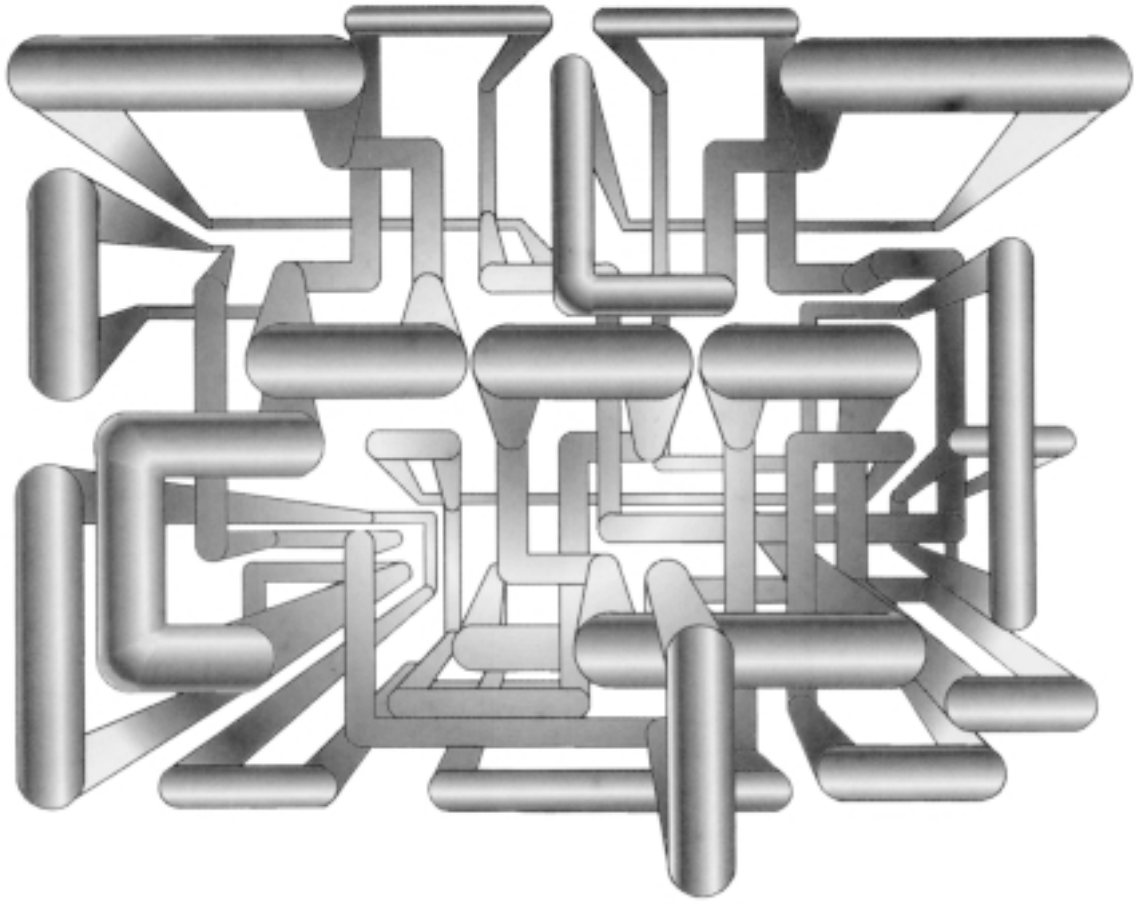
GAYESCO®

TUBESKIN



TEMPERATURE MEASUREMENT

PRODUCT CATALOG

TUBESKIN TEMPERATURE MEASUREMENT

REFRACTO-PAD™ & XTRACTO-PAD™

TUBESKIN TC

Improvement in Design

GAYESCO® has taken TubeSkin Thermocouple (TSTC) design to the next level. This has been accomplished by listening to our customers and evaluating our own field experience in the installation of these critical temperature sensors.

Experience has proven to field personnel that install TSTC's, that a consistent, repeatable, easy method of installing the sensor and its radiant heat shield provides:

- Improved performance
- Better accuracy
- Decreases need for specially trained personnel

GAYESCO® has now added this design characteristic to our TSTC's. This is all due to the fact that a new moldable insulation is now used in place of the blanket type refractory traditionally used in the heat shield.

In the past it was possible for the insulation to fall out of the heat shield causing the TSTC to read higher than the actual tube temperature. This same offset occurs when personnel, who do not understand the critical nature of this material, remove it believing it to be packing material. ***With the moldable insulation the geometry of the shield locks in the insulation so that it cannot "fall" out. In addition due to its more rugged density it takes extra effort, and tools, to remove this material.***

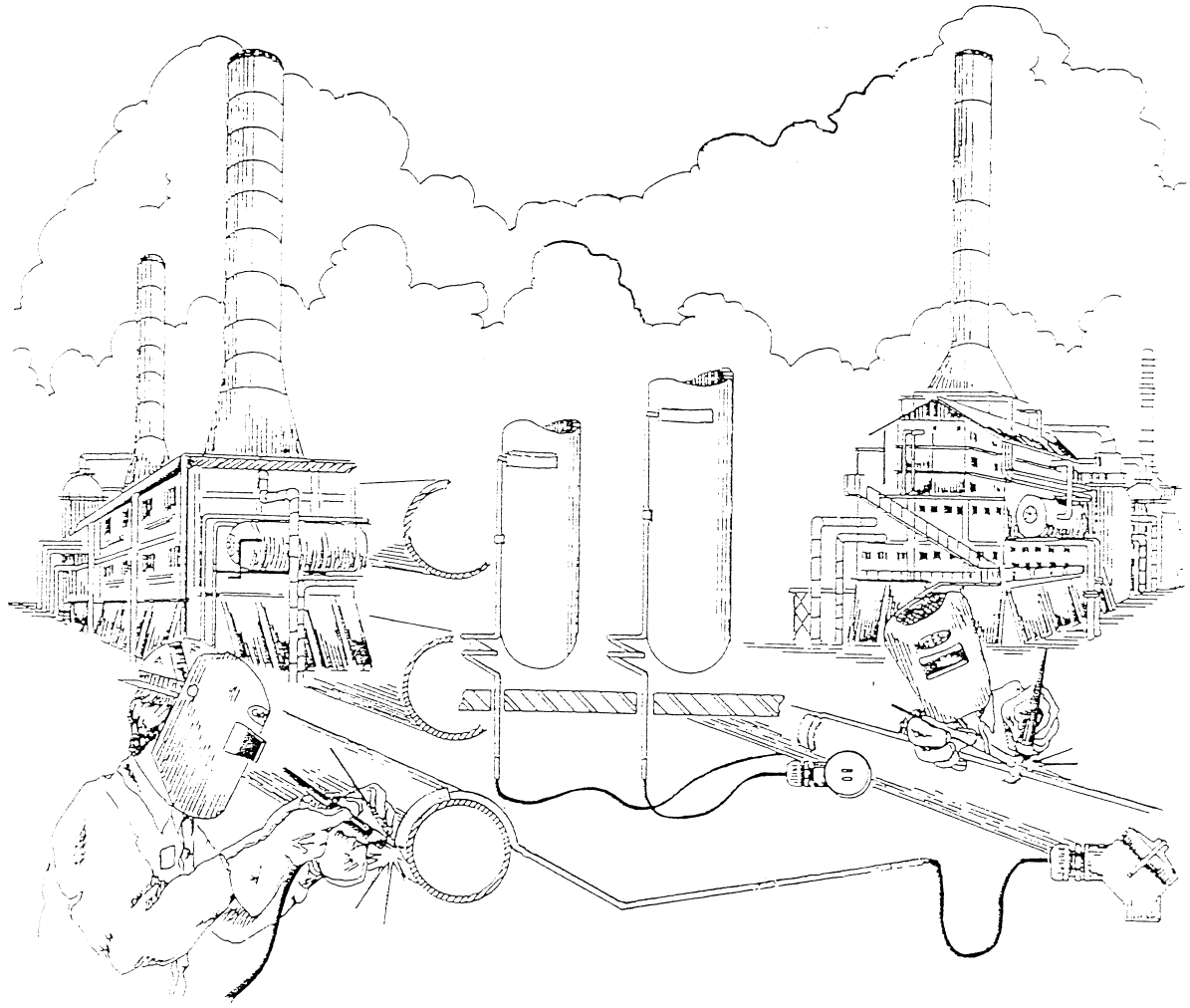
A second possibility for creating error occurs when the shield is located incorrectly over the thermocouple/ weld pad. The Refracto-Pad™ and Xtracto-Pad™ design relies on specific orientation of these two pieces for its high accuracy reading. This was the responsibility of the welder, in the field, in the past. ***With the molded impression of the new insulation material it is impossible to install the two components incorrectly in relation to each other. This results in easier to achieve consistency in installation.***

The dependability of the Refracto-Pad™ basic design has been proven over time. Industry has helped to verify the accuracy of the moldable insulation and the new Xtracto-Pad™. Combining these enhancements has increased the value to our customers. Please contact: GAYESCO® at (713) 941-8540 or fax: (713) 944-3715 to discuss your needs.

The

REFRACTO-PAD™

TUBESKIN THERMOCOUPLE ASSEMBLY



The REFRACTO-PAD™ TUBESKIN THERMOCOUPLE ASSEMBLY

APPLICATION

The Refracto-Pad™ accurately measures tubeskin temperature in fired process furnaces and boilers. The patented Refracto-Pad™ thermocouple is designed to minimize temperature measurement problems caused by flame impingement and radiant heat. The accurate measurement of tubeskin temperature increases furnace efficiency, provides accurate tube life data, and assists in decoking operations.

DESIGN and INSTALLATION

Proper installation of the Refracto-Pad™ is the single most critical factor in assuring long thermocouple life. Successful Refracto-Pad™ installations are achieved through prior planning and adherence to these guidelines, and result in optimum sheath protection. An important fact to remember is that there is no one answer applicable to all furnaces. Each installation must be given individual consideration to ensure optimum thermocouple performance. Two primary factors contribute to the successful Refracto-Pad™ installation. First, keep the thermocouple sheath in intimate contact with the process tube and on its coolest side if possible. In many furnaces there is no cool side of the tube. When this is the case it is even more important to keep the sheath in contact with the tube. Second, allow for expansion and movement associated with furnace tubes. Keeping these two considerations in the forefront of your planning will result in a successful installation and a long Refracto-Pad™ life.

The REFRACTO-PAD™ TUBESKIN THERMOCOUPLE ASSEMBLY

CONTACT AND ROUTING

Keeping the thermocouple sheath in intimate contact with the tube and routing it on it's coolest side are of paramount importance because it allows the thermocouple to utilize the process tube as a heat sink. The thermocouple sheath remains close to the same temperature as the tube, thereby ensuring it's normal life expectancy. This is best accomplished by the liberal use of weld-on "tube clips". A sufficient number of tube clips must be used to ensure that all portions of the thermocouple sheath exposed to radiant heat and/or direct flame impingement remain in contact with the tube. Only where tube clips are impossible to use, or where time constraints are a consideration, should banding be considered. Please note that keeping the thermocouple sheath in contact with the tube occasionally requires drilling through the tube support structure.

EXPANSION AND GROWTH

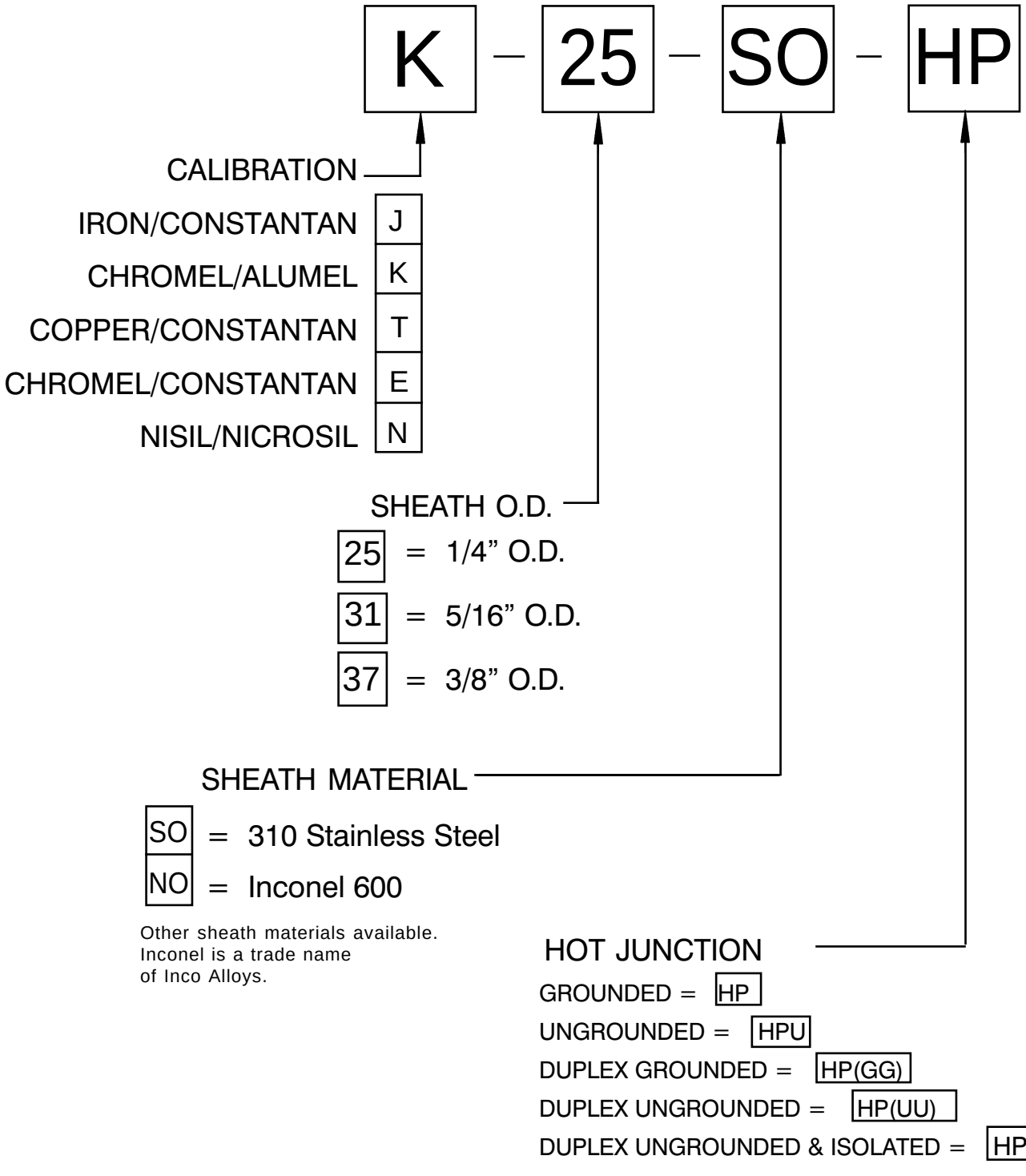
Furnace tubes reaching process temperature will move a substantial distance (two to twelve inches is typical.) Such movement will destroy the thermocouple if no compensation is provided. Tube growth compensation can be achieved with expansion coils or on the outside of the furnace fire box. However, compensation outside the furnace is, in many cases, the best approach. The optimum location for the expansion loops is just before the furnace firebox exit. It is recommended that this be done at floor level to minimize exposure to flame and/or radiant heat.

These are only guidelines. Due to limitations of time, material and labor, compromises are often necessary. Such compromises however, may shorten the life of the Refracto-Pad™ thermocouple assembly. Nonetheless, the Refracto-Pad™ is relatively inexpensive in material and installation costs.

This is especially true when comparing it to other tubeskin designs.

The
REFRACTO-PAD™
TUBESKIN THERMOCOUPLE ASSEMBLY

CATALOG NO: EXAMPLE



The
REFRACTO-PAD™
TUBESKIN THERMOCOUPLE ASSEMBLY

K-25-SO-HP-L-E7-HA35AB-8N

"L" – E7 – [ ] – [ ] –

MOUNTING HARDWARE

NIPPLE ONLY

8N	1/2" NPT
12N	3/4" NPT
16N	1" NPT

NIPPLE UNION NIPPLE

8NUN	1/2" NPT
12NUN	3/4" NPT
16NUN	1" NPT

HEAD CONNECTION

HA35	HEAVY DUTY CAST ALUMINUM HEAD
SHA35	SNAP-LOCK HEAD
HIX	EXPLOSION PROOF CAST IRON HEAD
HA20	STANDARD HEAD
HN20	NYLON OR PLASTIC HEAD

NOTE: TO SPECIFY PROCESS AND CONDUIT CONNECTIONS USE, A = 1/2", B = 3/4", C = 1" NPT
ie.....HA35AB

EXTENSION LEAD WIRE

E2	PVC/PVC
E3	GLASS BRAID / GLASS BRAID
E4	PVC/PVC
E5	GLASS BRAID / GLASS BRAID WITH METALLIC OVERBRAID
E6	PVC METALLIC OVERBRAID PVC
E7	TEFLON FEP/ TEFLON FEP EXTRUDED
E8	TEFLON FEP/ GLASS / TEFLON FEP/ TEFLON
E9	TEFLON TFE/ TEFLON TFE
E10	PVC/ METALLIC OVERBRAID PVC WITH GROUND WIRE
E11	PVC / METALLIC OVERBRAID PVC
C3	FUSED KAPTON / FUSED KAPTON

SHEATH LENGTH

LENGTH OF SHEATH MATERIAL FROM TRANSITION TO TIP OF THERMOCOUPLE, CONSULT OFFICE

NOTE: EACH REFRACTO -PAD© IS SUPPLIED WITH A HEAT SHIELD AND FACTORY BENT EXPANSION LOOPS. PLEASE CONTACT SALES OFFICE FOR DETAILS.

The
REFRACTO-PAD™
TUBESKIN THERMOCOUPLE ASSEMBLY

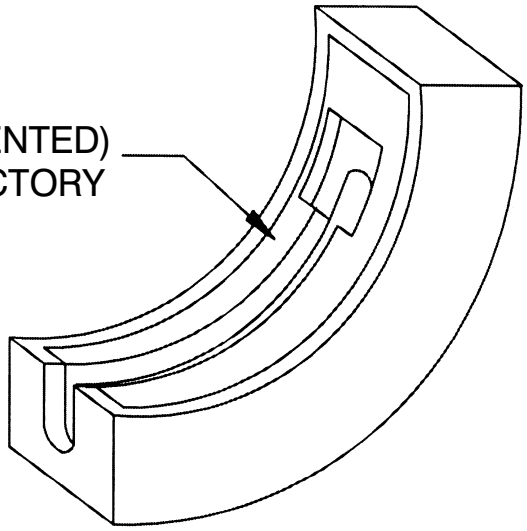
The
XTRACTO-PAD™
REPLACEABLE FURNACE TUBESKIN
THERMOCOUPLE ASSEMBLY

REFRACTORY FILLED

HEAT SHIELDS

CUSTOM FORMED FOR THE CURVATURE OF YOUR TUBE

THE NEW CUSTOM FITTED (PATENTED)
MOLDABLE INSULATION REFRACTORY



ENSURES PERFECT SHIELD PLACEMENT ON THE TUBE RESULTING IN;

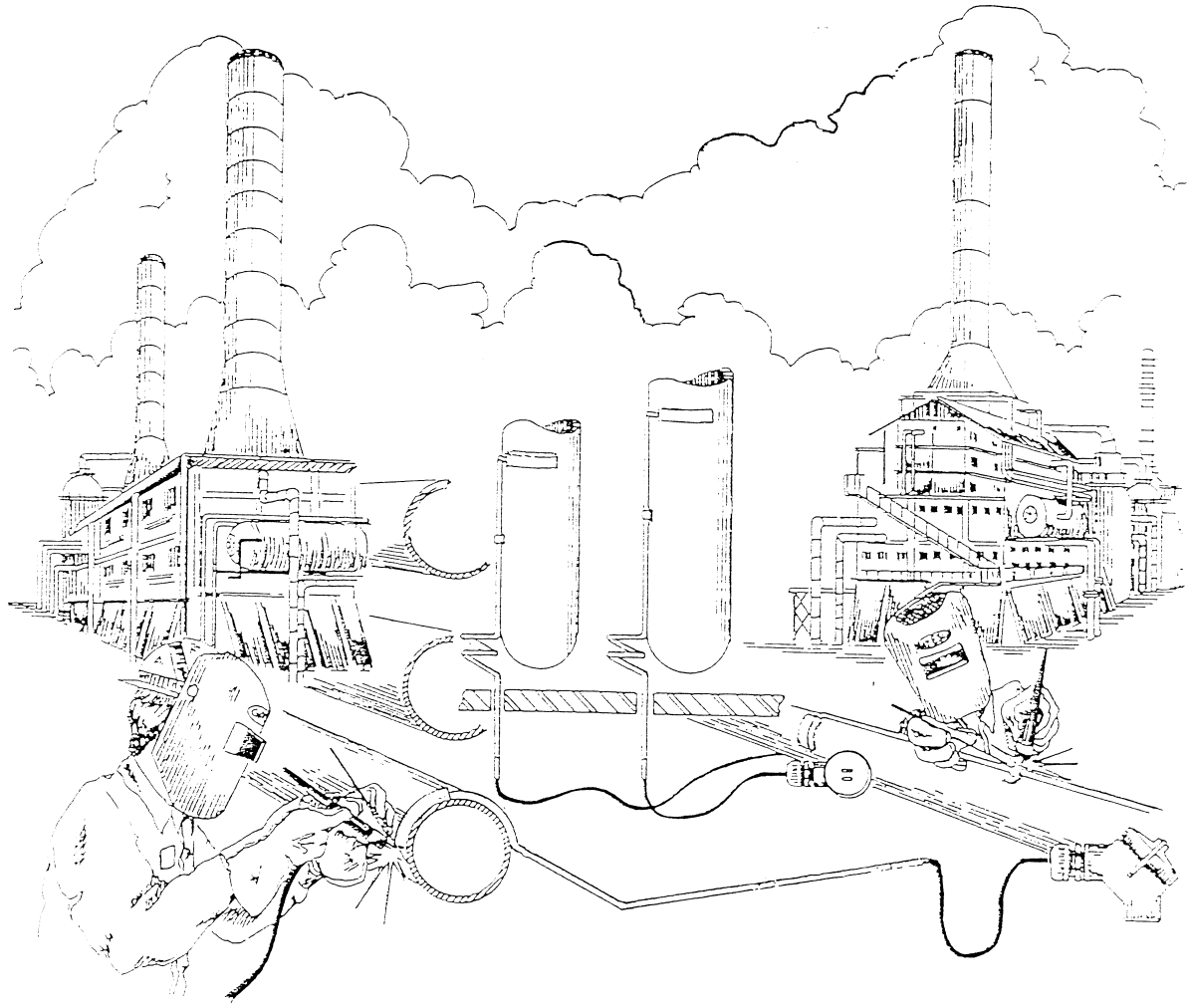
- ACCURACY
- SAVINGS (TIME & MONEY)
- CONSISTENCY INSTALLATION TO INSTALLATION

CONSULT WITH OUR INSIDE SALES DEPARTMENT FOR DETAILS ON HOW TO ORDER.

GAYESCO®

The XTRACTO-PAD™

REMOVEABLE FURNACE TUBESKIN THERMOCOUPLE ASSEMBLY



The XTRACTO-PAD™

REPLACEABLE FURNACE TUBESKIN THERMOCOUPLE ASSEMBLY

Accurate reliable temperature measurement for process furnaces is a priority throughout the refining and petrochemical industry. Traditionally tubeskin temperature measurement systems have required the welding and or peening in of the thermocouple on the tube. This activity had to be repeated if the thermocouple failed.

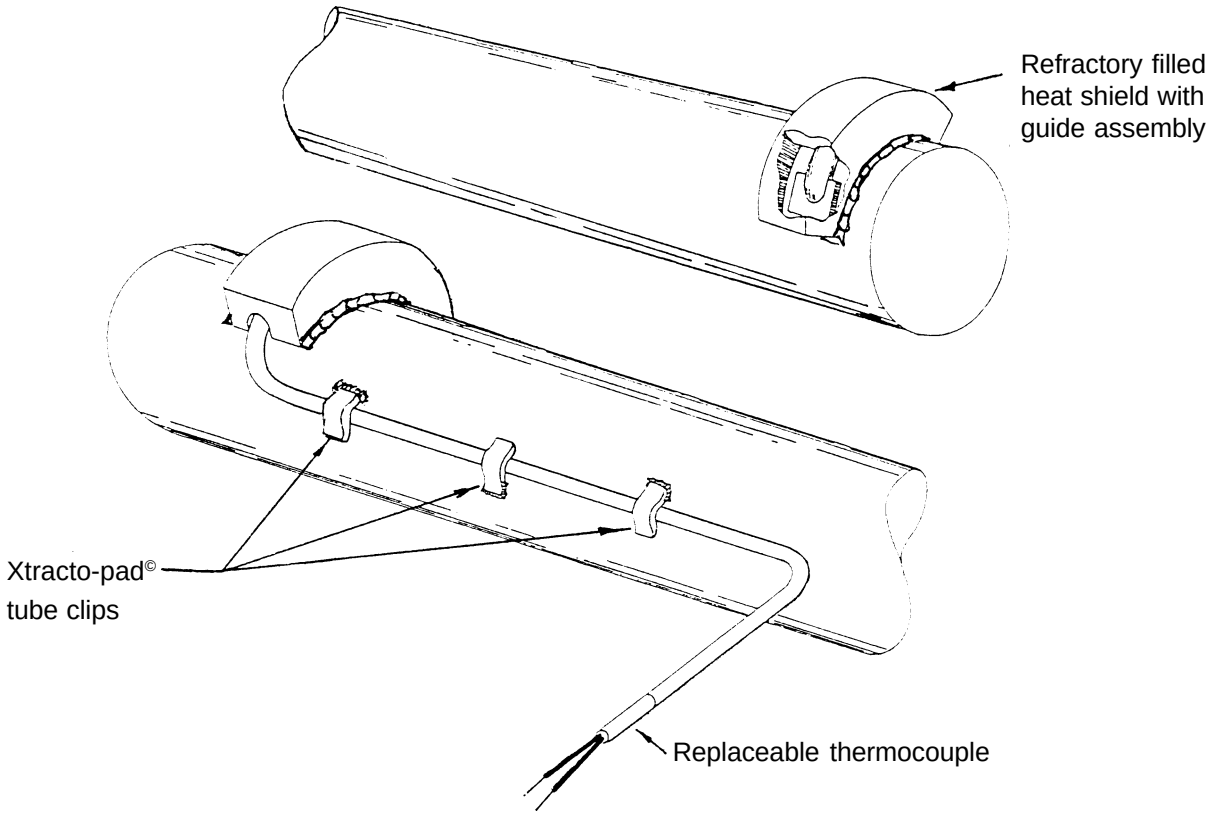
GAYESCO®'s new patented "XTRACTO-PAD™" thermocouple system allows for replacement of the thermocouple without rewelding. This results in ***significant cost savings*** to the operator and provides a ***practical solution*** to tubeskin temperature measurement.

The basic configuration for the ***"XTRACTO-PAD™"*** design is similar to the "REFRACTO-PAD™". This design has proven to be a popular means of furnace tubeskin temperature measurement throughout industry. The novelty of the ***"XTRACTO-PAD™"*** involves improvement in the area of replaceability, while maintaining the accuracy and dependability of the device.

The differences are:

1. **The weld pad is fabricated as part of the guide assembly.**
2. **The heat shield is modified to keep the weld pad/guide assembly in position.**
3. **The tube clips that hold the thermocouple in place are reusable.**

*For more information about how to specify the new "XTRACTO-PAD™" for your application or our installation services, call GAYESCO® at 713/941-8540.



"XTRACTO-PAD™" Advantages

- **Accurate - Based on industry proven design**
- **Replaceable - Following initial application, thermocouple element can be replaced by a single craft without welding.**
- **Cost Effective - Considerable savings in installation time, manpower, and replacement thermocouple cost.**
- **Ease of Installation - Only single pass welds required for initial installation.**
- **Fast Delivery - Common thermocouple raw materials stocked at factory.**
- **Reliable - When properly installed, the Xtracto-Pad™ provides dependable temperature measurement in a variety of process furnace and boiler applications.**

The
XTRACTO-PAD™
REPLACEABLE FURNACE TUBESKIN
THERMOCOUPLE ASSEMBLY

CATALOG NO: EXAMPLE

XTPD – K – 25 – SO – G –

FOR XTRACTO-PAD© ONLY

CALIBRATION

IRON/CONSTANTAN	J
CHROMEL/ALUMEL	K
COPPER/CONSTANTAN	T
CHROMEL/CONSTANTAN	E
NISIL/NICROSIL	N

SHEATH O.D.

25 = 1/4” O.D.

31 = 5/16” O.D.

SHEATH MATERIAL

SO = 310 Stainless Steel

NO = Inconel 600

Other sheath materials available.
Inconel is a trade name
of Inco Alloys.

HOT JUNCTION

GROUNDED = G

UNGROUNDED = U

DUPLEX GROUNDED = GG

DUPLEX UNGROUNDED = UU

DUPLEX UNGROUNDED & ISOLATED = U/U

The
XTRACTO-PAD™
REPLACEABLE FURNACE TUBESKIN
THERMOCOUPLE ASSEMBLY

XTPD-K-25-SO-G-L-E7-HA35AB-8N

"L" – E7 – [ ] – [ ]

MOUNTING HARDWARE

NIPPLE ONLY

8N	1/2" NPT
12N	3/4" NPT
16N	1" NPT

NIPPLE UNION NIPPLE

8NUN	1/2" NPT
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HA35	HEAVY DUTY CAST ALUMINUM HEAD
SHA35	SNAP-LOCK HEAD
HIX	EXPLOSION PROOF CAST IRON HEAD
HA20	STANDARD HEAD
HN20	NYLON OR PLASTIC HEAD

NOTE: TO SPECIFY PROCESS AND CONDUIT CONNECTIONS USE, A = 1/2", B = 3/4", C = 1" NPT
ie.....HA35AB

EXTENSION LEAD WIRE

E2	PVC/PVC
E3	GLASS BRAID / GLASS BRAID
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E8	TEFLON FEP/ GLASS / TEFLON FEP/ TEFLON
E9	TEFLON TFE/ TEFLON TFE
E10	PVC/ METALLIC OVERBRAID PVC WITH GROUND WIRE
E11	PVC / METALLIC OVERBRAID PVC
C3	FUSED KAPTON / FUSED KAPTON

SHEATH LENGTH

LENGTH OF SHEATH MATERIAL FROM TRANSITION TO TIP OF THERMOCOUPLE, CONSULT OFFICE.

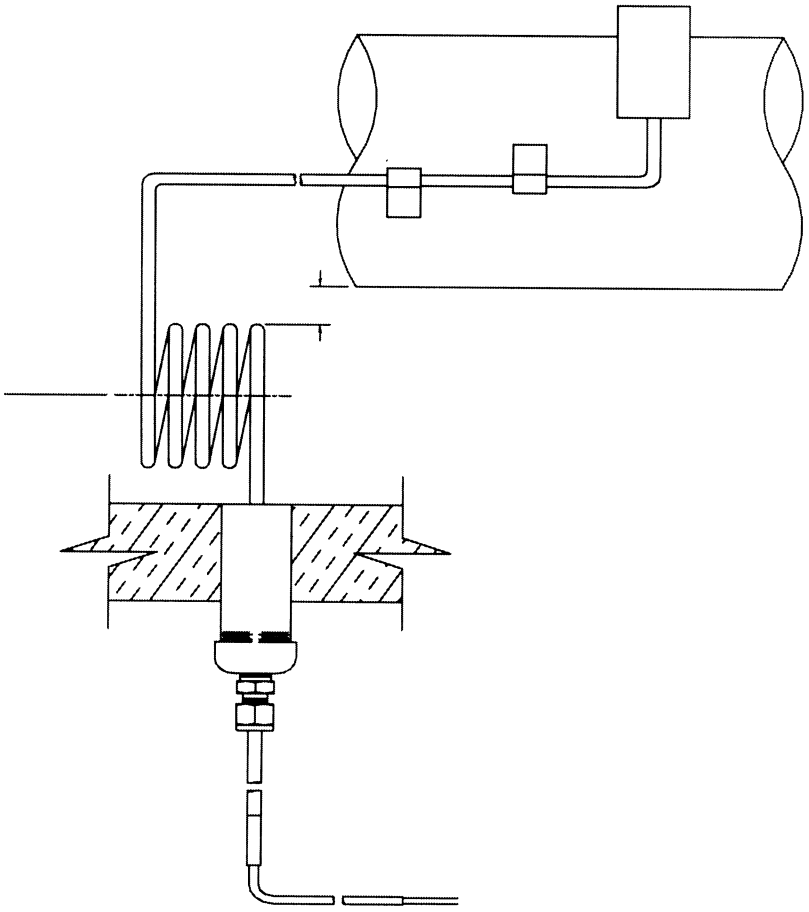
NOTE: EACH XTRACTO-PAD© IS SUPPLIED WITH A HEAT SHIELD AND FACTORY BENT EXPANSION LOOPS. PLEASE CONTACT SALES OFFICE FOR DETAILS.

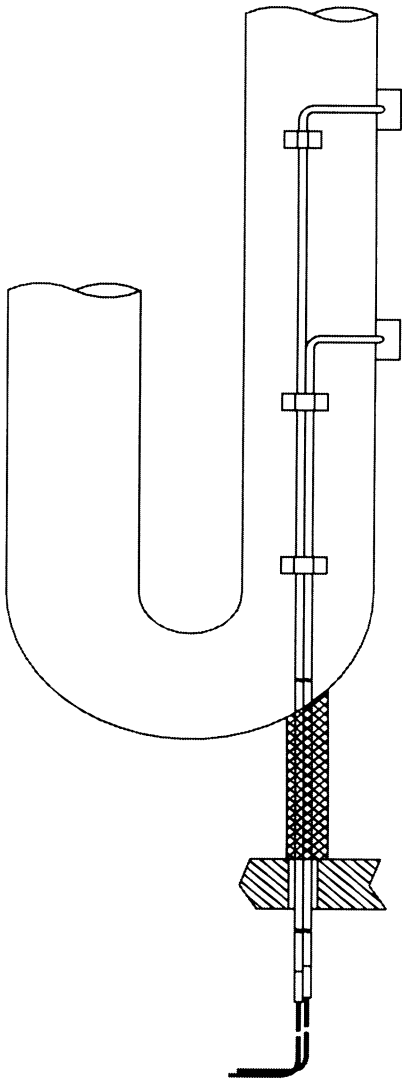
Teflon and Kapton are trade names of E.I. Dupont Co.

The
REFRACTO-PAD™
TUBESKIN THERMOCOUPLE ASSEMBLY

The
XTRACTO-PAD™
REPLACEABLE FURNACE TUBESKIN
THERMOCOUPLE ASSEMBLY

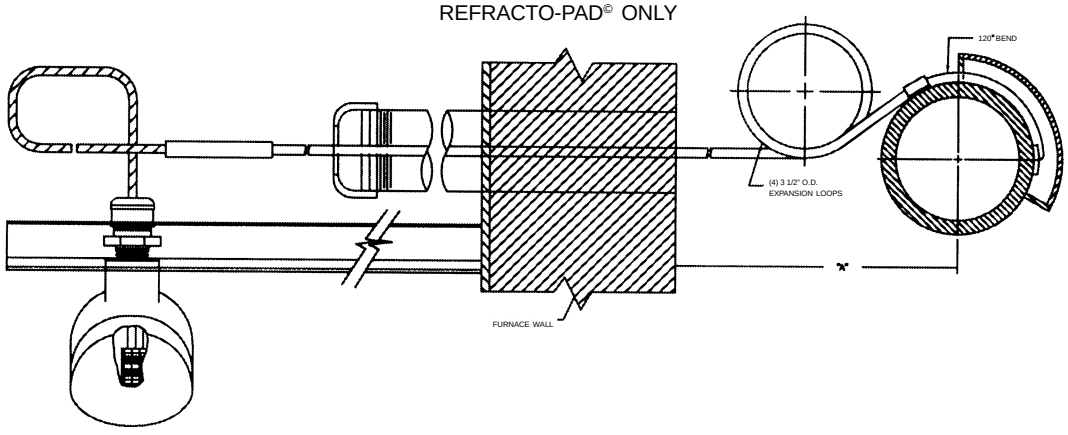
DRAWINGS & ROUTING





COMMON APPLICATION

REFRACTO-PAD© ONLY



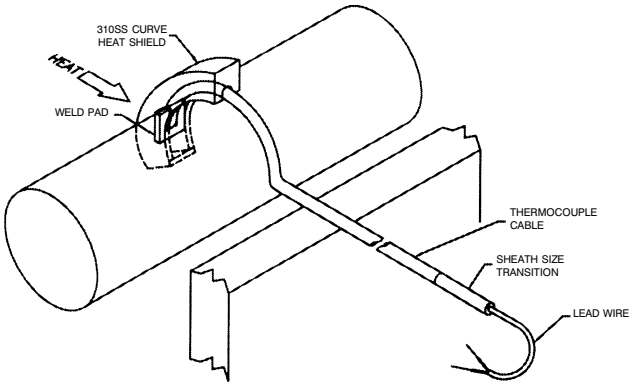
The
REFRACTO-PAD™
TUBESKIN THERMOCOUPLE ASSEMBLY

The
XTRACTO-PAD™
REPLACEABLE FURNACE TUBESKIN
THERMOCOUPLE ASSEMBLY

DRAWINGS & ROUTING

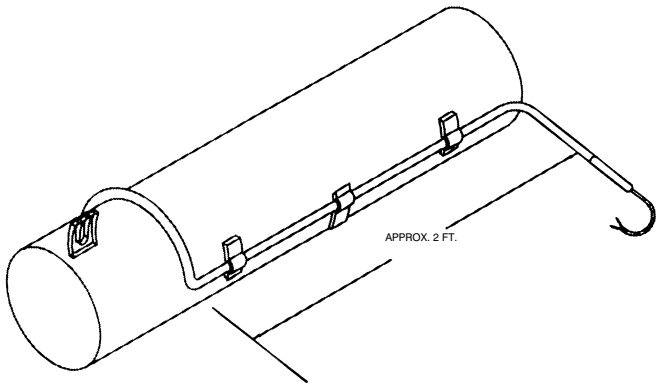
SHEPHERDS HOOK DESIGN

REFRACTO-PAD© ONLY



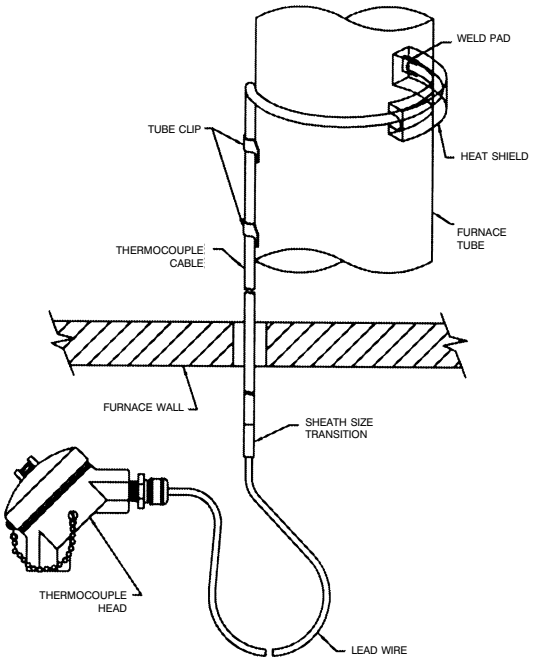
SIDE ENTRY DESIGN

REFRACTO-PAD© AND XTRACTO-PAD©



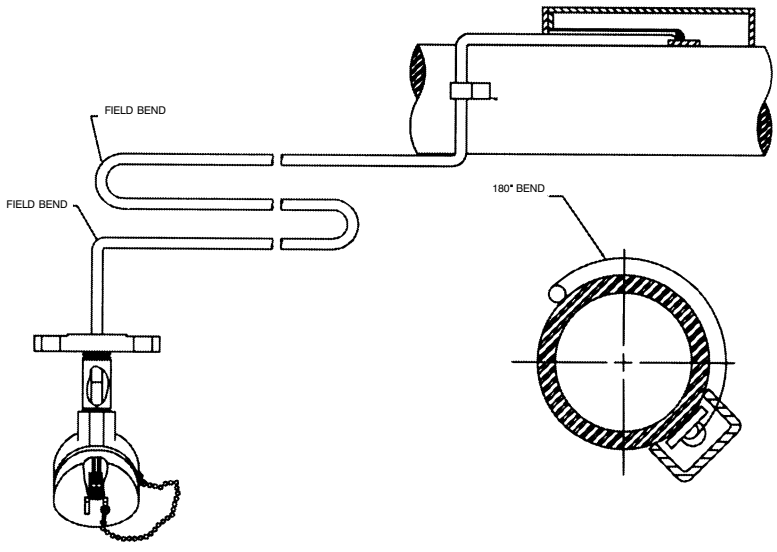
BOTTOM ENTRY DESIGN

REFRACTO-PAD© AND XTRACTO-PAD©



STRAIGHT HEAT SHIELD DESIGN

REFRACTO-PAD© AND XTRACTO-PAD©



Field Engineering & Installation Services by GAYESCO©

Company

GAYESCO® is one of the world's largest manufacturers of temperature measurement systems. With a 40 year history of engineering solutions to process control temperature measurement, an onsite engineering and design staff, and a 20,000 sq. ft. manufacturing facility located close to the Houston Ship Channel. Gayesco® is well positioned to respond quickly to your needs, on a worldwide basis.

Products

In addition to offering a complete line of thermocouples, thermowells, and RTDs, GAYESCO® has specialized expertise in reactor profiling and furnace tubeskin temperature measurement. GAYESCO® holds numerous patents in this area including the "FIex-R®", our flexible reactor temperature profiling system and the "XTRACTO-Pad™", our replaceable furnace tubeskin thermocouple.

Onsite Service

GAYESCO® offers many on site services to help our customers with their temperature measurement needs. The following items detail some of those services.

Engineering

GAYESCO® staffs an innovative team of electrical and mechanical engineering professionals who provide project design assistance following the various industry codes and standards. Our certified Professional Engineer heads the department.

Installation Supervision

GAYESCO® offers onsite startup supervision to ensure proper handling and installation of temperature measurement systems. Many customers have asked for GAYESCO®'s involvement from the initial shutdown planning stage to the final loop check.

Field Repair Services

GAYESCO® can help in repairing or modifying temperature measurement devices in the field. Typical field work includes troubleshooting, soldering, welding, and splicing.

Welding Services

GAYESCO® welders are qualified to ASME Section IX. Installation of "Refracto-Pad™" or "XTRACTO-Pad™" tubeskin thermocouple assemblies is one of GAYESCO® field service specialities. Since the service life of these assemblies is dependent upon proper installation, many customers have turned to us for assistance in this area.

Global

GAYESCO® services are offered world wide. We have provided onsite engineering, shutdown planning and installation services throughout the world.

Installation Services

GAYESCO® can provide all labor, training, and tools required for installation of our temperature measurement products. Our crew has extensive safety training and experience installing temperature measurement systems in all types of working environments.

Gayesco®'s Note

Our goal in providing these services is to give our customers the support they need from the initial design stage all the way through start up.

The

REFRACTO-PAD™

TUBESKIN THERMOCOUPLE ASSEMBLY

Installation Instructions

Installation of the GAYESCO® Refracto-Pad™ tubeskin thermocouple assembly can be completed in a few simple steps.

WARNING: DO NOT REMOVE REFRACTORY MATERIAL FROM HEAT SHIELD!

1. **Prepare the furnace tube for welding.**

2. **Place the thermocouple in position.**

3. **Weld the thermocouple to the tube using a *118"* fillet weld on three uninterrupted sides of the weld pad.**
4. **Place the heat shield over the thermocouple so that the thermocouple fits into the molded impression in the refractory and the heat shield fits flush to the tube. Again use a 1/8" fillet weld on three uninterrupted sides.**

WARNING: Placement of the shield is a critical dimension. Do not force heat shield on thermocouple. It should fit into the molded cut out.

5. **Tack welds are not acceptable. Welds must be continuous on three sides.**

6. **Refractory material must remain in heat shield to achieve specified accuracy.**

Installation of the Gayesco “Refracto-Pad” tubeskin thermocouple assembly can be completed in a few simple steps. Consult with Plant Metallurgist for correct or proper welding procedures. Contact the responsible person for required Inspection and Test.

STEP 1

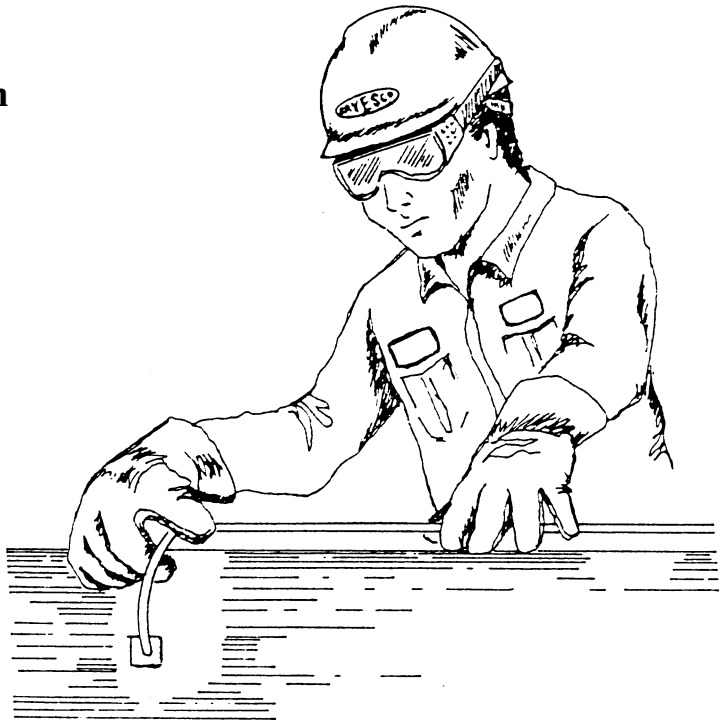
Prepare the furnace tube for welding. Refer to Steps 2, 4 and 5 for determining correct placement of weldable components.

Grind the surfaces of the furnace tube perfectly clean to bright metal, where welding is to be done - **DO NOT USE A WIRE BRUSH**. This should include the Weld Pad, Heat Shield and the location of the Tube Clips areas.

All scale and oxide must be cleaned from the tubes before attaching the thermocouple sheath. Grinding is preferred; wire brushing is insuficient.
.

STEP 2

Place the thermocouple with weld pad in position on the prepared surface.



The grinded areas shall be dye penetrate tested by the welding inspector. The COMPANY welding inspector shall check the tube thickness to determine if the tube is safe for further service (**if required**).

Locate thermocouple pad on the face of the tube subjected to the highest heat input (facing the burners) and 6” [150mm] longitudinally away from any old skin-point location and 12” [300mm] away from any tube supports.

STEP 3

Weld the thermocouple Weld Pad to the tube with a 1/8” fillet weld (continuous pass) on the three sides.

COMPANY inspector shall examine and verify the new locations before any welding is done(if required).

Install as per approved WPS orend-user standard practices.

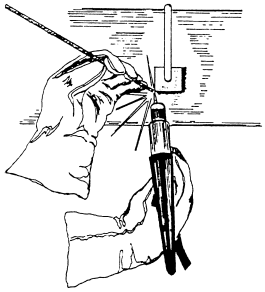
Make sure that the heat shield and thermocouple are spotlessly clean of all oil, cuttings, dirt or dust, as the presence of even the smallest amount of foreign material will impair the accuracy

Check the thermocouple contact with the tube surface The gap should not exceed 0.060 inches [1.5mm].

Weld the front end of the pad and then the sides to the tube, making only one continuous pass. Do not weld the end where the sheath leaves the pad.

Important! Welds must be continuous on three sides.

COMPANY welding inspector shall dye check for acceptance (if required). If dye check is required, it is acceptable to weld the tube clips (Step 5) prior to welding the heat shield (Step 4).



STEP 4

Weld the Heat Shield in position over the thermocouple with the closed end 30° (approximately ½” or 12.5mm) past the center of the Weld Pad. Sides of Heat Shield do not touch Weld Pad.

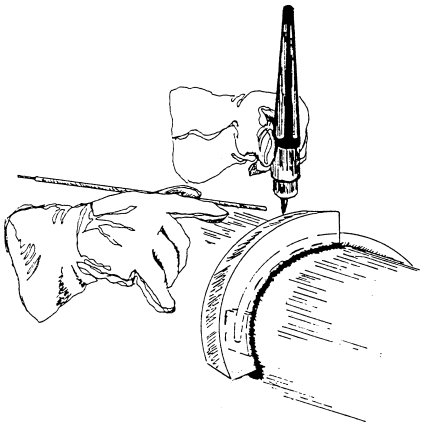
Heat shields on furnace skin points must never be installed empty.

GAYESCO’s Heat Shields are factory filled with high temperature ceramic fiber or with moldable insulation. If heat shield is not properly filled, it must be done before proceeding. Fill shield with high temperature ceramic fiber (KAOWOOL) insulation. Use of the moldable insulation recommended and provided by GAYESCO upon request.

Heat Shield must be centered on thermocouple Weld Pad and extend 30° (approximately ½” or 12.5mm) past the front end of the Weld Pad. The sides of the Heat Shield must NOT touch the edges of the Weld Pad.

Use a 1/8” [3.2mm] fillet weld to weld the Heat Shield to the tube on the front end, then the two sides making only one pass.

COMPANY welding inspector shall dye check the welds for acceptance (if required).



STEP 5
Weld Tube Clips on the prepared surface using a single pass fillet weld (ends only)

The thermocouple should be routed along shady side of tube (opposite side from the flame).

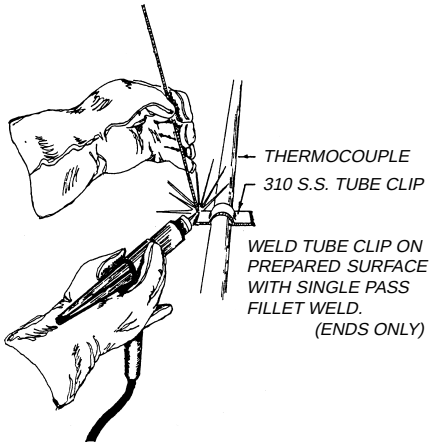
Use 310SS tube clips to secure sheath. DO NOT WELD THE CLIPS TO THE SHEATH.

Weld one end of the clip to the tube. Important! The thermocouple sheath must be under tube clip before final welds.

Weld opposite end of clip to the tube. Both ends of tube clip to be welded to the tube so the thermocouple sheath is held flush against the furnace tube. Refer to end-user Installation Drawings.

Weld additional clips as needed every 12” to 18” [300mm to 450mm].
Space clips at 12” minimum if gas temperature is 1850°F [1000°C] or greater, otherwise space clipsevery 18”.

The clips are installed to ensure the thermocouple sheath remains in contact with the furnace tube as the sheath is routed along the tube. The sheath should not bow away from the tube between tube clips.



STEP 6
Furnace Connection

Pack the TI exit orifice on the furnace wall with high temperature ceramic fiber (KAOWOOL) insulation to keep outside connections cool.
NOTE, THIS IS CRITICAL FOR TI RELIABILITY.

Mount TI head on a mechanical support. Do not mount connection head on the end of metal sheated TI. This will cause failure of the epoxy filled moisture seal. The critical area is approximately 2” [50mm] long.

Run the thermocouple lead to the TI head. To ensure that the transition temperature does not exceed 350 Deg F [175°C]. The transition should be approximately 6” [150mm] away from the furnace entry connection.

The

XTRACTO-PAD™

REPLACEABLE FURNACE TUBESKIN THERMOCOUPLE ASSEMBLY

Installation Instructions

Installation of the GAYESCO® Xtracto-Pad™ tubeskin thermocouple assembly can be completed in a few simple steps.

WARNING: DO NOT REMOVE REFRACTORY MATERIAL FROM HEAT SHIELD!

1. **Prepare the furnace tube for welding.**

2. **Place the thermocouple in position.**

3. **Weld the thermocouple to the tube using a *118”* fillet weld on three uninterrupted sides of the weld pad.**

4. **Place the heat shield over the thermocouple so that the thermocouple fits into the molded impression in the refractory and the heat shield fits flush to the tube. Again use a 1/8” fillet weld on three uninterrupted sides.**

WARNING: Placement of the shield is a critical dimension, Do not force heat shield on thermocouple. It should fit into the molded cut out.

5. **Tack welds are not acceptable. Welds must be continuous on three sides.**

6. **Refractory material must remain in heat shield to achieve specified accuracy.**

Installation of the Gayesco "Xtracto-Pad©" tubeskin thermocouple assembly can be completed in a few simple steps. Consult with Plant Metallurgist for correct or proper welding procedures. Contact the responsible person for required Inspection and test.

STEP 1

Prepare the furnace tube for welding. Refer to Steps 2, 4 and 5 for determining correct placement of weldable components.

Grind or sandblast the surfaces of the furnace tube perfectly clean to bright metal, where welding is to be done - **DO NOT USE A WIRE BRUSH**.
This should include the Weld Pad, Heat Shield and location of Tube Clip areas.

All scale and oxide must be cleaned from the tubes before attaching the thermocouple sheath. Grinding is preferred; wire brushing is insufficient.

The grinded areas should be dye penetrate tested by the welding inspector.

COMPANY welding inspector should check the tube thickness to determine if the tube is safe for further service ***(if required).***

STEP 2

Place the thermocouple with weld pad in position on the prepared surface.

Locate weld pad on the face of the tube subjected to the highest heat input (facing the burners) and 6" (150mm) longitudinally away from any old skin-point location and 12" (300mm) away from any tube supports.

COMPANY inspector should examine and verify the new locations before any welding is done ***(if required).***

STEP 3

Weld the pad with guide tube to the furnance tube a 1/8” fillet weld continuous pass on the three sides.

Install as per approved WPS or end-user standard practices.

Make sure that the guide tube/ weld pad, heat shield and thermocouple are spotlessly clean of all oil, cuttings, dirt or dust, as the presence of even the smallest amount of foreign material will impair the accuracy of the thermocouple.

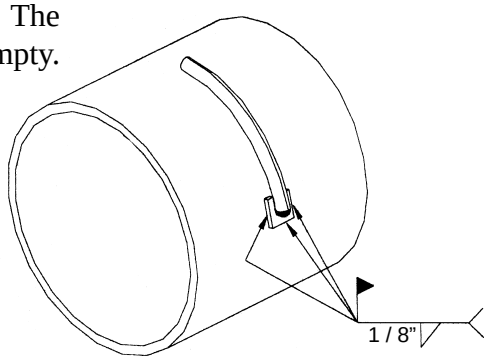
Tack weld the front of the pad first, then the sides. During fit-up, the gap between the mating parts should be kept to absolute minimum.

Check the guide tube contact with the tube surface. The gap should not exceed 0.060 inches *(1.5mm)*.

Weld the front of the end of the pad and then the sides to the tube, making only one continuous pass. Do not weld the guide tube. The guide tube open end to be empty.

COMPANY welding inspector shall dye check for acceptance ***(if required).***

If dye check is not required proceed to Step 4, heat shield or Step 5, tube clips.



Important! Welds must be continuous on three sides.

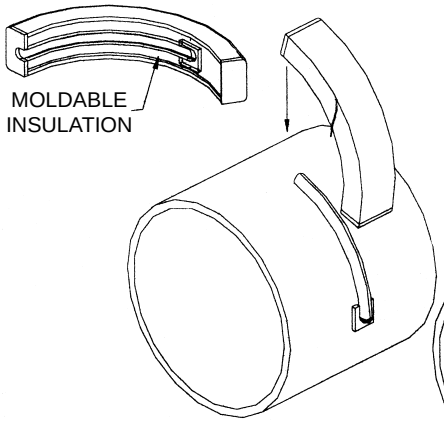
STEP 4

Place the heat shield in position over the guide tube/weld pad making sure the tube and weld pad fit into the molded impression of heat shield. If the heat shield does not have a molded impression, place the closed end 30° (approx. ½” or *12.5mm*) past the front end of the weld pad. NOTE, the sides of heat shield do not touch weld pad.

Heat shields on furnace skin points must never be installed empty. GAYESCO’s Heat Shields are factory filled with high temperature ceramic fiber or with moldable insulation.

If heat shield is not properly filled, it must be done before proceeding. Fill heat shield with high temperature ceramic fiber (KAOWOOL) insulation.

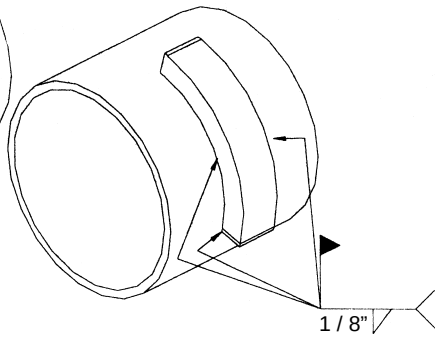
Use of moldable insulation recommended and provided by GAYESCO upon request.



Heat shield must be centered on guide tube weld pad and extend 30° (approx. ½” or *12.5mm*) past the front end of the weld pad.

The sides of the heat shield must NOT touch the edges of the weld pad.

Use a 1/8” *(3.2mm)* fillet weld to weld the heat shield to the tube on the front end, then the two sides making only one pass.



COMPANY welding inspector should dye check the welds for acceptance ***(if required).***

STEP 5
Weld tube clips on the prepared surface using a single pass fillet weld (one and only).

The thermocouple should be routed along cold side of tube (opposite side from the flame).

Use 310SS half tube clips to secure sheath. **DO NOT WELD THE CLIPS TO THE SHEATH.**

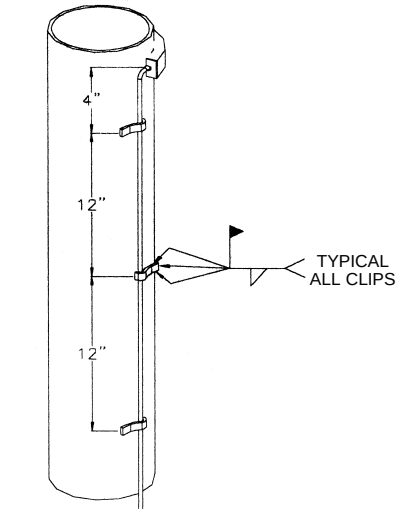
Weld one end of the clip to the tube. Clips should alternate (welded ends) on opposite side of sheath. See Detail "X"

Tube clip to be welded to the tube so the thermocouple sheath is held flush against the furnace tube.

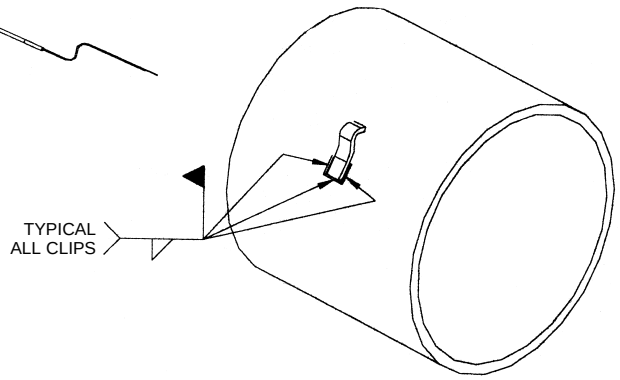
After tube clip welding and heat shield assembly is complete it is now possible to install the thermocouple (TI). When the thermocouple is under tube clips, use a small hammer to tap unwelded end of clip over top of sheath and against furnace tube. This should force thermocouple sheath into contact with furnace tube.

Weld additional tube clips as needed every 12" to 18" *(300mm to 450mm).*

Space tube clips 12" maximum if gas temperature is 1850°F *(1000°C)* or greater, otherwise space tube clips every 18".



Detail "X"



The tube clips are installed to ensure the thermocouple sheath remains in contact with the furnace tube as the sheath is routed along the tube. The sheath should not bend away from the furnace tube between tube clips.

COMPANY inspector should verify the tube clips are welded and spaced properly. ***(If required).***

Step 6
Furnace connection

Pack the TI exit orifice on the furnace wall with the high temperature ceramic fiber (KAOWOOL) insulation to keep outside connections cool. **NOTE, THIS IS CRITICAL FOR TI RELIABILITY.**

Mount thermocouple head on a mechanical support. Do not mount connection head on the end of metal sheathed TI. This will cause failure of the epoxy filled moisture seal. The critical area is approx. 2" *(50mm)* long.

Run the thermocouple lead to the TI head. To ensure that the transition temperature does not exceed 350°F *(175°C)*. The transition should be approx. 6" *(150mm)* away from the furnace entry connection.

GAYESCO® TUBESKIN THERMOCOUPLE COMPARISON

Test Site - Midwestern Refinery Crude Furnace

Purpose

The purpose was to obtain data comparing the XTRACTO-Pad™ tubeskin thermocouple assembly, with moldable insulation in the heatshield, with a known standard. The standard will be a GAYESCO® Refracto-Pad™ tubeskin thermocouple with the standard Kaowool® insulation and a spot welded bare wire thermocouple which will use the furnace tube as it's measuring junction.

Procedure

The tubeskin thermocouples were installed as part of the refinery's standard turnaround. Three sets of XTRACTO-Pad™, Refracto-Pad™ and bare wire thermocouples were placed in close proximity (approx. 9" apart) on three different 6 5/8" O.D. tubes. Each thermocouple was routed out of the furnace and enough extension lead wire was provided to read the thermocouples at a central location (at grade). Readings were recorded for a period of two days using a Fluke 2635A Data Bucket.

Results

The attached tables and graphs indicate data that was obtained while operating the furnace in the 1100 to 1200 degree F tubeskin temperature range, followed by a cool down to around 700 degrees F. One of the bare wire thermocouples (Point 15) was lost on start up. As the furnace was being operated at a constant firing rate, all thermocouple readings within each set tracked at or very near the same reading. As the firing rate was increased or decreased, the bare wire thermocouples responded to the change much faster than either the Refracto-Pad™ or the XTRACTO-Pad™ design. This is to be expected due to the small mass of the measuring junction on the bare wire thermocouple relative to the other designs. Once steady state was achieved, all thermocouple readings were once again at or very near the same temperature. In nearly all cases, the new XTRACTO-Pad™ design with the moldable insulation provided readings that were equal to or just slightly higher than that of Refracto-Pad™ design.

TUBESKIN THERMOCOUPLES

by

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This paper discusses Chevron's experience with tubeskin thermocouples. The broad temperature range of common interest spans two distinct problem areas.

In "garden-variety" process furnaces, the main problems are accuracy, reproducibility and occasional failures. By contrast, in the higher-temperature pyrolysis furnaces, primary ammonia reformers and steam reformers, the real headache is getting the thermocouples to survive at all.

This paper will discuss Chevron's investigation of the former problem, as well as our view of today's best answer to process furnace tubeskin temperature NiCroSil assemblies in steam reforming furnaces.

INTRODUCTION

Thermocouples placed on the outside of furnace tubes warn against overheating. In order to perform this function, they must accurately reproduce the actual tube surface temperature.

Problems relate to longevity and placement. No matter how cleverly designed, the thermocouple is useless as soon as it fails, for whatever reason. Most so-called "thermocouple failures", however, are really lead failures.

The leads must be taken out of the furnace with the least possible exposure to radiation and flame. Often they are clipped to tubes to afford as much protection as possible en route from the combustion zone. The best path is determined by common sense.

The location problem is really twofold. First, the hottest spot on the furnace tube can't measured if there is no thermocouple there. Tubeskin thermocouples must be placed where the tubes are expected to be hottest, based initially on process design conditions and later on observations of the furnace in operation. If none were provided in such places in the initial installation, thermocouples should be retrofitted to locations that are observed to get hot.

Chevron requires at least three tubeskin thermocouples per pass: normally, one or more on the outlet tubes, as these are usually the hottest. A method of predicting furnace tube hot spots due to direct flame radiation is used. In vertical cylindrical furnaces with burners on the floor, for example, hot spots are usually found about one-third of the way up in the radiant section of the outlet tubes.

The second location problem is the circumferencial temperature variation. The temperature on the "shady" side of the tube away from the flames is 50° to 1500° F lower than on the side facing the fire. It is poor practice to put the thermocouple on the back side of the tube, away from the fire.

BACKGROUND

Chevron's investigations of the accuracy of tubeskin thermocouples date back many years. In 1935, a study reported that the old "Socal Standard" thermocouple (Fig. 1) read 30° to 60° F higher than the actual temperature.

Thereafter, there was a great deal of interest in the swaged magnesia “Welding-pad” type of tubeskin thermocouple(Fig. 2). Through 1970, over a dozen different Chevron tests compared the Welding-Pad with the Socal Standard. The collective results suggested that the Welding-Pad read 400° to 1000° F higher than the Socal Standard. Still other Chevron comparisons indicated that Welding-Pads read about 250° to 125°F higher than the actual temperature.

From all of this, the only firm conclusion that could be reached was this: of the two types of tube skin thermocouples commonly used, those properly installed generally read high by something like 30° to 1500° F. Small wonder that Chevron had no generally accepted, “best” tubeskin thermocouple.

The Socal Standard had been used “successfully” for years. It was long-lasting. Everybody knew it read high, but nobody knew by how much.

The craftsmanship necessary for installing the Socal Standard was becoming increasingly hard to find. Improper installation had even led to tube failure at the point of attachment.. .which can be likened to “catching the cure and dying.”

There seemed to be a number of other promising designs; and in 1975, Chevron undertook to resolve this dilemma with a comprehensive test program.

THERMOCOUPLE TYPES

Thermocouples can generally be classified as unshielded, shielded, and shielded with a refractory-filled shield. The Welding-Pad is an example of the unshielded type, and the old Socal Standard was an example of the shielded type.

Other examples of each of these types of thermocouples are shown in Fig. 3 and Fig. 4 and 5. Also shown (Fig. 6) is the method of installing peened thermocouples, which are not rugged enough for refinery service, but provide an accurate measurement of the tubeskin temperature for comparative purposes during short test periods.

Not surprisingly, we learned that others in the industry had investigated the thermocouple skin point question. Based in part on the favorable experience of others, we judged the refractory-filled shielded type “A” (Figure 5) to be a promising candidate. Still needed was a side-by-side comparison test with accurate but fragile peened thermocouples, and other rugged, commercially available alternatives.

DIRECT COMPARISON TEST

A direct comparison test was carried out in an operating furnace. A variety of commercial thermocouples, together with peened reference thermocouples, was arrayed on a single tube in close proximity. The test array and typical results are shown in Figure 7.

A test confirmed that the refractory-filled shielded type “A” (Figure 5) gave accurate readings. The “knife-edge” configuration was about 30° F high, and Welding-Pad about 40° F high, not quite as high as historical tests might lead us to expect. In this test, however, the unshielded thermocouples may have been made to look a little better because they were not exposed to direct flame radiation.

FIELD EXPERIENCE

Since standardizing on the refractory-filled shielded type “A” thermocouple assembly in 1978, Chevron field experience has been excellent. Both new construction and retrofit installations are confirming the type “A” thermocouple’s longevity, which had already been experienced by other major refiners.

One special operational note deserves emphasis. With older skin point designs, we have occasionally said something like, “Don’t worry about moderately high skin points. They always read high, anyway.” Type “A” does NOT read high!

Many type “A” thermocouple assemblies have been retrofitted into older furnaces, either replacing failed skin points or augmenting the existing pattern. All of our experience has been good, with the exception of the occasional lead failures.

For example, in an older arbor-type catalytic reformer furnace, 100 type “A” assemblies were installed. At or shortly after start-up, 20 percent “failed.” This attrition is not unusual, in view of the difficulty of protecting the leads from the flames in this type of furnace.

In furnaces with wall-hung tubes, it’s easy to extract the leads by running them around the tubes and out the back, away from the burner flames and directly through the furnace wall. But in a furnace like the double-arbor reactor preheat section of a catalytic reformer furnace with tubes hung in the middle of the firebox, it is not so easy. In such a furnace, the best route out of the firebox is to clip the thermocouple leads to the radiant tubes and run them straight down and out the floor. (We learned that the hard way.. .it’s what we didn’t do in the case cited.)

NISIL-NICROSIL ASSEMBLIES

More recently, we have been told that the traditional Chromel-Alumel thermocouple assemblies suffer “metal structure changes” and consequent “calibration failures” when they cycle through temperatures around 900° - 1000° F. That is exactly the range in which our “Rheniformer” furnaces operate, and we do have problems, getting maybe only four years of average service from type “A” thermocouples in these furnaces.

This brings me to NiSil-NiCroSiI. This “new” thermocouple material pair evidently was originally developed as an answer to that mid-range cycling problem. But we have found that NiSiI-NiCroSil assemblies have good staying power in several of our steam reforming furnaces, in which the costly alloy tubes typically run at 1700°-1800° F.

We do not have extensive service experience under our belts, as yet. But thus far (discounting infant mortality), we are getting temperature indications that are close to optical pyrometer measurements, as well as service life in excess of one year.. .about a year longer than ever before. We intend to continue testing these promising high-temperature thermocouple assemblies.

CONCLUSION

In summary, test experience since 1935 with the old “Socal Standard” and other thermocouple assemblies in common use showed that properly installed tubeskin thermocouples generally read high by up to 150°F. On the other hand, they were often placed on the back (“shady”) side of the tube, away from the fire, where it is cooler by up to 150°F. To some extent, these errors balanced one another, but nobody knew to what degree this was so.

Type “A” thermocouple assemblies, properly placed on the side of the tube that faces the fire, accurately reproduce the actual tubeskin temperature, and they last a long time. Today, Chevron regards type “A” as the best answer to furnace tubeskin measurement in “garden-variety” process furnaces.

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