CONSTRUCTION (INSTALLATION) STANDARD

FOR

TEMPERATURE INSTRUMENTS

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1. SCOPE

This Standard represents the minimum and general technical requirements for the construction and installation of different types of temp. measuring and control instruments, which are used in oil, gas and petrochemical industries.

In any case, manufacturer installation instructions should be strictly followed.

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 Contractor.

API (AMERICAN PETROLEUM INSTITUTE)

RP 550	"Manual on Installation of Refinery Instruments and Control Systems"
Part III	"Fired Heaters and Inert Gas Generators"

ISA (INSTRUMENT SOCIETY OF AMERICA)

ANSI/Mc 96.1	"Temperature Measurement: Thermocouples"

ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

PTC 1 9.3	"Performance Test Code-Temperature Measurement"

IPS (IRANIAN PETROLEUM STANDARD)

IPS-E-GN-100	"Units"
IPS-C-EL-272	"Cabling and Wiring"
IPS-C-IN-190	"Transmission Systems"

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 & fitting threads, which shall be in inches of NPT.

4. GENERAL

4.1 All field mounted instruments shall be located so that they are readable from the point of operation. They shall be mounted so as to be free from vibration and be accessible for maintenance and services.

4.2 Temperature Instruments (such as local controllers and transmitters) shall not be supported by the inst. process piping.

Adequate independent supports shall be provided for every instrument.

4.3 All supports shall be located so as not to obstruct footpaths, vision or access to any item of equipment.

4.4 Instruments and instrument cables, ducting/conduits shall be installed rigidly and absolutely normal to the vertical or the horizontal plane as required unless otherwise specified.

4.5 Installations for which detailed project drawing and sketches are not supplied shall conform to the user standard hook-up drawing where applicable if the hook-up drawings are not applicable, the installation shall conform to a high engineering standard and good workmanship to the satisfaction of the engineer.

4.6 Transmission systems and inst. piping shall not introduce obstacles preventing access to the inst^{s}. etc.

4.7 Electrical wiring shall be carried out in accordance with standard electrical construction specification. Electrical inst^{s}., fittings etc. shall comply with the area requirements of IP safety code for electrical installations.

4.8 Installation of electrical/electronic instruments associated with temperature devices shall be strictly in accordance with the manufacturers instructions and to the satisfaction of the engineer.

4.9 No electric welding will be permitted on existing inst. panels containing electrical insts. Any cut outs, brackets etc. shall be cold cut, drilled or bolted as applicable.

4.10 All inst. control and/or alarm wiring shall be tested for continuity and resistance to ground in accordance with standard electrical construction specifications.

4.11 A functional check out shall be made on systems to ensure that the correct wires, capillaries, etc., are connected to the correct terminals.

5. FILLED SYSTEM AND BIMETALLIC DIAL THERMOMETERS

5.1 In all installations of filled-system temperature instruments, it is necessary to protect the bulb and capillary tubing from mechanical damage.

It is usually desirable to use armored capillary tubing and to support the tubing run between the bulb and controller or transmitter to protect it from accidental damage. The capillary tubing should not be cut, opened, or pinched in any manner.

5.2 Instrument work starts from the installation of the thermowell and includes the running of the capillary tubing and the mounting of the instrument. The capillary tubing shall be adequately supported and clamped.

5.3 The element of thermometers shall be installed in thermowells, unless other wise specified.

5.4 Care should be taken to ensure the readability of the dial from a convenient location. Some times a type that can be adjusted to various angles may be recommended.

6. RESISTANCE AND THERMOCOUPLES TEMPERATURE MEASUREMENTS

6.1 Thermocouples elements and RTDs shall be installed in thermowells.

6.2 Electrical measuring and control signal lines shall not be run in the same conduit nor the same trench as electrical power lines.

6.3 Precautions and practices encountered using thermocouples also apply to resistance temperature devices with two exceptions, which must be applied for RTD only:

a) Ordinary copper wire is used to connect the readout device to the sensor. For three wire system 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.

b) The reading is absolute, so a reference junction is not needed. 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. (pt 100)

6.4 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 0.75mm^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. Installation practices as outlined in IPS-C-IN-190 "Transmission Systems", should be followed.

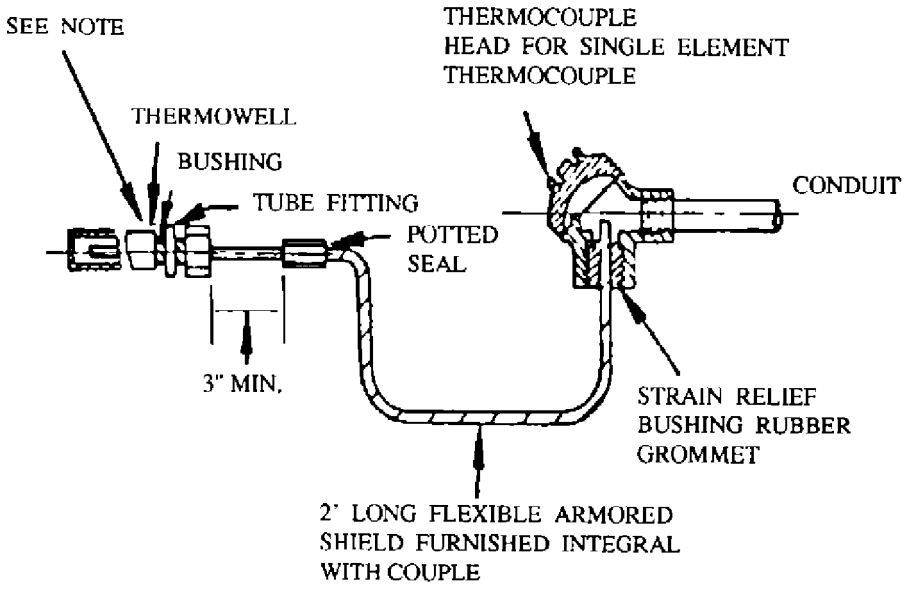
6.5 To minimize temperature lags (response time), it is essential that the thermocouple be in contact with the bottom of the well.

6.6 The correct type of extension wires for the particular thermocouple must be used in connecting the thermocouple to the instrument.

6.7 Metal-sheathed, mineral-insulated thermocouples where applicable such as fire boxes or furnaces are sometimes installed with the thermocouple head separated from the thermowell. An example of this type of installation is shown in Fig. 1.

6.8 There are applications where metal-sheathed, mineral insulated thermocouples are sometimes installed as bare elements without thermowells, usually to obtain better speed of response. Where thermocouples are installed without the use of thermowells, special wiring tags of a distinct color and durable material are usually attached as a warning to maintenance personnel. An example of this type of installation is shown in Fig. 2.

6.9 Metal-sheathed thermocouples provide longer life and improved long-term accuracy when compared to bare wire thermocouples. Metal-sheathed thermocouples have generally been more satisfactory in applications requiring long installation lengths, such as in reactors.



SHEATHED-TYPE THERMOCOUPLE AND HEAD ASSEMBLY

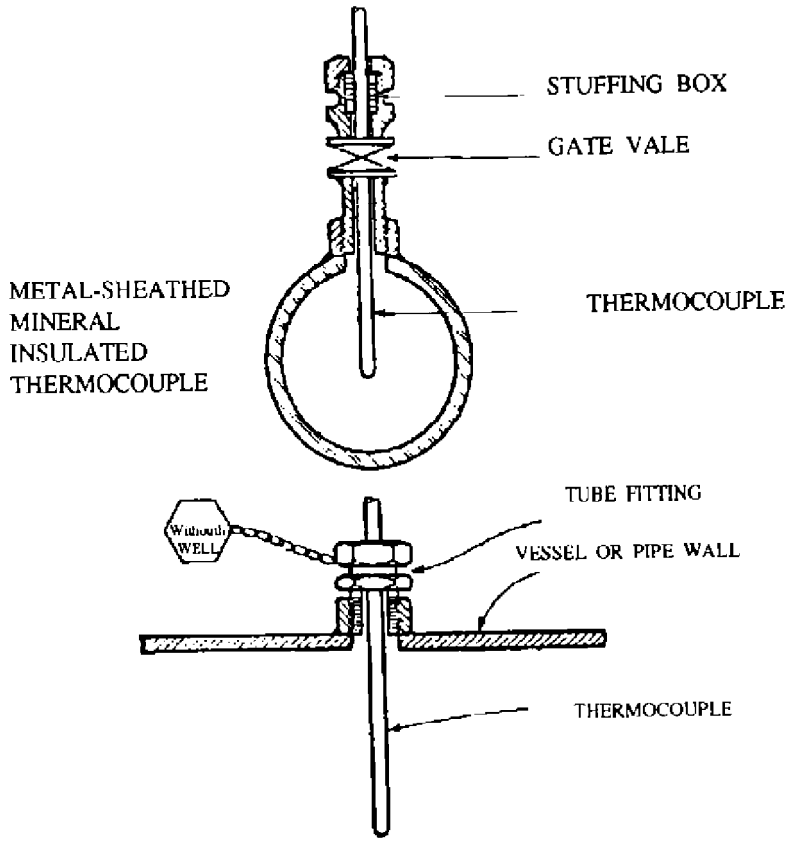
Fig. 1

Note:

Male tubing fitting for thermocouple to pass through. Install ferrule and nut and push couple to bottom of well then tighten tubing nut to secure couple in well.

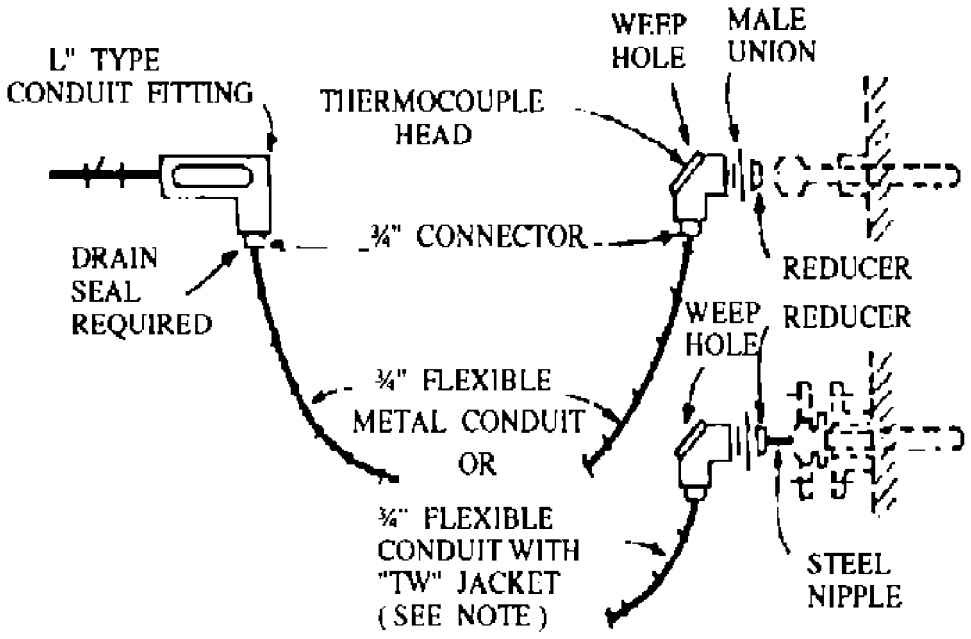
6.10 For field installation where the thermocouple cannot be directly connected to rigid conduit, a flexible conduit may be used as shown in Figs 1 and 3. A seal-off with drain at the thermocouple end of the conduit and seal-off with drain at the control room entry provides a double block and bleed in case the thermowell should fail and process fluid or gas enter the conduit. The choice of grounded or ungrounded thermocouples is dictated by the application. Regardless of the type used for measurement, grounding should only be done at one point.

6.11 For additional information on installation of thermocouples, refer to IPS-C-IN-190 "Transmission Systems"



INSTALLATION OF THERMOCOUPLES WITHOUT WELLS

Fig. 2



THERMOCOUPLE HEAD-TO-CONDUIT CONNECTIONS

Fig. 3

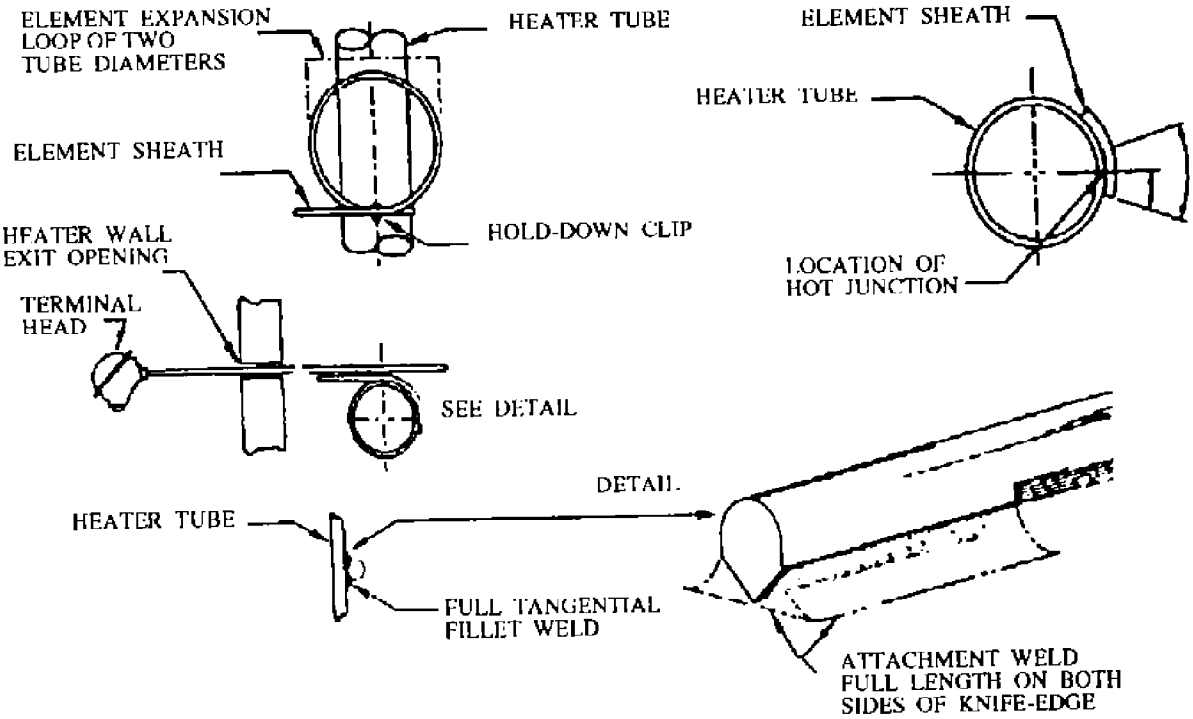
Note:

Where "TW"jacketed flexible steel conduit is used, it should be vented to relieve the pressure in case of thermocouple well failure.

6.12 Tube Surface Temperature Measurement

A special application of thermocouples is the measurement of skin-point or tube-metal surface temperature of furnace tubes. Such installations require careful attention to ensure that the thermocouple is properly attached to the tube and is shielded from furnace radiation. Care must be exercised to avoid adding mass at the point of measurement. The addition of mass may result in a temperature different from that of the relatively cool tube wall to which it is attached. Gaps between the tube wall and the thermocouple junction should be minimized. Many companies have their own standards for this application. These installations can be costly, are complex, and may not be entirely reliable.

One design for attaching this type of thermocouple to heater tubes is shown in Fig. 4. Other designs give satisfactory service. Thermocouples of this type are also used to measure external wall surface temperature of reactors or other vessels. They require the same care as the furnace tube surface temperature installations.



KNIFE EDGE TUBE SURFACE THERMOCOUPLE FOR HEATER TUBE

Fig. 4

6.13 Firebox Temperature Measurement

The application of thermocouples in fireboxes requires some special handling because of the wall construction. For typical installation, refer to Fig. 5. and for further information on this measurement, refer to API-RP-550, Part III, also see the attached typical drawing, on page 16.

6.14 Thermocouple Extension Wires

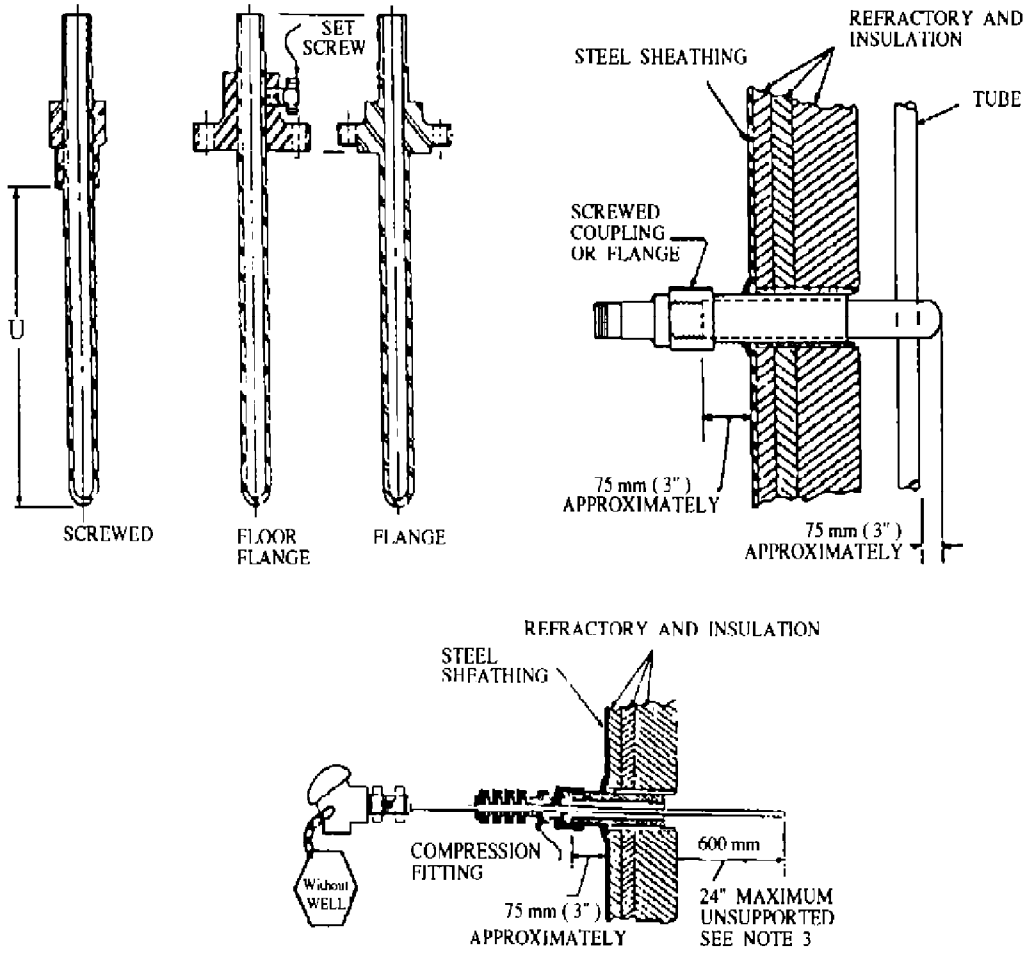
Thermocouple extension wires must have the same electromotive force (emf) temperature characteristics as the thermocouple to which they are connected. This will, in effect, transfer the reference junction to the end away from the thermocouple to a point where the temperature is reasonably stable and where the effect of temperature variations can be compensated. The use of incorrect extension wire will cause errors in the temperature readings by creating spurious thermocouples at the thermocouple terminal block or in the instrument.

Thermocouple extension wires (available either in pairs or bundles with multiple pairs) should be installed as described in IPS-C-IN-190 "Transmission Systems".

Materials for thermocouple extension wires are listed in Table 1. For limits of error associated with extension wire, refer to ANSI MC96.1. The wire sizes normally used for extension wire either singly or in pairs are 2, 1.3 and 0.75 mm^2 (14, 16, and 18 American Wire Gage "AWG"), with 1.3 mm^2 (16 gage) being the most common size used. When bundled and reinforced to provide strength for pulling, 0.5 mm^2 (20 gage) may be used.

TABLE 1 - THERMOCOUPLE EXTENSION WIRE MATERIALS

ANSI SYMBOL	THERMOCOUPLE MATERIALS	EXTENSION WIRE MATERIALS
EX	CHROMEL-CONSTANTAN	CHROMEL-CONSTANTAN
JX	IRON-CONSTANTAN	IRON-CONSTANTAN
KX	CHROMEL-ALUMEL	CHROMEL-ALUMEL
SX	PLATINUM, 10% OR 13% RHODIUM-PLATINUM ALLOY	COPPER-COPPER NICKEL
TX	COPPER-CONSTANTAN	COPPER-CONSTANTAN



TYPICAL FIREBOX THERMOCOUPLE INSTALLATION

Fig. 5

Notes:

1) Materials external of firebox may be other than those specified in Table 1.

2) 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-RP550, Part III, Table 1-1.

3) 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 6 mm (-inch) and potted with compound.

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

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

6.16 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.

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

6.18 To measure the same temperature for two different purposes, a duplex thermocouple should be used. When two or more thermocouples are used to measure the same temperature 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.

6.19 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.

6.20 Thermocouple 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 "Cabling and Wiring".

6.21 Trunking and conduit must be of adequate size and provided with sufficient inspection covers, etc.; to facilitate maintenance and sealing where necessary.

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

b) The complete installation shall be weather and dustproof, 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.

6.22 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-RP 550, part III, also see the attached typical drawing 6, on page 19.

6.23 Under no circumstances shall extension wires run in trenches, conduits, or trunking with power wiring.

Normally extension wires should run above ground only. Any alternative proposal should be agreed with the user. see 7.11, and see for more details IPS-C-IN-190 "Transmission Systems".

6.24 The immersion length is the distance from the free end of the temperature sensing element or well to the point of immersion in the medium, the temperature 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.

7. THERMOWELLS

7.1 It is important to maintain good contact between all temperature sensing elements and the bottom of their wells.

7.2 The installation of thermowells shall be as prescribed under the relevant section of the piping specification.

7.3 Spare thermowells, i.e. those for which a sensing element or instrument is not supplied, shall be plugged as soon as installed in the line.

7.4 The thermowell should extend sufficiently deep into the medium for the temperature-sensitive portion of the measuring element to be subject to the medium's actual temperature. Insufficient immersion can result errors because heat will be conducted to or away from the sensitive end of the thermowell.

7.5 When the thermowell is installed perpendicular to or at a 45 degree angle to the pipe wall, the tip of the thermowell should be located in the center third of the pipe on lines up to 760 mm (30 inches) in diameter. If the thermowell is installed at an angle or in an elbow, the tip should point toward the flow in the process line. See Dwg. No. 1 page 12.

7.6 Thermowells installed in lines having high velocities may be subject to vibration, which may cause a rupture of the well below the mounting. Tapered stems and U lengths established from a stress analysis are recommended for high velocity lines (see ASME PTC 19.3).

7.7 Unless otherwise agreed, temperature detecting elements and dial thermometers, shall be installed in thermowells. See Dwgs. on pages 13 through 19.

7.8 In case where thermowells are installed in erosive catalyst systems, they should be fitted with lubricated plug cocks between the well and the element 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.

7.9 Thermowells inserted in furnaces tubes or headers shall meet the specifications of the furnace designer and shall conform to the tube or header plug design.

7.10 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 Related typical Drawing on page 12.

7.11 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. (see: 7.6).

The maximum immersion length shall be 150 mm (6 in.) for pipes of 300 mm (12 in.) and above.

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

8. TEMPERATURE SWITCHES

- The temperature element of the switch assembly is to be mounted in a thermowell and the switch should be mounted on a pedestal or a stand pipe with brackets wherever applicable, such as capillary type switches.

- The capillary tubing shall be adequately supported and clamped.

THERMOWELL INSTALLATION (GENERAL SERVICE)

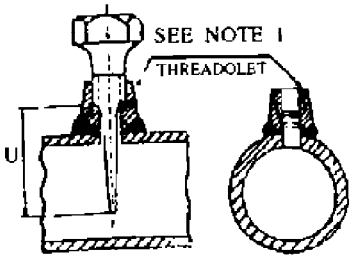


Fig. 1

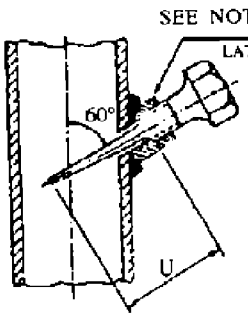


Fig. 2

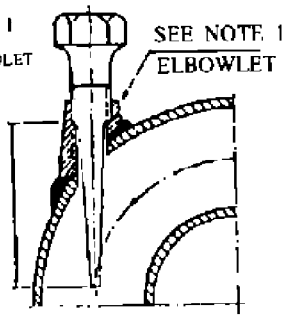


Fig. 3

TABLE 2 - THERMOWELL INSTALLATION SMALL BORE LINES

LINE SIZE	3"	4"	6"	8"	10"	12"	14"	16"	18"	20"
LENGTH "U"	100	100	100	150	200	200	300	300	300	300
LENGTH T/C	450	450	450	600	600	600	750	750	750	750
Max. Vel. M/S				25	15	15	7	7	7	7

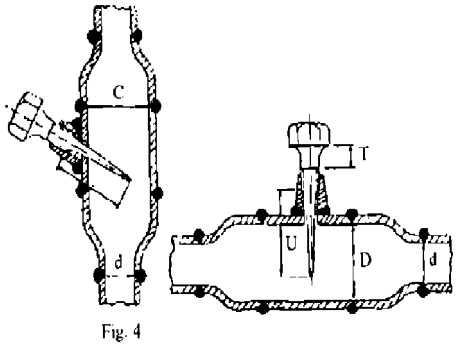


Fig. 4

Fig. 5

TABLE 3 - d & D NOMINAL LINE SIZE

d	D	U
2"	4"	100 mm
3"	4"	100 mm

Notes:

1) (1"API) threadolet, latrolet, or elbowlet minimum rating class 3000.

2) Outer end of thermowell shall face upward.

3) For 80 mm(3") or 100 mm (4") lines, elbow installation is preferable if practicable.

4) On an insulated line, the thermowell shall be insulated up to the bottom of the hexagon head. "T" DIM. shall include A 50 mm. Lagging extension.

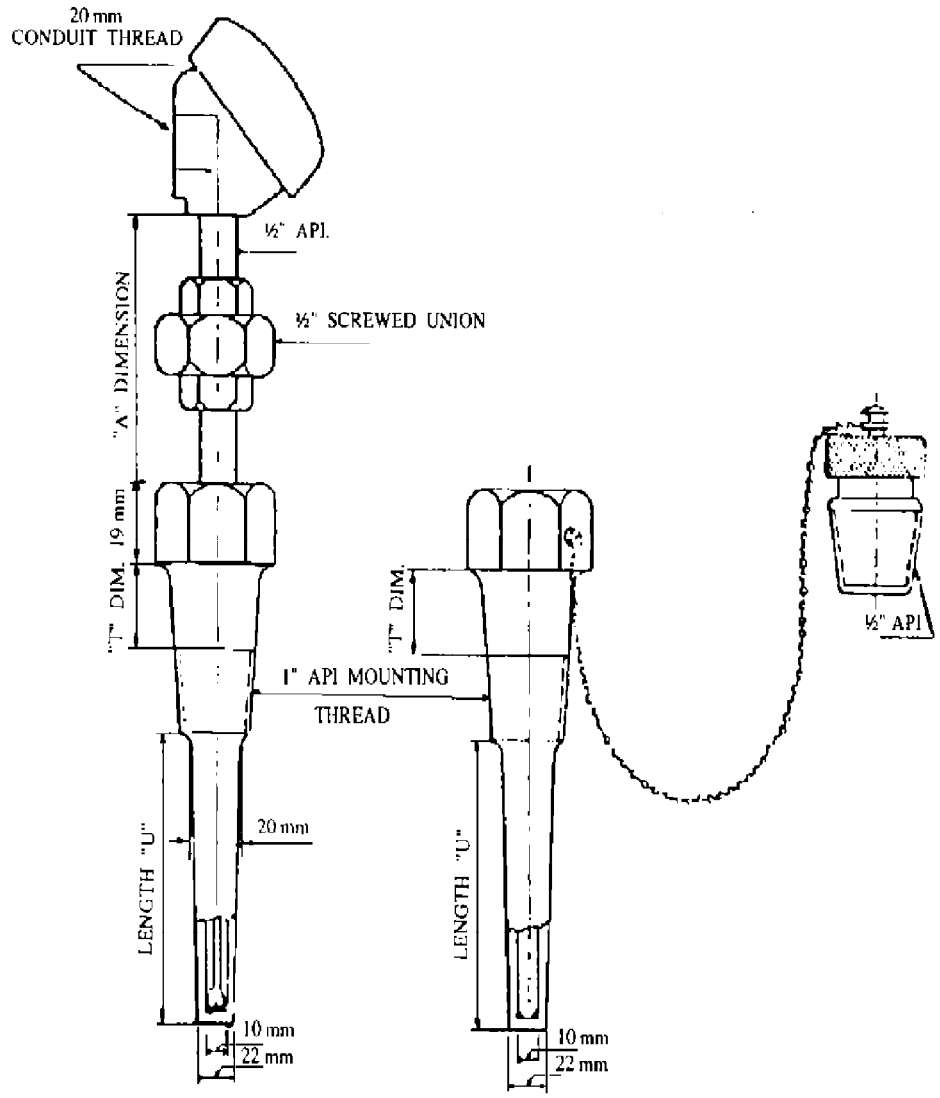
5) Welding to be in accordance with IPS engineering practices.

6) Dimension "U" refers to length of well from end of thread to tip of well.

7) Maximum allowable "U" length shall be limited to the figures given in Table 1.

TYPICAL DRAWING 1
THERMOWELL INSTALLATION (SCREWED)

THERMOWELLS



All dimensions are in millimeters.

TYPICAL DRAWING 2

THERMOWELL AND THERMOMETER POCKET (SCREWED)

(to be continued)

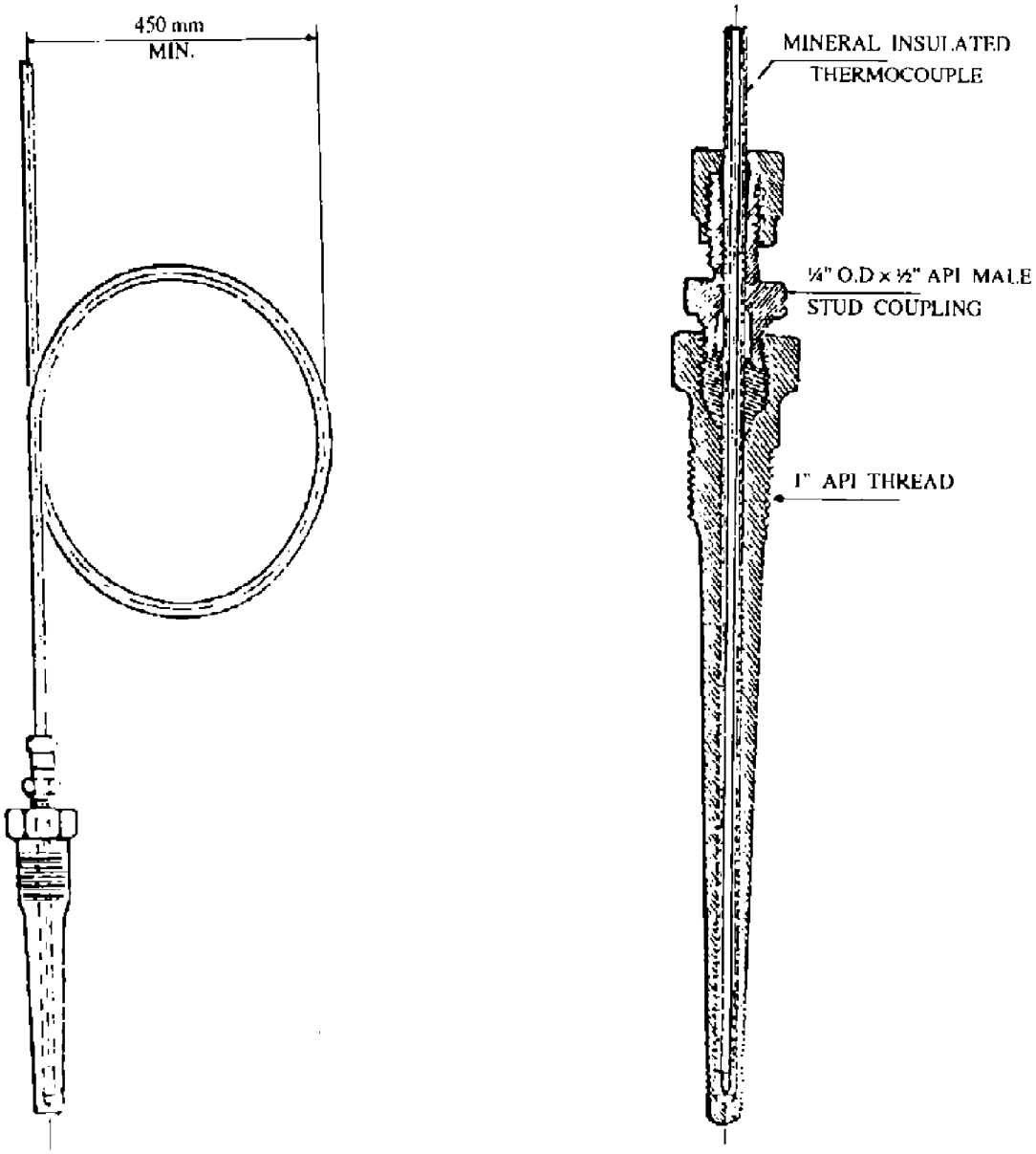
Notes:

1) The details shown of the hexagon and plug are typical only. Manufacturers standards may also be considered.
2) The well, plug, chain and rings shall be stainless steel type AISI-316.
3) The well shall be fabricated from solid bar stock, the bore shall be concentric to 10% of wall thickness.
4) The well shall be polished below mounting threads to 0.25 microns surface finish.
5) The well shall have an (ANSI STD. B2.1 one inch taper pipe thread) modified to have at least twelve effective threads, two of which are below a standard ring gage. This provides two additional full threads at each end beyond a standard pipe thread engagement.
6) The well shall withstand an internal hydrostatic test pressure of (140 bar).
7) The maximum cold working pressure is (70 barg).
8) On an insulated line, the thermowell shall be insulated up to the bottom of the hexagon head. "T" dimension shall include A 50 mm lagging extension.

LENGTH "U" mm

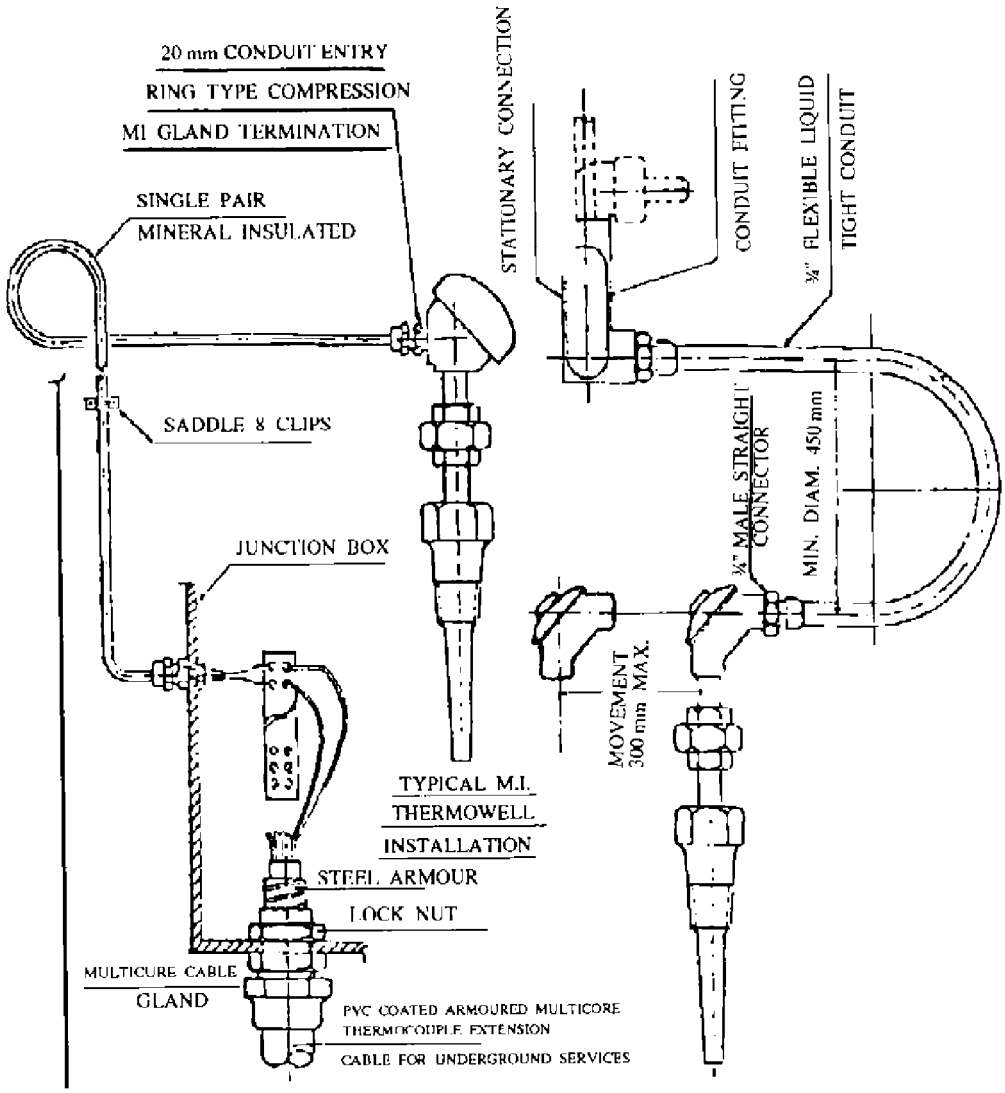
1 - Normal immersion into pipes should be approx. 75 mm except for bulbs which require approx. 125 mm immersion and the corresponding lengths "U" are 100 to 150 and 150 to 200 mm.

2 - For pipes the maximum allowable "U" is 300 mm



TYPICAL DRAWING 3

THERMOWELL AND THERMOCOUPLE INSTALLATION FOR LINES SUBJECTED TO VIBRATION

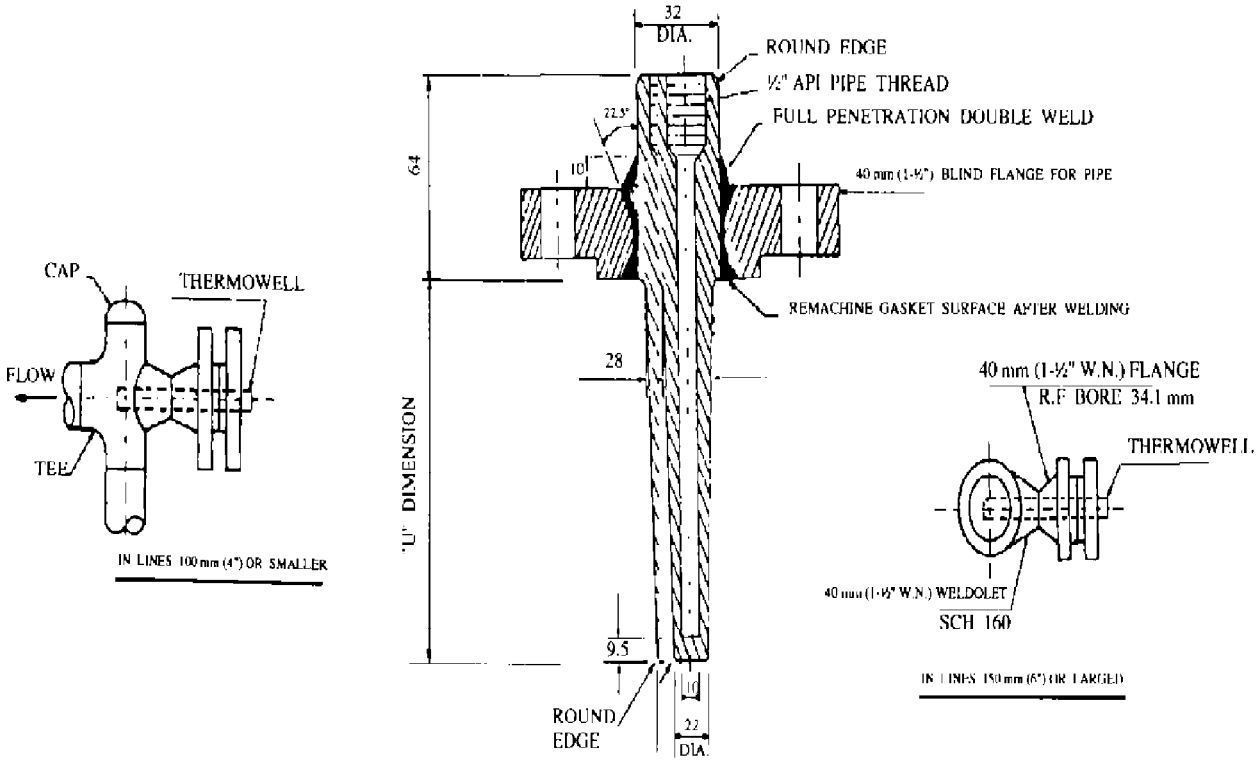


Notes:

1) Cable connector entry fittings to be of steel with rubber bushings to provide positive grip on cable and weather-tight seal.
2) All fittings outside the junction box to be weather protected with plastic tape or corrosion resistant paint.
3) All fittings to be of the safety compression type.
4) Junction box to be made of welded sheet steel, duly protected against corrosion and the cover to be fully neophrene gasketed.
5) Each end of the junction box to have assorted knockouts to provide adequate accommodations for multicore junctions and terminations.
6) Terminal block shall be installed as high as possible in the box.

TYPICAL DRAWING 4

THERMOCOUPLE EXTENSION LEAD AND THERMOWELL INSTALLATION ARRANGEMENT



LINE SIZE	3"	4"	6"	8"	10"	12"	14"	16"	18"	20"
LENGTH "U"										
Max. ALLOWABLE	150	150	200	200	300	300	300	300	300	300
Max. Vel. M/S	25	25	15	15	7	7	7	7	7	7

*** For vessels, blind flange size shall be 50 mm (2 inches) and Length "U" may be larger than listed.**

All dimensions are in millimeters.

TYPICAL DRAWING 5

THERMOWELL INSTALLATION (FLANGED)

Notes:

1) The well shall be AISI -316 stainless steel or other materials as required for fluid.
2) The well shall be fabricated from solid bar stock, the bore shall be concentric to 10% of wall thickness.
3) The well shall be polish finished below mounting flange to 0.25 microns.
4) Welding to be in accordance with IPS engineering practices
5) For test wells (½" API) plug and chain shall be provided.
6) The standard lengths "U" for piping installations are 150, 200, 250 and 300 mm.
7) The well shall withstand A hydrostatic test pressure according to the flange rating.
8) Flanges to be ANSI 300 R.F minimum rating and ANSI 1500 R.F maximum rating.

(to be continued)

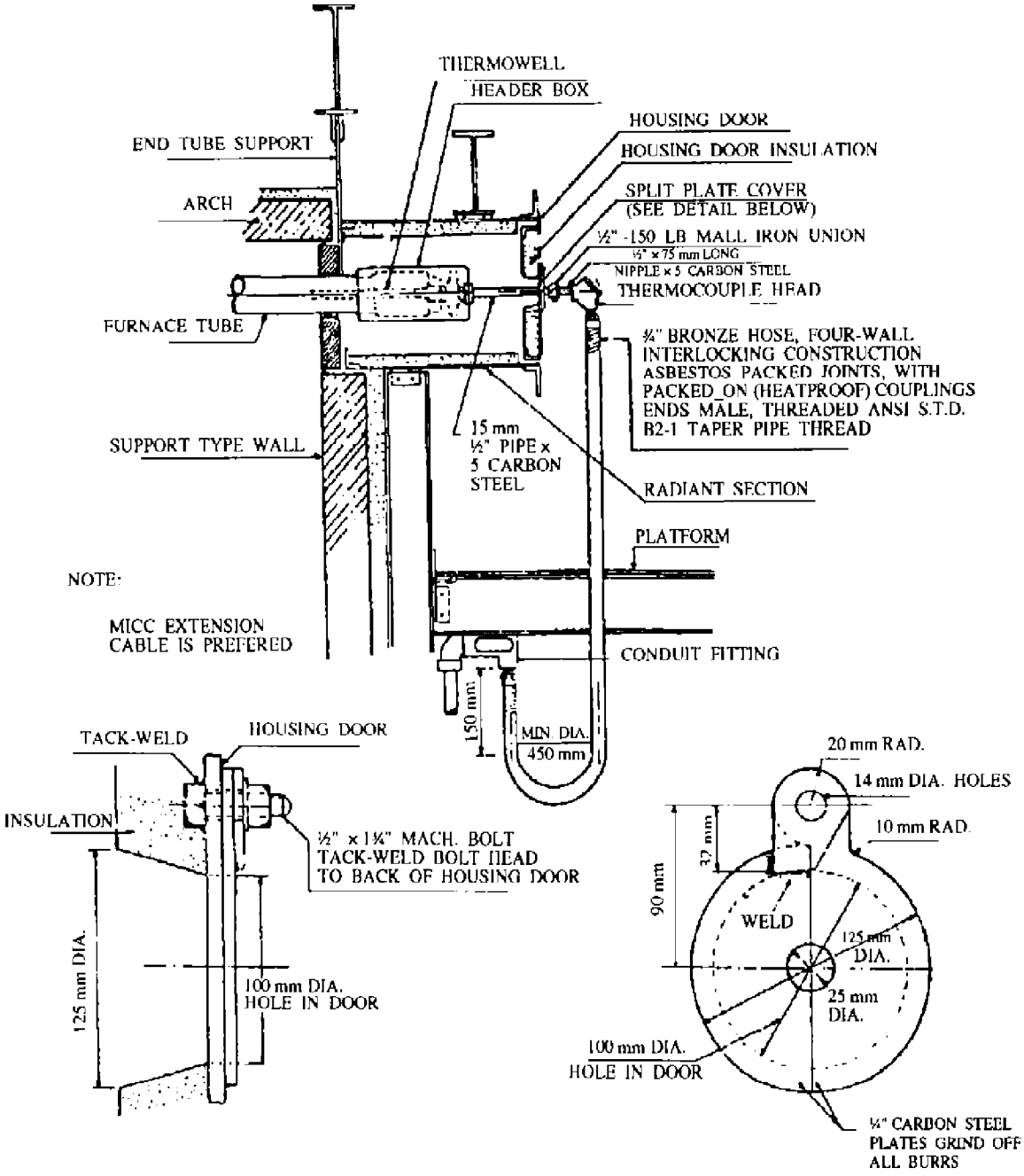
(ANSI) FLANGE RATING RF OR RTJ AS REQUIRED CLASS	MAXIMUM COLD WORKING PRESSURE (BARG)	HYDROSTATIC TEST PRESSURE (BARG)
(300)	(50)	(75)
(600)	(100)	(150)
(900)	(150)	(225)
(1500)	(250)	(375)

LENGTH "U" mm

1 - Normal immersion into pipes should be approx. 75 mm except for bulbs which require approx. 125 mm immersion and the corresponding lengths "U" are 150 to 200 and 200 to 250 mm.

2 - For pipes the maximum allowable "U" is 300 mm

DETAIL OF SPLIT PLATE COVER



TYPICAL DRAWING 6

THERMOWELL INSTALLATION IN FURNACE FIREBOXES