow	Yellow	Red
R or S	SPX	SNX	Green	Black	Red
T	TPX	TNX	Blue	Blue	Red

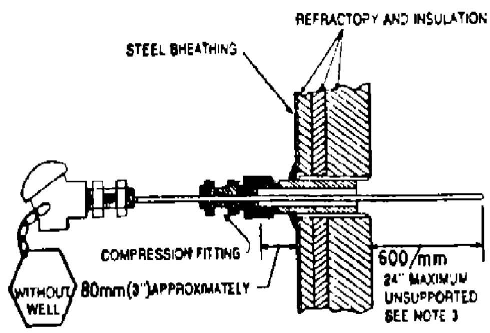
*** A tracer having the color corresponding to the positive wire code color may be used on the negative wire color code.**



Notes:

1) See API-RP 550, Part III, Table 1-1 for materials.

2) Material external of firebox may be other than specified in Table 1-1.



Notes:

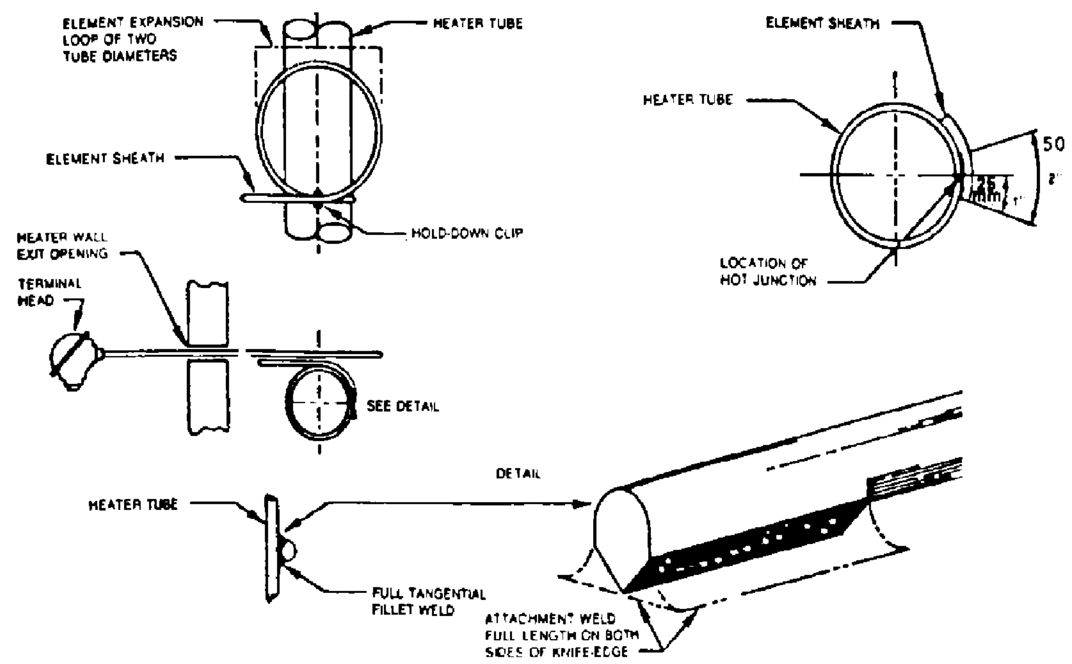
1) Thermocouple should be 13 mm (0.500-inch) outside diameter by 3 mm (0.120-inch) wall MgO insulated 2 mm^2 (14 gage) nickel (90 percent)- chromium (10 percent) thermocouple wire with 446 stainless sheath, or material listed in API-RP-550, Part III, Table 1-1.

2) The head end of the thermocouple should have 50 mm (2 inches) of exposed wire. The mineral insulation shall be removed to a depth of at least 7 mm(¼ -inch) and potted with compound.

3) The 600 mm (24-inch) maximum immersion does not apply to top-entering installations.

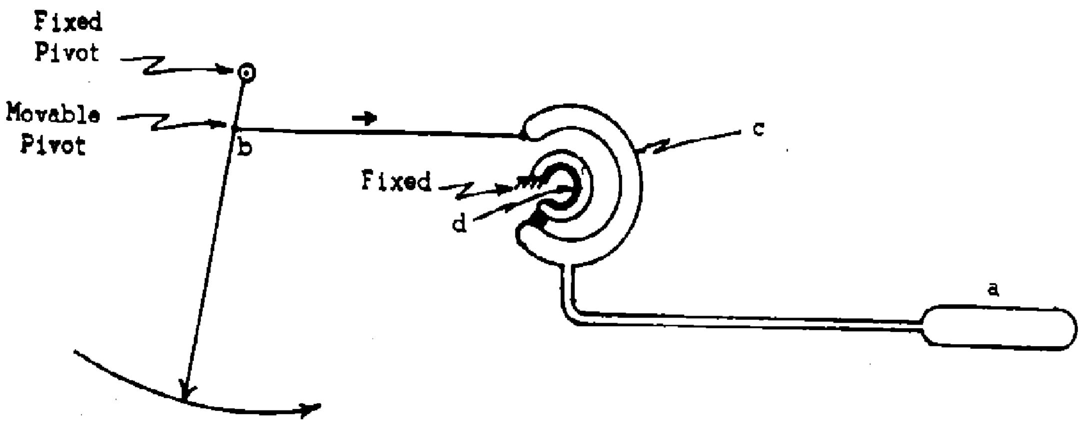
TYPICAL FIRE BOX THERMOCOUPLE INSTALLATIONS

Fig. 32



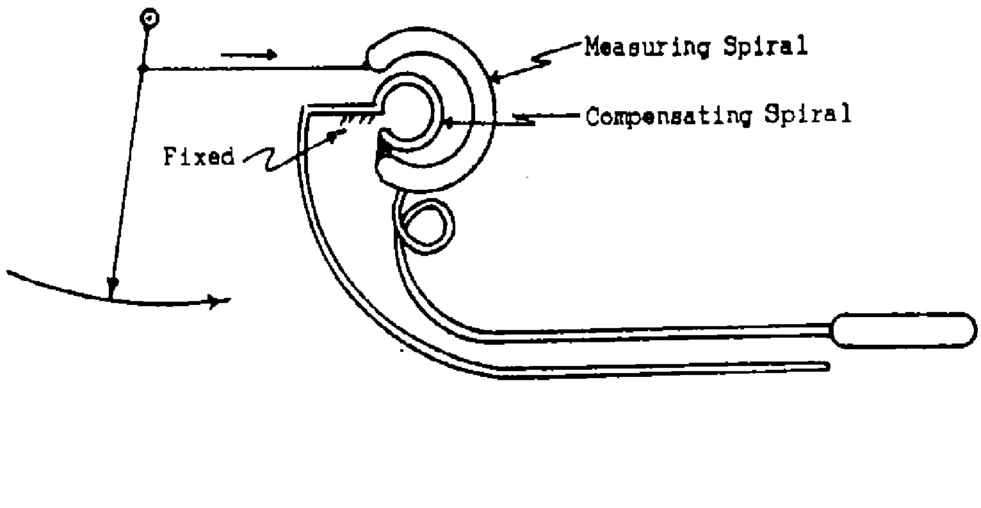
KNIFE EDGE TUBE SURFACE THERMOCOUPLE FOR HEATER TUBE

Fig. 33



CASE COMPENSATIONS

Fig. 34



CASE AND CAPILLARY COMPENSATION

Fig. 35

TEMPERATURE INSTRUMENTS (POTENTIOMETER PYROMETER & RESISTANCE) SPECIFICATION SHEET	INSTRUMENT SPECIFICATION				**SHEET ——— OF ———**		
	No.	BY	DATE	REVISION	SPEC. No.		REV
					CONTRACT		DATE
					REQ. P.O.		
	PROJECT				BY	CHK'D	APPR.

	1	Tag No.	Service
	2	Function	Record b Indicate b Control b Blind b Transmit b Other ———
	3	Type	Auot Bal. b Man Bal b Galv b Other ———
	4	Case	MFR STD b Nom Size ——— Color: MFR STD b Other———
	5	Mounting	Flush b Surface b Rack b Multi-Case b Other ——— For Multiple Case Spec, See Sheet ———
GENERAL	6	Enclosure Class	Gen Purp b Weather Proof b Explosion-Proof b Class ——— Other ———
	7	Power Supply	Hz b Other ———
	8	Chart	——— Strip b ——— Cire b Time Marks b Range ——— No ——— Chart Speed: ——— Change Gears ———
	9	Scale	Type ——— Range: 1 ——— 2 ———
	10	Printout	No. of Points ——— Sec Per Point ——— Full Travel Speed ——— Print Character and Color ——— Point Select b
	11	Selector Switches	No. and Form ——— In Case b External b Switch Cabinet Spece ———
XMTR	12	Trans. Output	4-20 mA b 10-50 mA b 21-103 kpa (3-15 psig) Ξ Other ——— Input-Output Isolation b For Receiver, See Sheet ———
CONTROLLER	13	Control Modes	p = Prop (Gain), i = Integral (Auto Reset), D = Derivative (Rate) Sub: s = Slow, f = Fast If b Df b P b PI b PD b PID b Is b Ds b Other ———
	14	Action	On Meas. Increase Output: Increases Decreases
	15	Auto-Man Switch	None b MFR STD b Specify ———
	16	Set Point Adj.	Manual b External b Remote b Specify ———
	17	Manual Reg.	None b MFR -STD b Other ———
	18	Output	4-20 mA b 10-50 mA b 21-103 kpa (3-15 psig) b Other ———
INPUT	19	Thermocouple Type	J (IC) b K (CA) b T (CC) b E(CHR-CON) b Other ——— Ref Junction Comp b Lead Resistance (Galv) ———
	20	Other Input	Resistance Temp Sensor b Calibration ——— Other ———
ALARM	21	Alarm Switches	Quantity ——— Form ——— Rating ———
	22	Function	Meas. Var. b Deviation b Contacts To ——— measure ——— Other ———
	23		Front Adj ——— Back Adj ———
OPTIONS	24	T/C Burnout Drive	None b Upscale b Downscale b
	25	Accessories	Case Illuminator b ——— Charts Filter Reg. b Other ———
	26	MFR & Model No.	———

Notes:

IPS-FORM E-IN-120.1a

TEMPERATURE INSTRUMENTS SPECIFICATION SHEET	INSTRUMENT SPECIFICATION				SHEET ——— OF ———	
	No.	BY	DATE	REVISION	SPEC. No.	REV
					CONTRACT	DATE
					REQ. P.O.	
	PROJECT				BY	CHK'D	APPR.

Rev.	Tag No.	Range	Type Input	Scale and Chart	No. of Points	Meas. Incr. Output	Service	

Notes

IPS-FORM E-IN-120.1b

POTENTIOMETER AND RESISTANCE INSTRUMENTS SPECIFICATION SHEET INSTRUCTIONS

Instructions for IPS Forms No. E-IN-120 1a & 1b

Prefix number designates line number on corresponding specification sheet.

1) To be used for single item. Use secondary sheet for multiple listing.

2) Check as many as apply.

3) Check one. Note that sheet may be used to specify galvanometric type of instrument.

4) Nominal size refers to approximate front of case dimensions; width x height.

5) It is assumed that the instrument has its own case or shelf suitable for single mounting unless "multi-case" is checked. Shelf or separable case for multiple case mounting instrument is not included in this sheet unless listed as an accessory.

6) Enclosure Class refers to composite instrument. If electrical contacts are in the case, they meet this rating inherently or by reason of the enclosure. Use NEMA or IEC identification system.

7) Specify electrical power to entire instrument.

8) For multiple instruments list ranges on second sheet, but specify other items here.

9) Ranges 1 and 2 refer to multi-channel instruments. The first listed is assumed to be the controller input (if any).

10) For multiple items list number of points on second sheet. "Point Select" permits by-passing any or all points by a switching mechanism.

11) For multiple items show number of switches on second sheet under "No. of Points."

12) Specify if applicable.

13) See explanation of terminology given on spec. sheet. Specific ranges of control modes can be listed under "other" if required.

14) For multiple items specify on second sheet.

15) If standard auto-manual switching is not or not known or not adequate, specify particular requirements, such as BUMPLESS, PROCEDURELESS, 4-POSITION, or as required.

16) Remote set point adjustment assumes full adjustment range. Specify limits if required.

17) Specify if applicable.

18) Specify if applicable.

19) Check if thermocouple input applies, Lead resistance required only for galvanometer.

20) Specify any input other than thermocouple. "Calibration" refers to curve used and does not imply that element is specifically calibrated for this instrument.

21) Form may be SPST, SPDT, DPDT, etc. Rating is electrical rating of switch in volt amps.

22) Check if alarm is actuated by measured variable or by deviation from controller set point. Give contact action if single throw form. Specify calibrated or blind alarm index setter.

23) Specify if applicable.

24) Specify if applicable.

25) Accessories for multiple items may be covered by "notes" second sheet.

26) May be filled in after selection is made.

SECONDARY SHEETS

For listing multiple instruments. List all instruments of the same type, specified on Primary Sheet, with variations as shown. "Notes" refers to notes listed by number at the bottom of the sheet. Or use Secondary Sheet to list and identify the multiple points of a single multipoint instrument.

TEMPERATURE INSTRUMENTS (POTENTIOMETER PYROMETER & RESISTANCE) SPECIFICATION SHEET	INSTRUMENT SPECIFICATION				SHEET ——— OF ———	
	No.	BY	DATE	REVISION	SPEC. No.	REV
					CONTRACT	DATE
					REQ. P.O.	
	PROJECT				BY	CHK'D	APPR.

	1	Tag No.	Service
GENERAL	2	Function	Record b Indicate b Control b Blind b Trans b Other ————
	3	Case	MFR STD b Nom Size ———— Color: MFR STD b Other ————
	4	Mounting	Flush b Surface b Yoke b Other ————
	5	Enclosure Class	General Purpose b Weather Proof b Explosion Proof b Class ———— For Use in Intrinsically Safe System b Other ————
	6	Power Supply	120 V 50 Hz b Other ac ———— dc b ———— Volts
	7	Chart	Strip b Roll b ———— Fold b ———— Circular ———— Time Marks.————
	8	Chart Drive	Speed ———— Power ————
	9	Scale	Type ———— ———— ———— Range: 1 ———— 2 ———— 3 ———— 4 ————
XMTR	10	Transmitter Output	4-20 mA b 10-50 mA b 21-103 kpa (3-15 psig) b Other ———— For Receiver, See Spec Sheet ————
CONTROLLER	11	Control Modes	p = Prop (Gain), i = Integral (Auto Reset), D = Derivative (Rate) Sub: s = Slow, f = Fast P b PI b PD b PID b If b Df b Is b Ds b Other ————
	12	Action	On Meas. Increase Output: Increases b Decreases b
	13	Auto-Man Switch	None b MFR STD b Other ————
	14	Set Point Adj.	Manual b External b Remote b Other ————
	15	Manual Reg.	None b MFR STD b Other ————
	16	Output	4-20 mA b 10-50 mA b 21-103 kpa (3-15 psig) b Other ————
ELEMENT	17	Fill	SAMA Class ———— Compensation ————
	18	Process Data	Temp: Normal ———— Max ———— Max. Press.————
	19	Range	Fixed b Adj. Range ———— Set At ———— Overrange Protection to ————
	20	Bulb	Type ———— Mtl. ———— Extension: Length .———— Type ———— Size: Diameter ———— Length ———— Insertion ———— Conn: ———— Location ———— Ft Above b Below b Instr.
		Capillary	MFR STD b Length ———— Mtl. ———— Armor ————
	21	Well	Mtl. ———— Insertion ———— Lag Ext. ———— Conn ————
	22		Const Drilled b Built-Up b Other ————
	23	Alarm Switches	Quantity ———— Form ———— Rating ————
	24	Function	Temp b Deviation b Contacts To ———— on Temp. Increase
	25	Options	Filt Reg. b Sup. Gage b Output Gage b ———— Charts Other ————
	26	MFR & Model No.	————

Notes:

IPS-FORM E-IN-120.2a

TEMPERATURE INSTRUMENTS (POTENTIOMETER PYROMETER & RESISTANCE) SPECIFICATION SHEET	INSTRUMENT SPECIFICATION				SHEET ——— OF ———	
	No.	BY	DATE	REVISION	SPEC. No.	REV
					CONTRACT	DATE
					REQ. P.O.	
	PROJECT				BY	CHK'D	APPR.

Rev.	Tag No.	Adj Range	Set Range	Well Conn.	Insert Length	Cap Length		Notes

Notes

IPS-FORM E-IN-120.2b

TEMPERATURE INSTRUMENTS SPECIFICATION SHEET

Instructions for IPS Forms No. E-IN-120 2a & 2b.

1) To be used for a single item. Use secondary sheet for multiple listing.

2) Check as many as apply.

3) Nominal size refers to approximate front of case dimensions; width x height.

4) Yoke refers to a bracket designed for mounting the instrument on a pipe stand.

5) Enclosure class refers to composite instrument. If electrical contacts are in the case, they must meet this classification inherently or by reason of enclosure. Us NEMA or IEC identification.

6) Specify electrical power to the entire instrument from an external source.

7) Specify chart type.

8) Chart drive mechanism assumed to be synchronous motor operating in 120 V 50 Hz and suitable for ENCLOSURE CLASS specified on line 5. If the chart drive is pneumatic so state-identify pneumatic pulser under options. Note deviations from standard (MFR) under notes i.e., dual speed or special speeds.

9) The scale type may be SEGMENTAL, VERTICAL, HORIZONTAL, DIAL (CIRCULAR) or other. Ranges 1, 2, 3 and 4 are used for multiple inputs. The first listed (No. 1) is assumed to be the controller input, if a controller is used.

10) Specify transmitter output if applicable.

11) See explanation of terminology given on specifications sheet. For further definition refer to American National Standard C85.1-1963, "Terminology for Automatic Control." Specific ranges of control modes can be listed after "OTHER", if required.

12) For multiple items specify on second sheet.

13) If standard auto-manual switching is not known or not adequate, specify particular requirements, such as BUMPLESS, PROCEDURELESS, 4-POSITION, or as required.

14) Remote set point adjustment assumes full adjustment range. Specify limits if required.

15) Specify if applicable.

16) Specify if applicable.

17) Filled thermal systems can be of the following SAMA classifications:

Class 1A: Liquid filled, uniform scale, fully compensated.

Class IB: Liquid filled, uniform scale, case compensated only.

Class IIA: Vapor pressure, non-linear scale with measured temperature above case and tubing temperature.

Class IIB: Vapor pressure, non-linear scale with measured temperature below case and tubing temperature.

Class IIC: Vapor pressure, non-linear scale with measured temperature above and below case and tubing temperature.

Class IIIA: Gas filled, uniform scale, fully compensated.

Class IIIB: Gas filled, uniform scale, case compensated only.

Class VA: Mercury filled, uniform scale, fully compensated.

Class VB: Mercury filled, uniform scale, case compensated only.

19) Range refers to process input span for which an output is desired. Adjustable range means that the unit can give its normal output over a range of inputs.

20) Bulb type can be plain, averaging, rigid, adjustable union connections, fixed union connection. Capillary extension length can be rigid or flexible, etc.

21) Capillary tube specifications.

22) Well Specifications.

23) Form may be SPST, SPDT, DPDT, etc. Rating is electrical rating of switch in volt amps.

24) Check if alarm is to be actuated by measured variable or by deviation form controller set point. Give contact action if single throw from.

THERMOCOUPLE AND THERMOWELLS SPECIFICATION SHEET	INSTRUMENT SPECIFICATION				SHEET ——— OF ———	
	No.	BY	DATE	REVISION	SPEC. No.	REV
					CONTRACT	DATE
					REQ. P.O.	
	PROJECT				BY	CHK'D	APPR.

1. Complete Assembly b Other ——————
MFR. & Model No. ——————

ELEMENT

MFR. & Model No. ——————
2. Type —————— Wire Size ———
3. Sheathed: ——— O.D. Material ———
Exposed b Grounded b Ungrourded b
Enclosed b Beaded Insulators b Spring Loaded b
4. Nipple Size ——— Dimension "N" ——— Union b
5. Packed Connector ——————

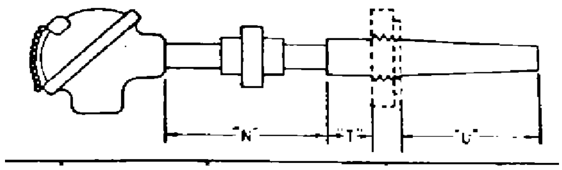
HEAD

6. Screw-Cap & Chain b Other ——————

7. Material ——— Conduit Conn. ———
8. Terminal Block: Single b Duplex b

WELL OR TUBE

9. Material ——————
10. Construction: Tapered b Straight b
Drilled b built-Up b Closed End Tube b
11. Dimensions: MFR. STD. b O.D. ——— I.D. ———
12. Connections: Process ——— INT ———
13. Other Specs.: ——————



Rev.	Tag No.	Well Dimens.		Element Length	Single Duplex	Type	Gage	Service	Notes
		"U"	"T"						

Notes:

IPS-FORM E-IN-120.3a

THERMOCOUPLE AND THERMOWELLS SPECIFICATION SHEET	INSTRUMENT SPECIFICATION				SHEET ——— OF ———		
	No.	BY	DATE	REVISION	SPEC. No.		REV
					CONTRACT		DATE
					REQ. P.O.		
	PROJECT				BY	CHK'D	APPR.

Rev.	Tag No.	Well Dimens.		Element Length	Single Duplex	Type	Gage	Service	Notes
		"U"	"T"						

Notes:

IPS-FORM E-IN-120.3b

THERMOCOUPLES AND THERMOWELLS

Instructions for IPS Forms No. E-IN-120 3a & 3b.

Reference: ANSI MC96.1 American National Standard for Temperature Measurement Thermocouples.

1) Check COMPLETE ASSEMBLY, or write in ELEMENT ONLY, ELEMENT & HEAD, etc.

2) Specify ISA type:

E	**Chromel/Constantan**
J	**Iron/Constantan**
K	**Chromel/Alumel**
R	**Platinum-13 percent Rhodium/Platinum**
S	**Platinum-10 percent Rhodium/Platinum**
T	**Copper/Constantan**

and wire diameter in mm. Thermocouple wire diameter normally runs from 0.5 mm (AWG No. 24) through 3.264 (AWG No. 8).

3) Specify required construction by filling in sheath diameter and material, or checking BEADED INSULATORS. Check type of junction, EXPOSED, ENCLOSED and GROUNDED, ENCLOSED and UNGROUNDED.

4) Specify nominal diameter of nipple, or write NONE. Specify length N (as defined on sketch below line 8) if appropriate.

Check UNION if required.

5) Specify connection size and material of packed connector, and whether Fixed or Adjustable. (For ceramic packed thermocouples only).

6) Specify general type of head.

7) specify material of construction of head.

8) A duplex terminal block accommodates two thermocouples as listed. Refer to Notes.

9) Specify material of well or tube.

10) A built-up well has a welded tip. Check as many as apply.

11) Give dimensions if required.

12) Process connection is external. However, INT will cover a thread dimension if well flange is threaded.

13) Fill in any applicable company standards or specifications.

Note:

For thermocouples other than arrangement shown in sketch, space has been provided for you to draw your own picture.

Tabulation: Fill in all applicable information. SINGLE/DUPLEX, need only be filled in on line 8 if they are the same for all thermocouples on the sheet.

RESISTANCE TEMPERATURE SENSORS SPECIFICATION SHEET	INSTRUMENT SPECIFICATION				SHEET ——— OF ———	
	No.	BY	DATE	REVISION	SPEC. No.	REV
					CONTRACT	DATE
					REQ. P.O.	
	PROJECT				BY / CHK'D / APPR.	

1. Complete Assembly Other

HEAD

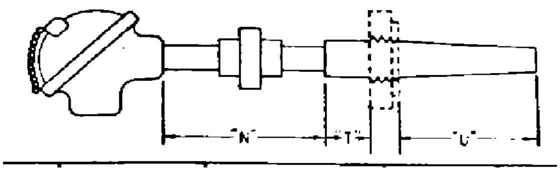
2. Screwed Cover b Other ——————
3. Explosion Proof b Class b ——————
4. Material —————— Cond. Conn. ——————
5. Nipple Size —————— Dim. "N" —————— Union b

ELEMENT

6. Platinum b Nickel b Other ——————
7. Ice Point Resistance ——————
8. Temperature Range ——————
9. Leads: STD b Potted b Herm. Sealed b
10. Sheath Material —————— O.D. ——————
11. Mounting Thread ——————
12. Connection: 2-Wire b 3-Wire b 4-Wire b
    Lead Wires b Receptacle b Bayonet Lock b
    Other ——————

WELL OR TUBE

13. Material ——————
14. Construction: Tapered b Straight b
    Drilled b Built-Up b Closed End b
    Tube
15. Dim: MFR. STD. b O.D. —————— I.D. ——————
16. Internal Thread ——————
17. Process Connection.: ——————



Rev.	Tag No.	Well Dimens.		Element Length	Single Duplex	Type	Gage	Service	Notes
		"U"	"T"						

Notes:

IPS-FORM E-IN-120.4a

RESISTANCE TEMPERATURE SENSORS SPECIFICATION SHEET	INSTRUMENT SPECIFICATION				SHEET ——— OF ———		
	No.	BY	DATE	REVISION	SPEC. No.		REV
					CONTRACT		DATE
					REQ. P.O.		
	PROJECT				BY	CHK'D	APPR.

Rev.	Tag No.	Well Dim.		Element Length	Single or Dual	Service	Notes
		"U"	"T"				

Notes:

Process connection, Flange size, Flange class & Thread

IPS-FORM E-IN-120.4b

RESISTANCE TEMPERATURE SENSORS

Instructions for IPS Forms No. E-IN-120 4a & 4b.

Refer to Scientific Apparatus Manufacturers Association (SAMA) Tentative Standard on Resistance, RC 5-10-1955.

1) Complete assembly includes head, element, and well; as shown in sketch.

5) Give size and pipe schedule of nipple. Check if union is required.

7) The ice point resistance in ohms usually defines the resistance vs. temperature curve. If not, provide additional data as an attachment.

8) Give maximum range over which the elements will be used.

9) Specify sealing of leads.

11) This thread is on the element termination, not the well.

12) It is necessary to specify the number of wires, depending on the compensation required. The other items refer to the element termination.

14) A built-up well has a welded tip and connection.

16) Internal thread of flange if well flange is threaded.

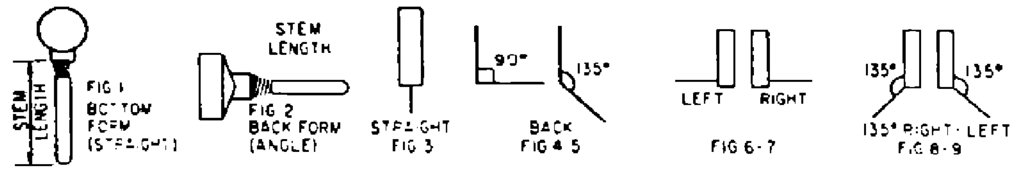
Instructions for the tabulation:

17) Process Connection is the connection on the element or well which is connected to the pipe or vessel.

Well dimensions are illustrated in the sketch. It is not necessary to specify "Element Length" if well dimensions are already given. Single or Dual elements are assumed to be within the same sheath. Refer to Notes by number or letter and explain in the space at the bottom of the form.

INDICATING BIMETAL THERMOWELLS SPECIFICATION SHEET	INSTRUMENT SPECIFICATION				SHEET ——— OF ———	
	No.	BY	DATE	REVISION	SPEC. No.	REV
	Δ				CONTRACT	DATE
	Δ					
	Δ				REQ. P.O.	
	Δ					
	Δ				BY / CHK'D	APPR.
	PROJECT					

THERMOMETER	WELL
1. Stem: Threaded b Plain b Union b Material ————————————	10. None b Included b By Others b
2. Stem or Union Thread: ¾" b ½ ½ ½" b	11. Material: 304 SS b 316 SS b Bayonet Lock b Other: ————————————
3. Stem Diameter: STD b 6 mm. b 9 mm. b	12. Construction: Drilled b Built-Up b Other ————————————
4. Case Material : STD b Other ————————	Well Length Must Suit Stem length.
5. Dial Size ———————— Color ————————	
6. Scale length ———————— Color ————————	
7. Form: Fig. No. ———————— Adjustable b	
8. External Calibrator b Herm Sealed Case b	
9. MFR. & Model No. ————————————	



Rev.	Tag No.	Range	Operating Temp	Stem Length	Well Conn.	Lag Ext.	Service	Notes

Notes:

IPS-FORM E-IN-120.5a

THERMOCOUPLE AND THERMOWELLS SPECIFICATION SHEET	INSTRUMENT SPECIFICATION				**SHEET ——— OF ———**	
	No.	BY	DATE	REVISION	SPEC. No.	REV
					CONTRACT	DATE
					REQ. P.O.	
	PROJECT				BY / CHK'D	APPR.

Rev.	Tag No.	Range	Operating Temp	Stem Length	Well Conn.	Lag Ext.	Service	Notes

Notes:

Process connection, Flange size, Flange class & Thread

IPS-FORM E-IN-120.5b

BI-METAL THERMOMETERS

Instructions for IPS Form No. E-IN-120 5a & 5b.

1) Specify mounting termination of stem and write in stem materials or "MFR. STD."

2) Select stem thread size.

3) Stem diameter standards may vary. Check specific size if this is important.

4) Write in case material if other than standard.

5) Write in nominal dial size and color.

6) Scale Length.

7) The form of the thermometer is illustrated on the form. The adjustable form may be set to any angle. If a stem connection form other than shown is required, make a sketch in the space provided.

8) Check applicable options.

9) List specific make and model number when selection is made.

10) Specify how well is to be furnished, if any.

11) Specify well material. If not all are the same, cover exceptions by notes in the tabulation.

12) Specify well construction. A "built-up" well has a welded tip. Special well designs should be described by a sketch in the space provided or on an attached sheet.

Tabulation:

Tag No: It is assumed that a tag number represents a single item. If multiple units have the same number, cover this with a special note.

Range: Write "F" or "C" at the top of the column. May be left blank on initial issue if Operating Temp. is specified.

Operating:

Temp. Must be filled in if range is not specified.

Stem Length: Refer to illustrations on form.

Well Conn: Show thread size, such at (1 in. NPT) or flange size and rating, such as (1 in. 150 1b). All flanges are assumed to be ANSI Standard; if not, cover by a special note.

Lag. Ext: Applies to screwed wells only.

Note:

Index notes by number or letter and specify in space below tabulation.

PRESSURE & TEMPERATURE SWITCHES SPECIFICATION SHEET	INSTRUMENT SPECIFICATION			SPEC. No.		REV
	PROJECT			DATE	CONT No.	
	No.	BY / DATE	REVISION			
	Δ			MANUFACTURER		
	Δ			P.O No.		
	Δ					
	Δ			BY	CHK'D	APPR.
	Δ					

	GENERAL					
1	TAG. No.					
2	TYPE					
3						
4	SERVICE					
5	RANGE					
	PRESSURE ELEMENT					
6	TYPE					
7	MATERIAL					
8	CONN: SIZE LOCATION					
	THERMAL ELEMENT					
9	TYPE SYSTEM					
10	TYPE & SIZE CONN					
11	EXTENSION NECK					
12	BULB MATERIAL					
13	BULB LOCATION TO CASE					
14	TUBING LENGTH					
15	TUBING TYPE & MAT'L.					
16	ARMOR MATERIAL					
17	WELL CONN SIZE & TYPE					
18	WELL MATERIAL					
19	"U" DIMENSION (NOMINAL)					
20	"T" DIMENSION					
	SWITCH					
21	TYPE					
22	QUANTITY FORM					
23	ENCLOSURE					
24	CONDUIT CONN SIZE & TYPE					
25	RATING: VOLTS CY OR D.C.					
26	AMPS WATTS KW					
27	LOAD TYPE					
28	MINIMUM DIFFERENTIAL					
29	DIFF: FLXED ADJUST					
30	ADJUSTMENT: INT EXT					
31	CON. OPEN ON INCR TACTS: CLOSE PROC DECR.					
	SERVICE CONDITIONS					
32	TEMP: OPER. MAX.					
33	PRESS. OPER. MAX.					
34	TRIP POINT					
35	MANUFACTURERS MODEL No.					

NOTES: U- Dimension means: Insertion lenght
T- Dimension means: Lag Extension

IPS-FORM E-IN-120.6

TEMP. SWITCHES

Instructions for IPS Form No. E-IN-120. 6.

2) Specify type: Blind or indicating.

5) Range to be specified in C.

9) Specify sensing element, filled or bimetallic.

10) Specify Conn. size such as ½" NPT.

11) Length of extension neck if applicable.

12) Such as 316 S.St.

13) Normally is bottom.

17) Such as 1" NPT and ½" NPT.

19) Insertion length.

20) Lag Extension.

21) Such as snap-action, mercury etc.

22) Such as single or dual SPDT (Single-Pole, Double Throw) or SPST (Single-Pole, Single Throw).

23) Specify either weather proof or Hazardous area, NEMA or IEC classification number to be mentioned.

24) Such as ½" NPT.

27) Such as inductive or non-inductive.