



**Preparation of the Claus Thermal Reactor Vessel  
for Installation of  
The HTP Series Claus Reactor Thermocouple  
Refractory Installer Instructions**

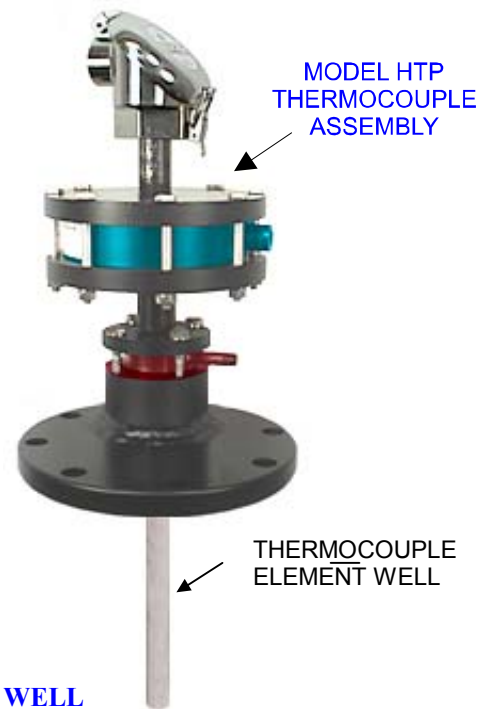
**For 2" S80, 50mm, Up Thru 3", S160, 80mm, flange Mounted Nozzles  
Nozzle ID from 1.9" (48mm) Up Thru 2.65" (88mm)**

The purpose of the Delta Controls **HTP Series Thermocouple** is to provide the operator with a reliable and accurate means of measuring the reactor temperature. A Claus Thermal Reactor probably represents the most severe and demanding temperature measurement application in all of heavy industry. Not only are the operating temperatures reaching nearly 3000°F (1650°C), but the corrosion and operating conditions are severe as well.

In spite of these conditions, failure of the **HTP** is rarely due to either the temperature or corrosion. Improper installation remains the primary reason for operational problems. Improper installation usually results from failure to follow the installation guidelines.

This document is intended to inform the vessel designer and refractory contractor of the proper installation techniques.

Note: See document #00-HTP48 for larger basic size nozzle installations.



**HRW 4&5 REFRACTORY WELL**

<b>Installation Position</b>	
1	The <b>HTP</b> should be installed in the vertical position on the top centerline of the vessel.
Reason	<p>A claus thermal reactor refractory lining has an expansion/contraction coefficient different from the reactor's steel shell, which supports the Delta Controls <b>Model HTP Thermocouple</b>. As the reactor is brought up to operating temperature, the refractory shifts relative to the vessel shell, to which the <b>HTP</b> is rigidly connected. The potential damage to the HTP element caused by movement of the refractory relative to the vessel shell (primarily the "shear" axis movement) is minimized by mounting the nozzle/HTP on the top centerline area of the reactor.</p> <p>Relative refractory movement is at a minimum on the vertical centerline of the cylindrical reactor vessel. During the expansion, contraction, and aging of refractory materials, bits and pieces break off and become dislodged. In a vertical installation, these "bits and pieces" tend to fall harmlessly down and into the vessel. However, in a horizontal installation, they fall on the <b>Refractory Well</b>, accumulating around the lower side of it. This creates pressure points, allowing subsequent expansion/contraction cycles to fracture the well.</p>

<b>Entrance Nozzle Size and Type</b>	
2	A 6-inch (150mm) nozzle size flange is recommended. However smaller sizes can be accommodated. ANSI 3" and smaller size flanged mounting nozzles require that the refractory well collar be recessed below the inside surface of the vessel shell. The small nozzle sizes range from 1.9" (48mm) up to 2.65" (88mm) inside diameter.
Reason	<p>Installation of the <b>HTP</b> in a Claus Thermal Reactor requires the use of the <b>HRW 4 or 5 Refractory Well</b> that fits into and rests on the vessel refractory. The small <b>Refractory Well</b> is 1.5" (38mm) O.D. and utilizes a 1.75-inch (45mm) O.D. collar which supports it from the bottom of the recessed hole on the top face of the refractory and holds it at the proper elevation. A 1.9" (48mm) minimum size I.D. nozzle affords enough space to install the proper amount and kind of insulation necessary to protect the nozzle and shell from excessive heating.</p> <p>The small-size refractory well collar must not come into contact with the I.D. of the nozzle as the refractory liner moves relative to it. Such an occurrence will break the refractory well. This requirement is met by providing a recess large enough for the refractory well collar to drop into and be below the inside surface of the vessel shell. The collar does not contact the nozzle/shell during movement, and adequate room for insulation to protect the nozzle is provided.</p>
<b>3 Height of the Nozzle</b>	
Reason	<p>The nozzle should stay hot to prevent condensation of water and sulfur. Tall nozzles, installed to get the HTP above the rain shield, are counterproductive.</p> <p>The HTP lower body can withstand 600°F (300°C) and the top chamber can withstand 400°F (200°C) continuously. Tall nozzles, e.g. 12" to 16" (300 to 450mm) cause the sensing element to be overly long; the nozzle to be too cool; the cost to be higher, and the HTP to be more difficult to install.</p>
<b>Refractory in the Nozzle</b>	
4	No refractory should be inside the nozzle. No refractory (or mortar) should protrude up into the nozzle above the top surface of the refractory liner.
Reason	<p>Refractory in the nozzle defeats a major advantage of the Delta <b>HTP</b>. The combination of the <b>Refractory Well, Woven Mineral Discs</b> and <b>Pressed Mineral Discs</b> are key to realization of the long life expectancy and good value of the <b>HTP</b>. If refractory material protrudes up into the nozzle above the bottom of the vessel shell, there is not adequate clearance for the <b>Refractory Protective Well</b> and the nozzle insulation to do their job.</p> <p>If, through movement of the refractory, the <b>Element Well</b> contacts the <b>Refractory Well</b>, it is probable that one or both wells will be broken. This will cause subsequent failure of the thermocouple element due to corrosion from the reaction gases.</p> <p>Lining the nozzle wall with castable also creates a smaller I.D. in the nozzle and limits the effectiveness of the insulation pieces that allow the refractory to move without damaging the ceramic components of the <b>HTP</b>. The Delta <b>Model HNP</b> insulation components have proven to provide adequate insulating properties while minimizing space for sulfur to precipitate into a solid. Solid sulfur acts like castable and can also cause mechanical damage to the <b>HTP</b> components.</p>

Use of the Casting Mandrel	
5	Use of the HRM mandrel, during the time that the vessel is being lined or relined, produces a correct refractory surface and bore hole.
Reason	<p>Proper installation requires that a 1.6 inch (41mm) hole must be created thru the refractory. The hole must be on the centerline of the nozzle, and must be perpendicular to the nozzle flange face. A 1.8 inch (46mm) by 1.0 (25mm) deep recess must also be created in the refractory on the centerline of the nozzle to receive the well support collar.</p> <p>The Delta Controls <b>Model HRM Installation Mandrel</b> provides an effective and accurate means to create the proper cavity and hole for installation of the <b>HTP</b>. To insure the proper clearances between the <b>Element Well</b> and the <b>Refractory Well</b>, it is necessary that the components be installed on the nozzle centerline, at the design elevation, and perpendicular to the face of the mounting flange. The <b>Mandrel</b> is equipped with a "<b>Stop-Disc</b>" that is required when the vessel is lined with refractory. It prevents refractory material from entering the base of the nozzle and upsetting the clearance between the bottom of the <b>Element Well</b> and the inside bottom of the <b>Refractory Well</b>. The "<b>Stop-Disc</b>" creates a concentric recessed hole for the collar of the <b>Refractory Well</b> to rest against. It also prevents any pressure point loading on the collar/tube.</p>
Disadvantage	The <b>HRM</b> mandrel must be installed before the refractory lining process is begun. The mandrel must protrude down inside the reactor. It must extend 1" (25mm) or more beyond the future position of the refractory hot face. The protruding mandrel is somewhat bothersome to the installation crew. They generally consider the <b>HRM</b> too much of a hindrance and prefer to drill the hole after the lining is complete. Drilling is equally effective, if properly done.

Preparing For Drilling of the Refractory Hole	
6	The cold face of the refractory liner must be flat and at 90° to the centerline of the mounting nozzle. See "Mandrel" above for a detailed explanation.
Reason	An <b>HRS</b> refractory stop must be installed in the mounting nozzle before the lining crew begins work. The <b>HRS</b> prevents refractory from entering the nozzle and also leaves a flat refractory face after the lining has been installed
Advantage	The <b>HRS</b> does not protrude into the reactor and is not considered to be a hindrance by the refractory installation crew .

7	
<b>Preparing The Mounting Nozzle before drilling</b>	
Excess welding bead, slag, etc. can be on the inside surface of the nozzle	
Reason	<p>Many mounting nozzles, particularly field installed ones, have inside surfaces that must be smoothed up before drilling begins. The drill bit bearings use the nozzle ID as a guide to insure that the drilled refractory hole is on the centerline of the mounting nozzle. "Rough" places are commonly the result of burning the entrance hole through the reactor shell, excess weldment deposited when installing a weldneck flange etc.</p> <p>This problem is solved by putting the "NSO" tool on the drill/water swivel and cutting out the large irregularities from the nozzle ID.</p>

Drilling the Hole Thru the Refractory	
8	Drilling may be used to create the hole through the refractory. Some installers believe that it is easier to drill the hole than to install refractory around the mandrel, which protrudes down into the vessel. An HRG Drill Unit must be used if the drilled hole is to be straight, and properly located on the centerline of the mounting nozzle.
Reason	<p>Drilling through a nozzle commonly creates an "off-center" bore and misalignment relative to the flange face. This occurs because it is nearly impossible to <b>manually</b> establish and maintain accurate alignment of the drill assembly, particularly when starting the core drill. Taller nozzles intensify the difficulty and lower the probability of obtaining a proper result to near zero.</p> <p>If the <b>HTP Thermocouple</b> is to be installed through existing refractory, then drilling is the only means available to create the required bore hole. In this case, it is necessary; to put the hole on the exact centerline of the nozzle and drill at 90° to the face of the mounting flange.</p>

Reason	<p>This can be reliably done by using the HRG Drill System. It utilizes the nozzle it self to guide the diamond refractory drill bit. This system provides a good reference that holds the refractory drill precisely on the centerline of the nozzle and at 90° to the flange face. The diamond core bit has two sleeve bearings which keep it running on the centerline of the nozzle.</p> <p>The drill bit bearings utilize the nozzle ID as a positioning race. It is necessary that the nozzle ID be relatively smooth and free of slag and irregularities.</p> <p>A nozzle ID smoothing cutter tool is provided to remove excess weld, trim slag, and other impediments from the inside the nozzle wall. The NSO has carbide cutters and is connected to the water swivel and drill motor. Open the water valve while the nozzle is being smoothed and prepped.</p>
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<b>Checking the Work</b>	
9	<p>It is necessary to verify that the refractory work is suitable for the proper installation of the <b>HTP</b>. Check the dimensions to be sure that they are correct, that there will be no interference between system components, and that spacing is correct. This will help ensure that no failures occur due to movement of the refractory, or from interference between components.</p>
Reason	<p>If the refractory work results in improper dimensions or misalignment of the bore, the <b>HTP</b> components are likely to fail as the vessel is brought on line and movement of the refractory begins, even if the HTP/well could be put into the hole.</p> <p>Steps to verify that the installation was properly performed:</p> <ol style="list-style-type: none"> <li>1. Check the through and recess hole sizes and other dimensions for correctness.</li> <li>2. Assure that the bottom surface of the recess hole is smooth, flat and 1.0 inch (25mm) deep. If it is uneven, the “bumps” must be removed. The top of the well collar must be below the bottom surface of the vessel shell. Use of the <b>Casting Mandrel</b> with the “<b>Stop-Disc</b>” during the initial lining or relining of the reactor should have produced a correct hole and recess.</li> <li>3. If the refractory was removed by drilling: <ol style="list-style-type: none"> <li>A. Place a bright light in the vessel directly below the thru-bore and observe that the thru-bore is clean with no protrusions. Also, using the light, observe the alignment of the bore relative to the centerline of the vessel nozzle. All diameters should be concentric to each other.</li> <li>B. Check that the thru-bore and recess hole diameters is 1.56”(40mm) for 2 inch nozzles; OR 2.18(55MM) FOR 3-inch nozzles.</li> <li>C. Check that the top recess hole is 1.85(47mm) for 2-inch nozzles; or 2.56(65mm) for the 3-inch nozzles.</li> </ol> </li> </ol> <p>Note: If access to the interior of the reactor cannot be obtained; then careful measurements can be used to verify that the hole and recess are proper.</p>

This document is intended only for the purpose of informing the refractory installation personnel of the key elements of the correct preparation of the vessel and refractory for installation of the **HTP**. Complete Instructions for installation of the **HTP** are contained in document 00-HRW03, which is available from Delta Controls.

Installation of the **HTP** should not be attempted without studying and following the detailed installation instructions contained in Document 00-HTP03.DOC.

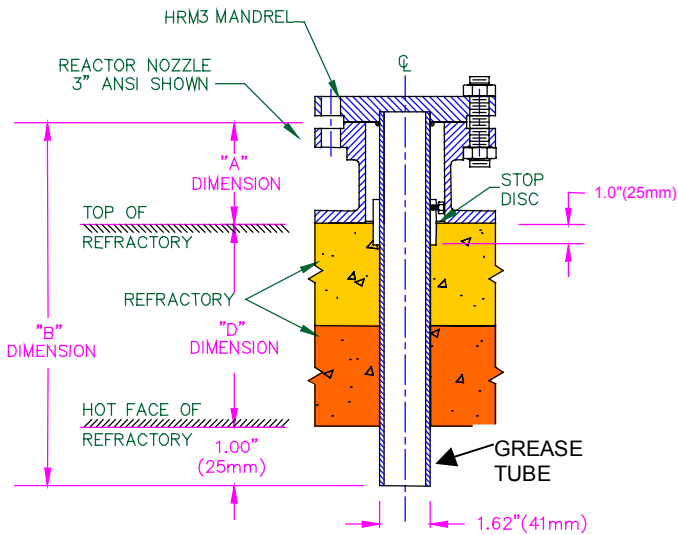
Please consult Delta Controls if any questions arise relative to the installation of the **HTP**. Proper installation and operation will provide maximum protection for the vessel/lining, and will result in a long and effective life for the **HTP** temperature sensor.

# CREATING A REFRACTORY HOLE BY USING THE HRM CASTING MANDREL

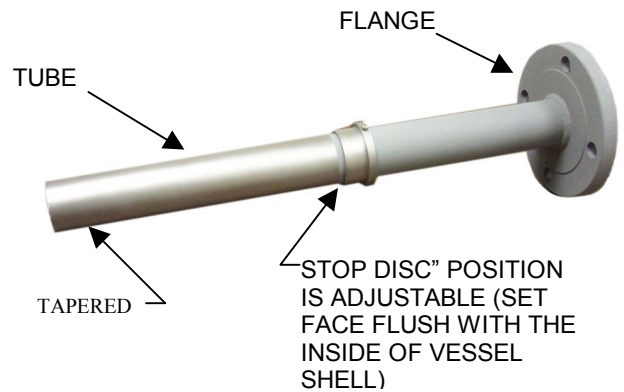
The HRM is used to create a completely aligned and centered hole, of the correct diameter, through the refractory lining of a Claus Thermal Reactor. A tapered tube, which has been greased, prevents the refractory from sticking to the mandrel tube and makes the arm easy to extract.

Low cost, as well as good results for the owner are achieved when the Delta HRM is used during the refractory installation process. Perfectly aligned holes of the right size are easy to produce with the Delta HRM Refractory mandrel.

Note that the tube does stick down into the reactor shell. It does somewhat obstruct access during installation of the refractory. Some installers consider this to be objectionable and prefer to drill the hole after the lining is installed.



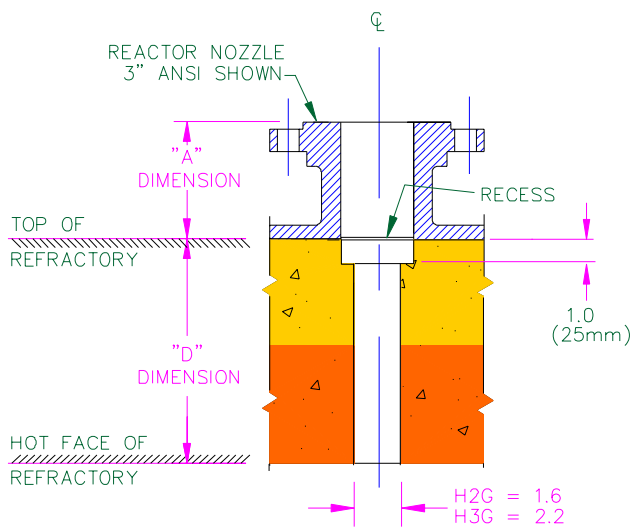
SHOWN BEFORE MANDREL IS REMOVED



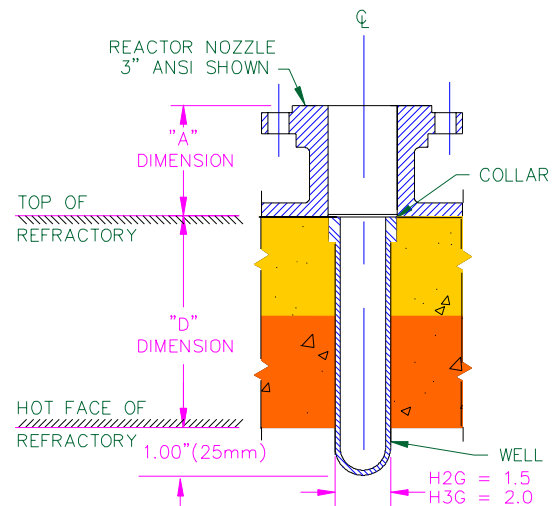
HRM MANDREL WITH 3\"/>

## FINAL RESULT

Either casting or drilling can produce the same desired result. The requirement is a concentric hole on the centerline of the mounting nozzle.

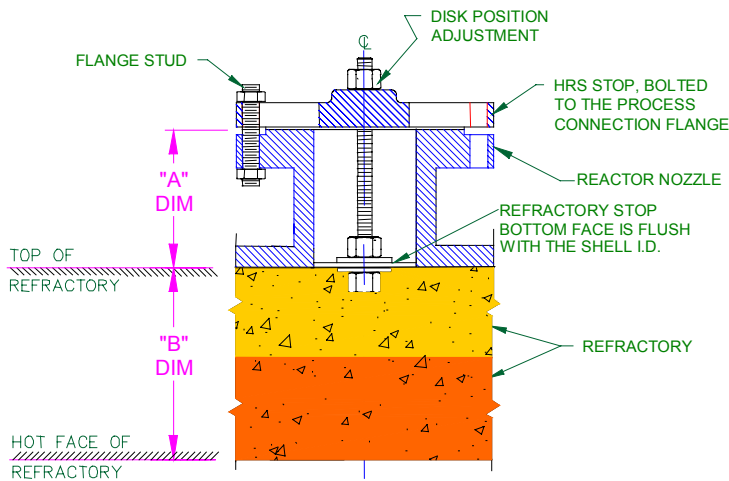


SHOWN WITH ENTRANCE HOLE COMPLETED

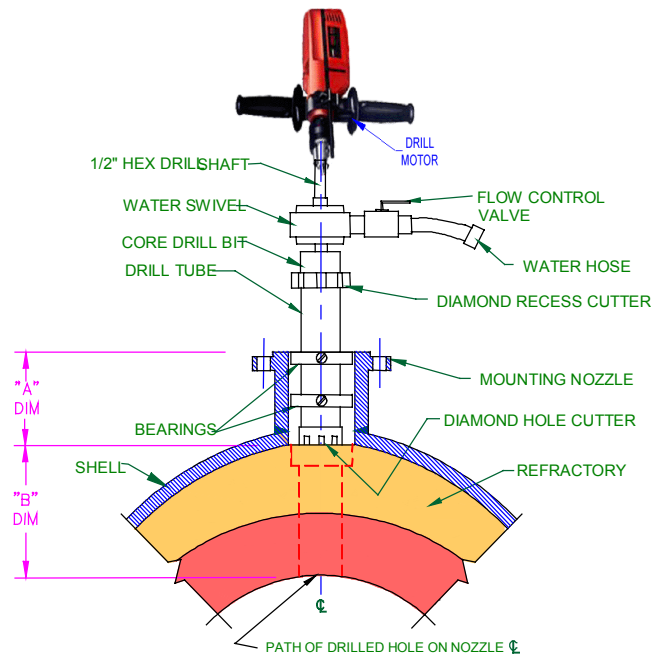


SHOWN WITH HRW WELL INSTALLED

# CREATING A REFRACTORY HOLE BY DRILLING WITH THE H2G/H3G DRILL



HRS REFRACTORY STOP IN PLACE



H2G/H3G DRILLING UNIT

Generally, refractory installers prefer to drill the bore hole through the refractory instead of using the casting mandrel. The common objection is that the mandrel requires that the refractory fire brick be cut and fitted around the mandrel tube.

It has been found that creating a "drilled hole" that is on-center, straight, uniform and of the proper bore size is difficult, in fact, nearly impossible, to achieve with hand held techniques. A correct hole is even more difficult to achieve properly when the nozzle length is long. Boring an incorrect hole through the refractory is very likely to cause the thermocouple assembly to become broken during installation or by shifting refractory, which will result in early thermocouple failure. Also, once an improper hole is cut through the refractory, it is very difficult, expensive, and time consuming to correct it.

The first step is to run the NSO smoothing cutter down through the nozzle. This cutter removes weld beads, slag etc. from the inside surface. A smooth inner surface is necessary to provide a guide and position race for drill bearings. Delete this step if the nozzle is smooth and clean.

The second step is to install an HRS refractory stop on the mounting nozzle before the refractory lining is installed in the reactor. The HRS prevents refractory from getting up into the nozzle. It also produces a flat smooth face on the refractory surface at the bottom of the nozzle. This allows the core drill bit to easily start straight and provides a smooth surface for the HRW refractory well to rest on.

The third step is to remove the HRS after the lining job is complete. Replace it with the HRG drilling unit. The drill bit is equipped with two separate cutters; the lower cutter produces the hole through the refractory. The upper cutter produces the recess needed for the well support collar.

Two sleeve bearings are located on the core drill bit. These slide against the inside of the mounting nozzle. The drill bit is kept aligned and produces a straight hole on the centerline of the mounting nozzle.

Attach a heavy duty variable speed drill motor to the shank of the drill bit. Start the flow of water. Turn the drill bit at speeds of 50 to 600 rpm, depending on the hardness of the refractory material. The resulting finished hole should be straight, smooth, and concentric with the centerline of the mounting nozzle.

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