Kiln Tracker®

GENERAL SYSTEM USER MANUAL

for use with

insight software

Issue 1

MA5020A

DATAPAQ®

A Fluke Company

Kiln Tracker®

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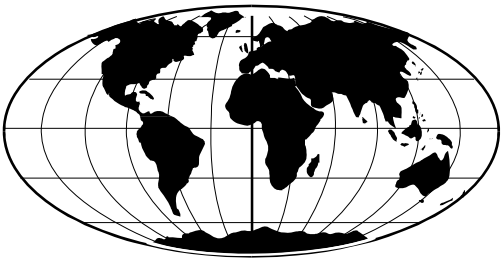

Datapaq is the world's leading manufacturer of process temperature-monitoring instrumentation. The company maintains this leadership by continual development of its advanced, easy-to-use Tracker systems.

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DATAPAQ PART NO. MA5020A

User manuals are available in other languages. Contact Datapaq for details.

SAFETY WARNINGS

For safe use of Datapaq equipment, always:

- Take care to follow its supplied instructions.
- Observe any warning signs shown on the equipment itself.

Indicates **potential hazard**.

On Datapaq equipment this normally warns of high temperature, but where you see the symbol you should consult the manual for further explanation.

Warns of **high temperatures**.

Where this symbol appears on Datapaq equipment, the surface of the equipment may be excessively hot (or excessively cold) and may thus cause skin burns.

CONTENTS

Introduction

Permanently installed fixed point thermocouples provide a useful, but localized indication of kiln temperature. They do not reflect temperatures as experienced by the product. The Datapaq® Kiln Tracker® system provides an effective solution to the difficult, but essential task of profiling both product *and* kiln temperatures during normal operation.

The Kiln Tracker system hardware comprises thermocouple temperature probes, a data logger and a special thermal barrier. This combination results in a self-contained data acquisition system which is able to travel through the kiln, monitoring product and ambient temperature, without trailing cables.

The easy to use Windows™ based software provides powerful sophisticated analytical tools, operating as both a quality inspection tool and an investigative diagnostic tool. In the Inspection role it allows comparison of current temperature characteristics with previously stored reference and target curves to detect operating abnormalities. In the Diagnostic role its innovative analysis techniques help to identify problems, fine tune the process, and reduce running costs.

Although generally used for continuous processes, systems are also available for intermittent or periodic kilns.

This manual contains information for all Datapaq Kiln Tracker system users from novice to experienced and is generally applicable to all Kiln applications. The chapters relevant to you depend on your knowledge of the system, and the information you require.

Thermocouples – Information on the types of thermocouple used for the various kiln applications.

Thermal Barriers Principles – describes the phased evaporation system used in the kiln range of barriers and its advantage over traditional barrier technology.

Tunnel Kiln Thermocouples – describes the thermocouples specific to tunnel kiln applications.

Tunnel Kiln Barriers - Information on the performance characteristics of the phased evaporation barriers used in tunnel kilns.

Tunnel Kiln Process - describes the process of setting up and conducting a test, including:

- The placement of the system, including the probes
- Measuring under car temperatures
- Installing the barrier and logger
- Installing the thermocouples
- Filling the barrier with water
- Running a trial

Recovering the System Tunnel Kilns - describes how to remove the system after the test and download the information from the data logger.

Roller Hearth Barriers - Information on the performance characteristics of the phased evaporation barriers used in roller hearth kilns.

Roller Hearth Kiln Process - describes the process of setting up and conducting a test, including:

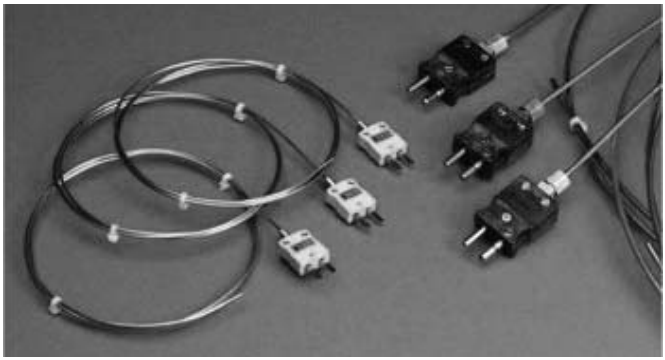
- Selecting the thermocouples
- Checking the height restrictions
- Installing the barrier and logger
- Installing the outer blanket
- Installing the thermocouples
- Running a trial

Recovering the System Roller Hearth Kilns - describes how to remove the system after the test and download the information from the data logger.

Troubleshooting and **Care and Maintenance** - provides practical advice on faultfinding, and looking after your system.

Thermocouples

Thermocouple probes utilize the Seebeck effect which, discovered in the 19th century, results in a voltage proportional to temperature being developed at the junction of any two dissimilar metals.



Roller hearth (left) and tunnel kiln (right) type K thermocouples.

The actual voltage measured is proportional to the temperature difference between the thermocouples "Hot" and "Cold" junctions (the "Hot" junction being the measurement junction, and the "Cold" junction being the junction of thermocouple and measurement instrumentation).

The practical implementation of thermocouples requires sophisticated electronics to eliminate potential measurement errors. These potential errors include poor linearity over the measurement range, and inaccuracy due to temperature variations at the "Cold" reference junction. To accommodate them the electronics in the measuring system must simulate a temperature of zero degrees at this second junction, as well as compensating for any non linearity over the operating range of the thermocouple.

Detailed view of thermocouple hot junctions.

Over the years, "standard" thermocouples have been developed using materials chosen for sensitivity (voltage change per temperature change), linearity, (consistency of sensitivity over the useful temperature range), price and availability. Current standards include types K, N, R, S and B, each type being identified by the color of its connector.

Thermocouples Supported by Datapaq Systems

Probe Type	Typical Application	Previous Plug/Socket Color	IEC Plug/Socket Color
B	Kiln	White	Grey
K	General purpose	Yellow	Green
R/S	Kiln	Green	Orange
N	Furnace, kiln	Orange	Pink

Thermal Barriers – Principles

Thermal barrier selection is based on:

- The process time/temperature characteristics
- The kiln type: Roller hearth kiln, tunnel kiln, etc.
- Physical size constraints

The thermal barrier provides the environmental and mechanical protection necessary for the data logger to survive in the kiln's hostile environment. For tunnel kiln systems connection to the thermocouples is by plug and socket external to the barrier. Roller hearth kiln systems connect internally.

Barriers using conventional heatsink technology have been discontinued in favor of phased evaporation technology where water becomes the phase change medium. These barriers are smaller, lighter and have far more thermal capacity than the conventional heatsink type.

In phased evaporation, the data logger is protected by boiling water and has to be designed to withstand a continuous operating temperature of 100°C /212°F. This of course requires specialized electronics and battery technology. The water within the barrier is protected by microporous insulation to delay the water reaching boiling point too quickly and to minimize the rate of heat transfer into the system.

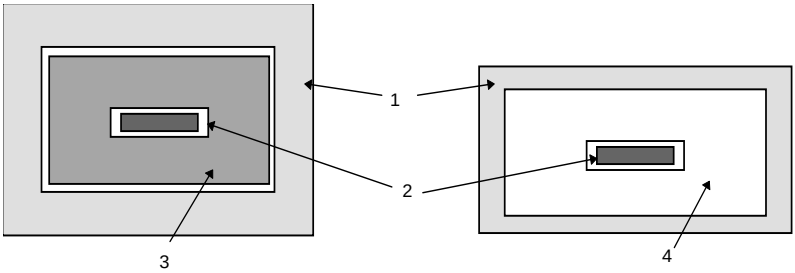
Size for size the phased evaporation barrier has over three times the thermal capacity of conventional barriers and can therefore be used in many longer or hotter processes. The only disadvantage of this type of thermal barrier is that it is necessary to fill it with cold water before running through the process. Although it is an easy task to do, it is also very easy to forget, and if the barrier runs through the process without water the thermal capacity will be greatly reduced, and the logger may be damaged beyond repair.

This technology is also applied in thermal barriers for roller hearth kilns, but in these barriers an extra layer of high temperature insulation is used to protect the thermal barrier against the direct heat of the kiln. These barriers designed for have therefore two stages of thermal protection:

1. Layers of ceramic fiber blanket (the first stage).
2. A stainless steel water jacket (the second stage) containing the data logger.

The selection of barrier type depends principally on the type of kiln, its height and width limitations, the data logger type, test duration, temperature and time at temperature.

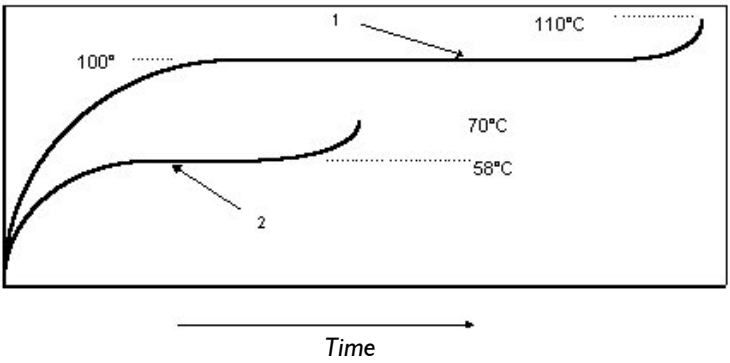
Basic Elements



Obsolete heatsink barrier on the left, phased evaporation barrier on the right.

1. Primary Insulation
2. Data Loggers
3. Heatsink
4. Water

Comparison of temperature inside conventional and "phased evaporation" thermal barriers (to logger cut-off point)



1. Temperature characteristics of Phased Evaporation barrier technology.
2. Temperature characteristics of conventional barrier technology.

Barrier Duration

The above graph shows an approximate comparison of how the temperature increases inside the two types of thermal barriers during a kiln trial. The phased evaporation barrier has far more thermal capacity than conventional barriers because the total volume of water inside the barrier is allowed to boil off throughout the process, and the rate of boiling is controlled. In a conventional thermal barrier the material in the heatsink is only taken to just beyond the point where it changes phase and is then reversed.

Tunnel Kiln Thermocouples

Selection

Thermocouple selection is based on the following:

Temperature

Select the probe with the appropriate temperature range. The ranges of some thermocouple probes overlap so there may be a choice.

Type of Product and Process

Will the probe be used to measure the product's internal temperature? If so use a type K Mineral Insulated probe. If the product is roof tiles fired at 1150 °C/2100°F, a type K with metal sheathed cable is appropriate. It may not be appropriate however if the process is firing glaze on pottery as the metal sheath may oxidize and contaminate the glaze.

Method of Loading the Product into the Kiln

Is the product loaded automatically? If so the probe cable must be flexible to avoid being snagged by the loading equipment. Type R thermocouples with rigid ceramic sheaths are therefore not suitable.

Economics

Made from platinum type R thermocouples are very expensive compared to type K, but may last longer, and therefore ultimately be more economical.

Insulation

Ceramic fiber Insulated probes have light gauge conductors providing maximum flexibility. The calibration of their exposed hot junction may be affected when in oxygen reduced atmospheres at temperatures in excess of 900 °C /1652 °F, for example "flashing" in brick firing processes.

Mineral Insulated (MI) probes have an enclosed junction providing protection against carbon and other aggressive atmospheres and increased immunity to electrical interference. The MI probes supplied by Datapaq have a Nicrobell™ sheath providing superior protection at high temperature and in corrosive atmospheres, but having some limitations in atmospheres with a high sulfur content. Consult Datapaq for advice.

Twin bore ceramic tube insulation is available for use with type K and type N thermocouples. Mechanical protection is provided by a closed-end outer ceramic tube.

Special compensation cable for type R, S and B thermocouple is available from Datapaq, reducing measurement errors.

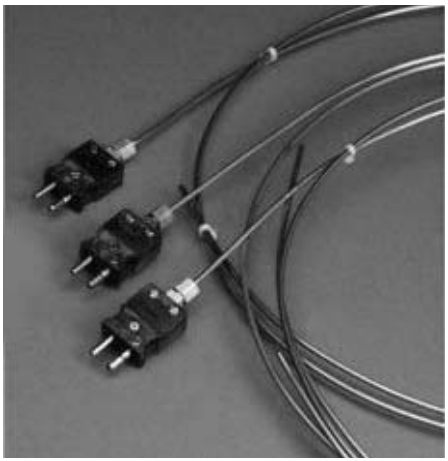
Mineral Insulation is suitable for type K and N thermocouples only

Typical Applications

Thermocouples for typical tunnel kiln applications are type K and type N but type R/S may be used at higher temperature levels for products such as refractory materials etc.

Type K Thermocouples

Type K thermocouple probes have a hot junction combining Nickel Chromium Alloy and Nickel Aluminum Alloy. They are the standard probe for kiln operation.



Datapaq's comprehensive range of Type K thermocouples.

International specifications for type K define a sensitivity and linearity over the range 0 °C to 1370 °C /2498 °F. Their practical operating range is limited by the properties of the cable insulation, normally Mineral or Ceramic Fiber, and the properties of the cable sheathing.

Specifications

Probe Type	Cable Insulation	Accuracy of probes supplied by Datapaq
K	Ceramic or MI	0 to 1250 °C /2282°F ±1.1 °C /2°F, or ±0.4% whichever is greater.

Thermocouple Cables

Thermocouple cable selection is based on both temperature and mechanical considerations.

The thermocouple's maximum practical operating temperature is limited both by thermocouple itself, and the temperature characteristics of the cable insulation material

Insulation	Practical Upper Temperature Limit
Ceramic Fiber (Type K only)	1000°/1832°F
Mineral Insulation (MI) (Type K and N)	1250°C /2282°F

A Kiln Tracker System ready to monitor bricks during firing.

Tunnel Kiln, High Temperature Applications

Thermocouples for high temperature tunnel kiln operation include the types B, R and S. Using platinum and platinum/rhodium alloy they offer higher temperature operation than types K or N, but require special compensation cable in order to reduce their overall cost.

Type R thermocouple probes suitable for kiln operation.

Thermocouple Specifications

Probe Type	Temperature Range	Insulation Material (Insulators and Tube)	Practical Operating Range
B	0 °C to 1820 °C/32°F to 3308°F	Re-crystallized Alumina	400 °C to 1700 °C/752°F to 3092°F
R/S	0 °C to 1768 °C/32°F to 3214°F	Re-crystallized Alumina	0 °C to 1600 °C/32°F to 2912°F

Type R, S and B thermocouples are available only on special request

Thermocouple Cables

As with the typical kiln application, the high temperature thermocouple's maximum practical operating temperature is limited both by thermocouple itself and the temperature characteristics of the cable insulation material.

Insulation Material	Practical Upper Temperature Limit
Aluminous Porcelain Insulators and Closed-end Tube	1400 °C/2552 °F
Re-crystallized Alumina Insulators and Closed-end Tube	1650 °C/3002 °F

Twin bore ceramic insulation is available for use with R, S and B type thermocouples. These use special compensating cable below the kiln car. Mechanical protection and protection from the atmosphere is provided by a closed-end outer ceramic tube.

It is not recommended to use type R,S or B thermocouples without the protection of a closed end ceramic tube in kilns where the atmosphere may be 'metallic' or where there is an oxygen reducing atmosphere.

Compensating Cable for Use with Type R, S and B Thermocouples

This cable is used under the kiln car as a connection between the thermal barrier and the thermocouple junction box. As the junction of thermocouple and compensation cable is subject to high ambient temperatures the use of inappropriate cable may result in errors affecting the system's overall accuracy.

Datapaq has selected thermocouple compensating cable to ensure these errors are minimized. Please contact Datapaq for further information.

Thermal Barriers for Tunnel Kilns

In tunnel kilns where the thermal barrier travels beneath the kiln car in relatively low temperatures the phased evaporation barrier system on its own is sufficient to keep the data logger cool.

TB6100, TB6200 and TB6400 range of thermal barriers.

These barriers do however require simple preparation before use which the conventional thermal barriers do not. These thermal barriers also require a special data logger, developed by Datapaq, which is able to operate at high ambient temperatures (up to 110°C/230°F).

The phased evaporation range of thermal barriers use the simple principal of water evaporation to keep the data logger cool.

The rate of evaporation is controlled by breaking it down into distinct stages or 'phases' which minimize the evaporation rate and therefore maximize the time

the data logger can spend within the process, or at high temperature. Control of the evaporative phases is obtained by design of the insulation layers around and within the thermal barrier.

Within the inner chamber of these barriers, where the data loggers are located, the temperature will rise to, and then remain at 100°C/212°F during the process. The data logger used must then be able to operate normally at this temperature which the Tpaq21high operating temperature logger is designed to do.

The Tpaq21 normal operating temperature logger cannot be used with these thermal barriers as the electronics and batteries are not designed to operate at these high temperatures.

Selecting the Thermal Barrier

To do this you will be required to establish under car temperature, and use this to establish the average under car temperature.

A temperature monitoring device comprising of a 5-cm/2-in square plate attached to which are four temperature sensitive strips can be supplied by Datapaq with your Tracker System. Having a total of 33 segments these strips divide the temperature range from 71°C to 260 °C/160°F to 500°F into bands of approximately 6 °C/11°F. Each segment changes from a light to a dark color as its temperature is exceeded, providing an indication of the maximum temperature experienced by the plate. As this color change is irreversible the plate can be only be used once.

Calculating Average Temperature Using the Temperature Monitoring Plate

Using wire, suspend the temperature monitoring plate at the barriers chosen location on the underside of the kiln car and run the car through the dryer/kiln cycle. After the run recover the plate examining each temperature element to determine the maximum temperature experienced. This will show the maximum temperature reached. To calculate the average temperature over the whole firing cycle, multiply the maximum temperature by 0.7.

Example:

Maximum temperature reached = 210°C/410°F

Average temperature = 150°C/270°F

Now proceed to ‘Temperature/Time Characteristics for the TB6000 Type K Thermal Barriers’ on page 23.

If the temperature has exceeded the maximum of strip E proceed to ‘Calculating Average Temperature Using a Trailing Thermocouple’ (below).

Calculating Average Temperature Using a Trailing Thermocouple

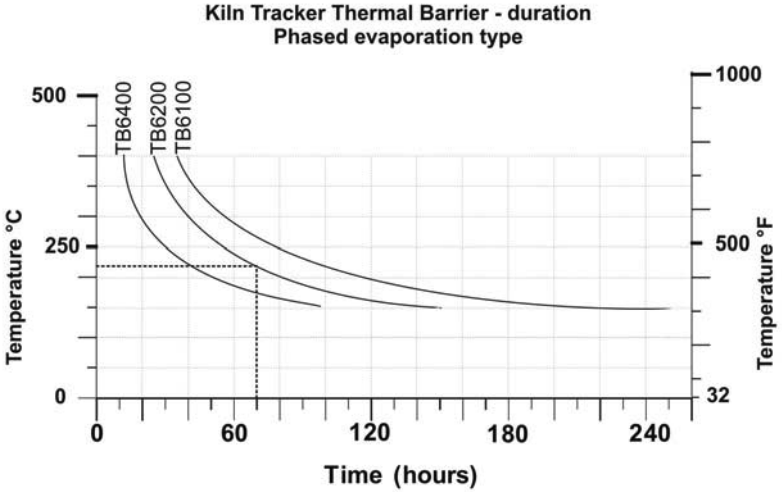
If the temperature range of all thermometer strips has been exceeded the temperature should be established using a trailing thermocouple. Mount the thermocouple in the location selected for the barrier and connect it to a data logger placed outside the kiln, and run the car through the dryer/kiln cycle.

Ensure the thermocouple's hot junction is clear of any under car steel work which may be at a temperature in excess of the ambient air temperature.

Download the data from the trailing lead thermocouple to the Kiln Tracker System software. Refer to your dedicated data logger manual and the software on line help for further information.

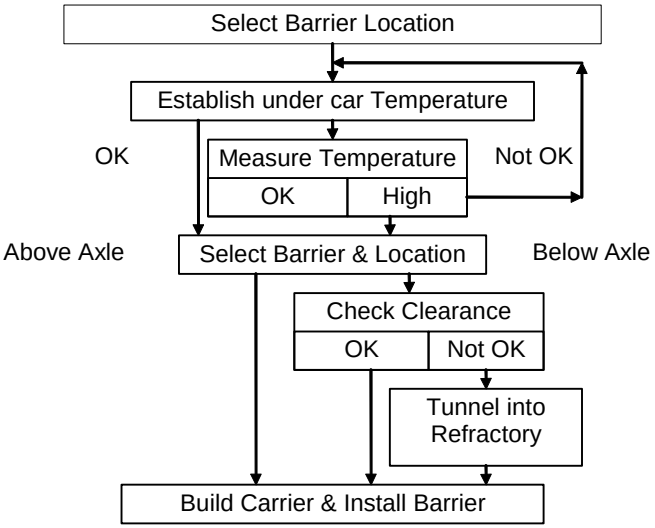
To select the appropriate barrier locate the calculated average temperature on the barriers time/temperature graph as shown below. Use the barrier specifications on page 24 to assist you if required. Drop a perpendicular to determine its thermal duration and choose the barrier having the appropriate characteristics.

Temperature/Time Characteristics for the TB6000 Type K Thermal Barriers



From this graph you can see that the intersection of temperature and time indicate the TB6200 can operate at an average temperature of 220 °C/428°F for approximately 70 hours.

Now you have the average under car temperature, you can select the appropriate barrier. The following diagram outlines the steps to be made to do this.



Thermal Barrier Specifications

The phased evaporation range of thermal barriers are available in three different sizes, the largest size (TB6100) being for long duration or higher under car temperature applications in the heavy clay industry, e.g. tunnel dryer and tunnel kiln combined, or refractory firing. The medium size thermal barrier (TB6200) is for normal under car temperature applications and 1 to 2 day firing schedules. The smallest of the range (TB6400) is for applications where the space beneath the kiln car is restricted, for example whiteware or sanitaryware firing.

More detailed information on the duration of the phased evaporation barriers is shown in the following tables.

TB6100

Temperature	150°C 302°F	200°C 392°F	250°C 482°F	300°C 572°F	400°C 752°F
Duration (hrs)	250	115	75	60	35
Dimensions	Height 180 mm 7 in.	Width 350 mm 13.8 in.	Length 480 mm 18.9 in.		
No. of thermocouple channels	8, 10, 16, 20				

TB6200

Temperature	150°C 302°F	200°C 392°F	250°C 482°F	300°C 572°F	400°C 752°F
Duration (hrs)	150	78	56	40	25
Dimensions	Height 155 mm 6.1 in.	Width 280 mm 11 in.	Length 430 mm 16.9 in.		
No. of thermocouple channels	8, 10, 16, 20				

TB6400

Temperature	150°C 302°F	200°C 392°F	250°C 482°F	300°C 572°F	400°C 752°F
Duration (hrs)	98	48	30	20	12
Dimensions	Height 120 mm 4.7 in.	Width 200 mm 7.9 in.	Length 370 mm 14.6 in.		
No. of thermocouple channels	8, 10				

TB6500

Temperature	150°C 302°F	200°C 392°F	250°C 482°F	300°C 572°F	400°C 752°F
Duration (hrs)	188	101	67	50	12
Dimensions	Height 250 mm 9.85 in.	Width 250 mm 9.85 in.	Length 450 mm 17.7 in.		
No. of thermocouple channels	8, 10				

All barriers shown here are available for use with type K, R, S, N, or B thermocouples. The barrier part number has the suffix -x-n, where x = thermocouple type, n = number of thermocouple channels, e.g. TB6100-S-16 (type S thermocouples, 16 channels).

Special thermal barrier TB6500 (design based on TB6400).

Tunnel Kiln Process

To conduct your first trial run you will need to:

1. Select the location for the thermal barrier and install it
2. Select and install the thermocouple probes

You will also be required to enter the kiln characteristics into the Kiln Tracker software to ensure that the test's data acquisition requirements are fully met (refer to the Insight software on line help).

The following sections discuss these requirements.

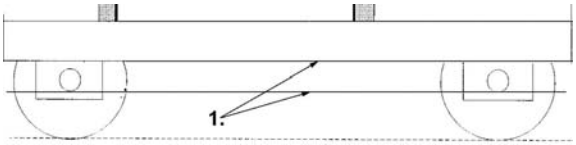
Selecting the Barrier's Location

The barrier's location is selected to ensure:

- It is well away from front and rear seals
- There is a clearance of greater than 25 mm (1") between the bottom of the car and the top of the barrier
- It is clear of any pusher gear
- There is sufficient clearance at the front to release screws and remove the data logger, and if necessary the barrier
- It is not in a position to catch on any concrete dams

Thermal Barrier in place on the underside of a kiln car with part of the 'skirt' removed for fitting.

Initially, for ease of installation establish a practical location under the kiln car.



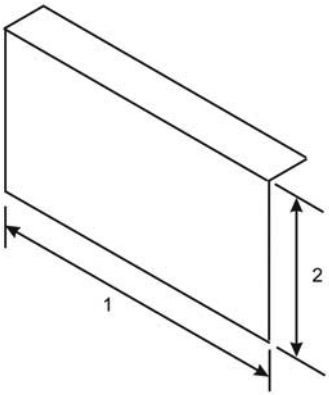
If the thermal barrier can be mounted in the space above the bottom of the axle (see 1. above), clearance is not a problem. In this case proceed to 'Mounting the thermal barrier' on page 29. If not, proceed to 'Establishing under car clearance'.

Establishing Under Car Clearance

When the barrier cannot be located above the bottom of the axle the under car clearance may be affected by dams, cooling vents, driving gear, rubble, etc. Check the clearance as follows.

Cut a template from 1-mm/0.04-in. thick aluminum sheet to the dimensions of the barrier mounting/support structure (see diagram below). Bolt it to the underside of the kiln car in the location selected for the barrier and send it through the dryer/kiln loading/unloading process.

At the end of each stage of the process, check the template for distortion resulting from an obstruction. Investigate, and if possible remove the obstruction if the template is distorted.

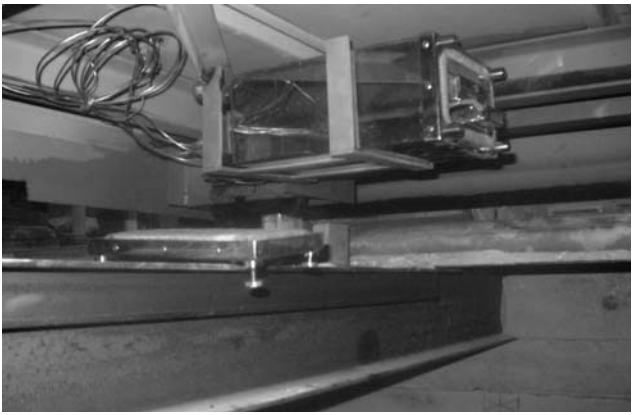


A template made from thin aluminum sheet.

1. Width of thermal barrier plus 25 mm (1")
2. Height of thermal barrier plus 25 mm (1")

If the obstruction cannot be removed, re-site the template at an alternative location if possible and run the test again.

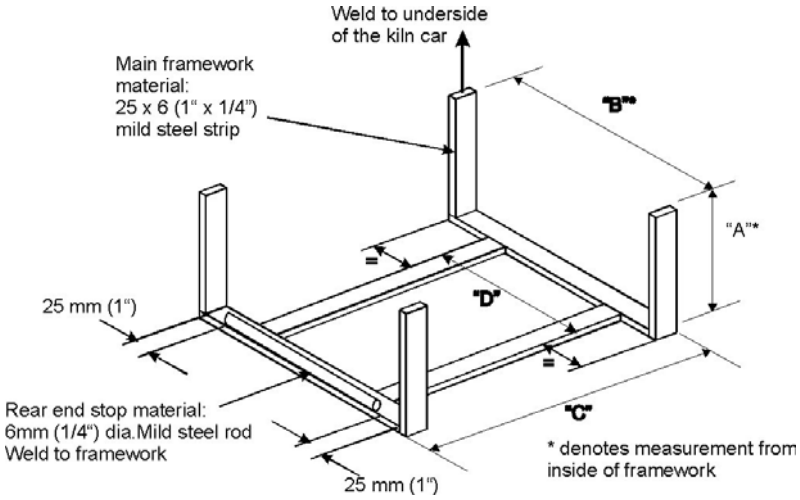
Mounting the Thermal Barrier



Barrier in position.

The thermal barrier should be attached to the underside of the kiln car by a purpose built framework. This framework and the points to which it is attached should be designed and selected to minimize heat transfer from the base of the car.

To minimize heat transfer and retention construct the support frame from light gauge material, i.e. 25 x 6 mm/1 x 0.25 in. mild steel strip. Avoid attaching the barrier support frame to elements of the kiln car structure that penetrate deep into the kiln car base.



Dimensions:

Barrier	A	B	C	D
TB6100	200 mm (8 in.)	375 mm (15 in.)	325 mm (13 in.)	27 mm 5 (11 in.)
TB6200	175 mm (7 in.)	305 mm (12 in.)	275 mm (11 in.)	205 mm (8 in.)
TB6400	135 mm (5¼ in.)	225 mm (9 in.)	225 mm (9 in.)	150 mm (6 in.)
TB6500	275 mm (10.8 in.)	300 mm (12 in.)	300 mm (12 in.)	175 mm (7 in.)

Mounting the Thermal Barrier in the Refractory Lining

The method adopted for any installation must depend on individual circumstances. Factors such as refractory base thickness, under car clearance, etc. differ from site to site. Considerations regarding the location and method of installation include accessibility, time involved and cost.

If refractory is removed a very high grade insulation material such as Microtherm (thermal conductivity 0.03 W/(m.K) / 0.21 Btu in/(ft²hr°F) or better must be used to compensate.

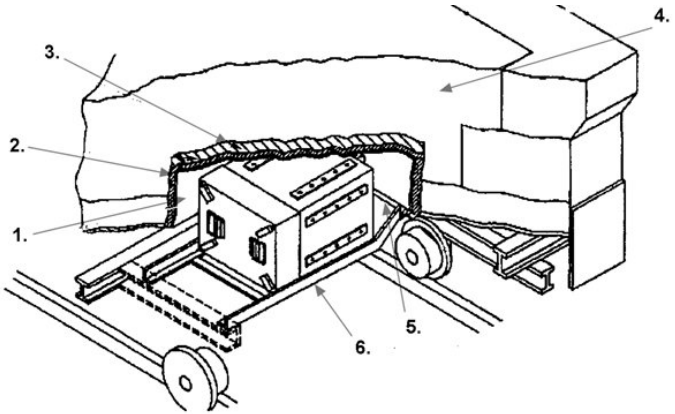
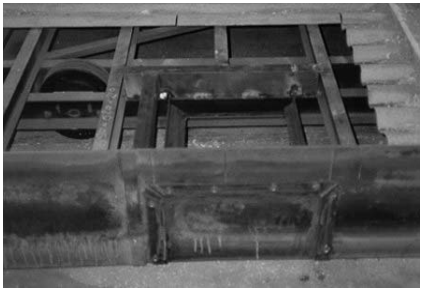


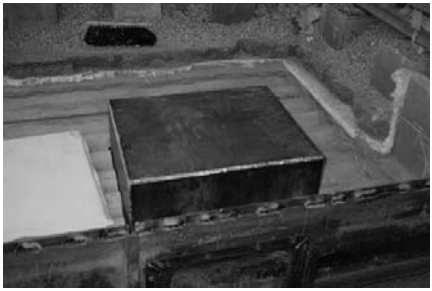
Figure 2

1. Steel casing.
2. Microtherm insulation 25 mm to 50 mm (1" to 2") thick.
3. Insulating fiber board 25 mm to 50 mm (1" to 2") thick.
4. Refractory.
5. Barrier frame hinge.
6. Frame hinges down or removes to allow access to thermal barrier.

The following example shows an installation allowing access through a removable panel built into the kiln car's 'side skirt'.



All refractory is removed, the chassis is cut strengthened and modified to accept a hinged carrier to support and house the thermal barrier.



A load bearing heavy gauge steel cover is welded to the kiln car chassis, stiffening the chassis and protecting the barrier.

Microtherm panels (minimum thickness 50 mm/2 in.) are fitted insulating all sides of the steel cover, leaving no gaps. The first castable refractory base layer is then poured.

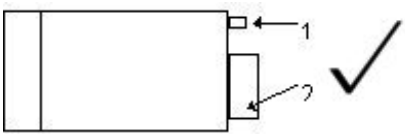
The refractory supports are replaced, those placed on the Microtherm panel are cut to size. All other refractory layers are built up as normal.

The hinged frame ready to accept the barrier (seen from the front of the kiln car).

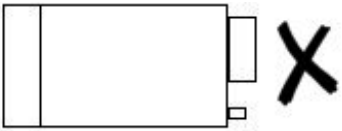
With the barrier in place and the frame lifted and locked into position the 'side skirt' is screwed in place.

Installing the Thermal Barrier

If possible install the thermal barrier under the kiln car before filling with water. This makes it far lighter and easier to handle when maneuvering it into position. Filling the thermal barrier with water is the last operation when setting up. The thermal barrier must always be installed with the inlet and overflow ports at the top and the thermocouple input sockets towards the bottom (see diagram below). Failure to do this will mean that the barrier will not fill completely with water and this will damage the logger severely.



Correct

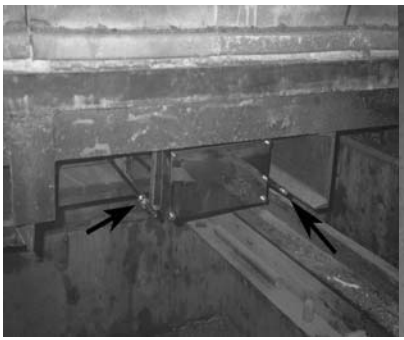


Incorrect

1. Inlet & overflow ports to top
2. Thermocouple sockets to bottom

Always make sure that the thermal barrier is set as level as possible to ensure there are no air pockets in the barrier when filling with water.

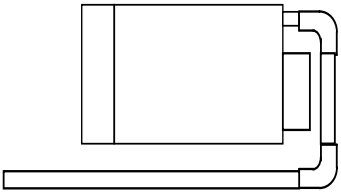
The inlet and overflow pipes are built to take standard 15 mm or ½" copper pipe fittings. Compression pipe fittings (90° elbows and connectors) and lengths of copper pipe are supplied with the thermal barrier so that the inlet and overflow points can be situated at a convenient point at the front or sides of the kiln car. If there is a need to use more fittings than those supplied, make sure that only compression fittings are used, as solder type fittings may break apart in the heat below the car.



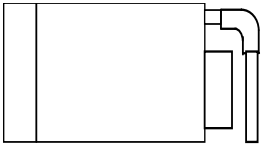
Thermal barrier with copper pipe fitted.

Inlet and overflow points piped to the front of the kiln car.

If it is not possible to fit pipes to the front or side of the kiln car (due to dams, etc.), always at least fit the smaller length of pipe to allow the boiling water to vent away from the thermocouple sockets, as shown below:



Inlet and overflow pipes to front of car.



Inlet and overflow pipes to avoid thermocouple sockets.

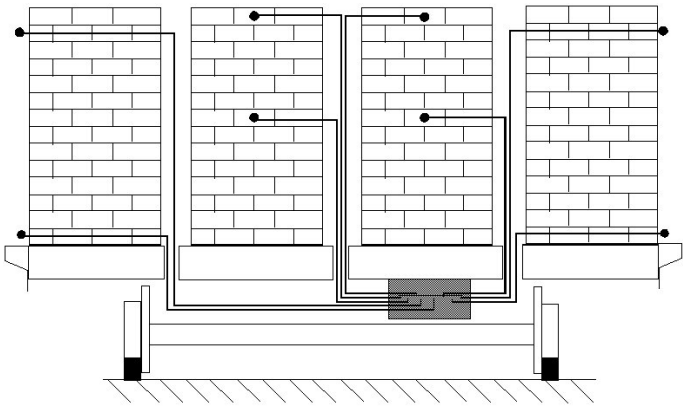
Inlet and overflow pipes must not be blocked or obstructed. There may otherwise be a build-up of pressure which could cause severe damage.

Installing the Thermocouples

Thermocouple probe installation can normally be separated into two categories. These are:

- Probes with flexible cable, i.e. type K with mineral insulated cable.
- Probes enclosed in a rigid sheath, i.e. type R with re-crystallized alumina insulators and closed end tube.

Probes with Flexible Cables



Type K probes distributed over four stacks of bricks.

Probe Location

The thermocouples must pass through a hole in the kiln car base to their connector on the underside of the kiln car (perhaps via an extension cable). This hole should be located so that:

- The thermocouple probes do not interfere with ware being loaded onto the kiln car.
- The probes do not exit the kiln car base near the sand seals.
- The length of thermocouple cable is minimized.

Probe Installation

Drill a hole in the base of the kiln car, pass the thermocouple cables through and seal the hole with ceramic fiber blanket to ensure heat does not leak through to the bottom of the kiln car.

Depending on the length of the kiln car, minimizing the length of the thermocouples by using extension cable on the underside of the car may reduce the total cost of the thermocouple installation.

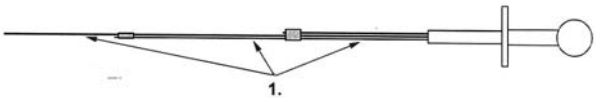
Probes Enclosed in a Rigid Sheath

Probe Location

Refer to probes with flexible cables as described on page 34.

Two or more R, S or B probes measuring the temperature at different heights can be contained inside one closed end tube.

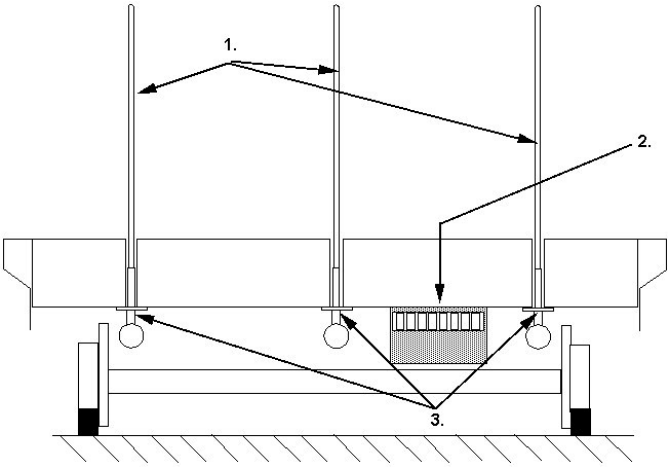
Probe Installation



Three type-R probes taped together (1.) ready for insertion into the closed end tube.

Assemble the required number of thermocouple probes, taping them together before installing them in the protective closed end, re-crystallized alumina tube.

Drill a hole in the base of the kiln car and pass the complete thermocouple assembly through from the underside. Weld the flange to the bottom of the car and seal the hole with ceramic fiber blanket to prevent heat leaking through to the bottom of the kiln car.



High temperature probes installed on a kiln car.

1. *Closed end tubes containing R, S or B thermocouple probes.*
2. *Thermal barrier with thermocouple connector.*
3. *Flanges welded to underside of car.*

Using thermocouple compensating cable complete the connection between probe and barrier thermocouple sockets.

The type of compensating cable used can have a significant effect on the accuracy of your results. Having evaluated suitable cables Datapaq are able to supply compensating cable minimizing these inaccuracies.

A kiln car loaded with sanitaryware and ready to go.

Testing Thermocouple Probes

Although thermocouple probes are generally robust they can be damaged during handling. Use the appropriate Datapaq digital thermometer to confirm their operation after installation, before committing the system to a run.

1. Attach thermocouple number one to the thermometer's connector.
2. Switch on the meter which should read ambient temperature. If the thermocouple cable is broken, the meter will indicate an open circuit.
3. If a satisfactory ambient reading is recorded, apply heat to the thermocouple tip via heat source, e.g., a hot air gun. The thermometer should register an increase.
4. If the thermometer reading does not change, the thermocouple is short circuit and must be replaced.
5. If the thermometer shows a decrease, the thermocouple connections are reversed.

Repeat stages 1 to 3 for all remaining thermocouples, replacing any found to be damaged.

A Brief Word about Data Loggers

Data loggers suitable for kiln operation include variants of the Tpaq21 which are available for use with type B, K, R and S thermocouples. The Tpaq21 superceded the Tpaq100 and Datapaq11 data loggers previously used in kiln applications.

Data Logger selection is based on:

- Process characteristics.
- The number and type of thermocouples required.
- The sampling interval required.
- The accuracy and resolution required.

Please refer to your dedicated logger manual for further details.

Programming the Data Logger

To prepare the data logger please refer to the dedicated logger manual and the Insight software on line help.

Installing the Data Logger

In the phased evaporation range of thermal barriers, the larger barrier sizes can accept up to 20 thermocouples, whereas the conventional Kiln Tracker thermal barriers will accept a maximum 8 thermocouples. Within the thermal barriers TB6100 and TB6200 there is space for 2 x 10 channel data loggers. With a full 20 channel system there are 2 cable assemblies which connect the individual data loggers to the sockets at the rear of the barrier. The internal plug assemblies on the cables are marked 'logger 1' and 'logger 2', and these correspond to the thermocouple sockets at the rear of the thermal barrier.

Data logger being installed into the thermal barrier.

When using a single 16 or 20 channel system, care should be taken to avoid connecting the data loggers to wrong thermocouple sockets. Always take care to ensure that the thermocouples in the sockets marked 'logger 1' are connected to the data logger via the plug assembly 'logger 1' inside the barrier. If there is any doubt, test the thermocouples from inside the thermal barrier as described in section 'Testing thermocouple probes' on page 36.

In the TB6400 and TB6500 it is only possible to fit one data logger with a maximum of 10 channels available for monitoring.

If two data loggers are being used in the thermal barrier (that is 16 or 20 channel operation) it is essential to note the serial number of the logger that has been designated as 'logger 1'. This will enable you to correctly identify the thermocouples when analyzing the information. See figures 1 and 2 below.

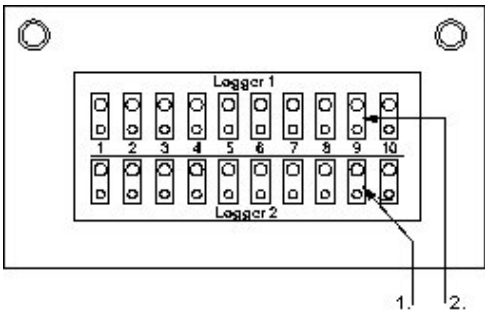


Figure 1, Rear View
1. Thermocouple Sockets for Logger 1 *2. Thermocouple Sockets for Logger 2*

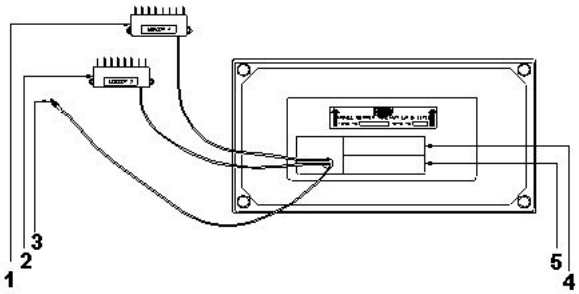


Figure 2, Front of barrier with lid removed.
1. Thermocouple Plugs for Logger 1 *2. Thermocouple Plugs for Logger 2*
3. Telemetry aerial *4 and 5. Data loggers*

Place the data logger into the thermal barrier ensuring the data logger sockets are the correct way up to accept the thermocouple connector's plugs. Holding the data logger push the thermocouple connector all the way into the data logger and fit the barrier's lid. Do not over-tighten the screws that hold the lid to the barrier – finger tight is sufficient.

Filling the Thermal Barrier with Water

Before the trial commences it is essential to fill the thermal barrier with water so that the evaporation process can take place during its passage through the kiln. This can easily be done by connecting a short length of plastic hose to the inlet port of the thermal barrier and filling with cold water until the water spills out of the overflow port (see above picture).

This operation is easily carried out if the copper pipes have been fitted so the inlet and overflow points can be accessed from the front of the car (see 'Installing the Thermal Barrier' on page 32).

Filling the thermal barrier before a trial.

Being able to fill the thermal barrier with water from the front of the kiln car has two important advantages:

1. It is possible to refill the thermal barrier during a long run if access to the kiln car is possible. For example in a trial where there is a tunnel dryer and tunnel kiln to be monitored it is sometimes possible to top up the thermal barrier when the kiln car exits the tunnel dryer. This will extend the thermal capacity of the barrier.
2. When the kiln car exits the kiln it is advisable to top up the thermal barrier if access to the data logger is not possible for some hours or days. This will again extend the thermal capacity of the barrier and avoid the possibility of damage to the logger.

After the Trial

If the under car temperatures are very hot, or corrosive gases are present (an example being where the process produces a Sulfurous atmosphere) then remove the thermal barrier from the kiln car.

If removing the thermal barrier between runs, allow sufficient time for the water in the barrier to cool (1 to 2 days)as it will still be very hot and there is a high risk of burns from any escaping water. If time is limited, then fill the barrier with cold water.

Removing the Logger

As soon as possible after the kiln car has exited the kiln, remove the lid from the thermal barrier and take out the data logger.

WARNING

*Delay in the removal of the data logger **will** result in serious damage.*

Always wear heat resistant gloves when removing the thermal barrier or logger as both will be at a high ambient temperature. After the logger has been removed, the lid of the barrier should be left to cool down separately. When the lid has cooled it should be replaced, and the thermal barrier again filled with water.

If the car goes back into normal operation (not monitoring) it is advisable to remove the thermal barrier. If it is not convenient to remove the barrier, it can be left beneath the kiln car (without the logger) but it **must be filled with water** before each cycle through the kiln.

Recovering the System – Tunnel Kilns

Safety Considerations

Please discuss the application of the Tracker System with your Health and Safety Officer. In general, wear appropriate protective clothing. Remember the Tracker System components will be hot after the test run so be prepared and handle with care.

Dismantling the System

Having passed through the kiln the heat stored in the kiln car and ware will continue to be transmitted into the thermal barrier after it has exited the kiln. It is therefore important that you remove the data logger as soon as possible. Note however that the data logger will be hot (100°C/212°F). You should re-fill the thermal barrier water tank with cold water before removal for safety.

Thermal Barriers TB6200, TB6100 and TB6400 should be removed from the kiln car.

WARNING

*Delay in the removal of the data logger and heatsink **will** result in serious damage to both.*

Placing a hot thermal barrier directly onto a cold surface will cause the barrier's case to distort due to the different cooling rates of the surfaces. Stand hot thermal barriers' on spacers, a ceramic fiber blanket or refractory material to ensure uniform cooling.

Thermocouple Probes

Types S, B or R

High temperature probes protected by closed end ceramic tubes are normally left in place.

WARNING

Take care to avoid damaging the protective ceramic tubes when removing the ware from the car.

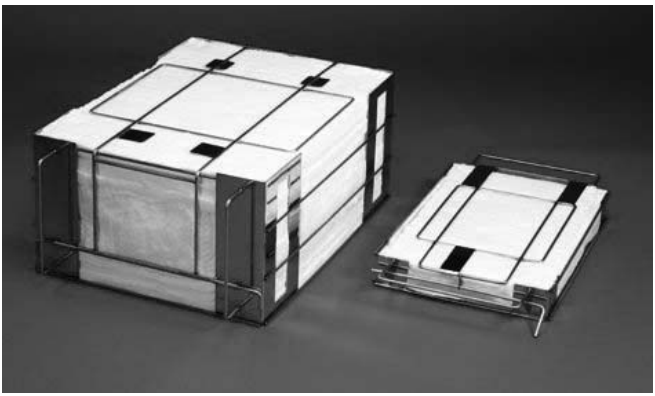
Type K

These probes are normally removed where unloading the kiln car is automated. Remove them carefully, coil ensuring the diameter of the coil exceeds 400 mm (16 inches), and store in a safe place.

Downloading Data

To download the data logger, please refer to the dedicated logger manual, and the Insight software on line help.

Thermal Barriers for Roller Hearth Kilns



Roller hearth kiln barriers.

In this application the tracker system travels through the kiln with the product and, as a result, is subjected to the full kiln firing temperature.

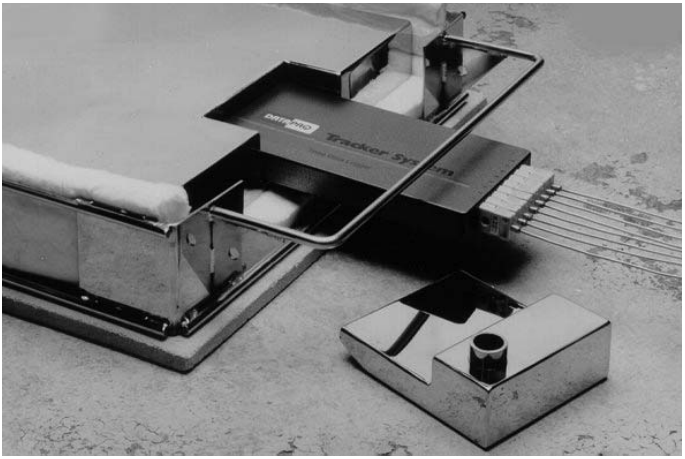
In order to survive the high temperature the tracker system experiences in roller hearth kilns the barriers are provided with two stages of thermal protection. Layers of fiber blanket providing the first stage and a stainless steel water jacket containing the data logger provides the second. The microporous insulation inside the water jacket greatly slows the rate at which heat is transferred to the water jacket. The fiber blanket protects the inner insulation against excessive temperatures and provides further insulation to slow down the boiling process.

The principle of operation is the same as for tunnel kilns in that on reaching the boiling temperature of water (100 °C/212 °F), the temperature around the data logger will stabilize, and this temperature will be maintained until all the water evaporates.

Selecting the Thermal Barrier

Selection of the thermal barrier is based on:

- Kiln temperature/time characteristics.
- Kiln height and width restrictions.



The TB3020 Thermal Barrier with data logger and rear water tank being loaded.

Safety Considerations, Roller Hearth Kilns

Dust exposure limits are based on the average amount of dust in an eight hour period. Although the insulation material used in roller hearth kiln barriers contains man-made fibers the possible exposure to any significant amount of dust is not likely as the exposure is over a very limited time period.

As it is not possible to assess the dust levels in any one application we recommend the user wear an approved dust respirator equivalent to EN 149 FFP2S, such as 3M 8810.

Thermal Barrier Specifications

TB3020

Thermal duration	1 hour at average of 700 °C/1292 °F 30mins maximum at average of 900°C/1652°F			
Maximum temperature	1200°C/2192°F			
Physical	Height 81 mm 3.2 in.	Width 400 mm 15.7 in.	Length 638 mm 25.1 in.	Weight 14 kg 30.8 lbs
Suitable logger	TP0106		TP0109	
Typical product	Wall tile			

TB3031

Average temperature	700°C/1290°F		900°C/1650°F	
Maximum temperature	1200°C/2192°F		1200°C/2192°F	
Duration in Hrs/Mins	5hrs		4hrs	
Physical	Height 150mm 5.9 in.	Width 382mm 15 in.	Length 610mm 24 in.	Weight 20kg 44 lbs
Suitable logger	TP0106			
Typical product	Roof tile			

TB3036

Average temperature	700°C/1290°F		900°C/1650°F	
Maximum temperature	1200°C/2192°F		1200°C/2192°F	
Duration in Hrs/Mins	7hrs		5hrs 30mins	
Physical	Height 200mm 7.9 in.	Width 432mm 17 in.	Length 660mm 26 in.	Weight 24kg 52.8 lbs
Suitable logger	TP0106			
Typical product	Tableware			

TB3038

Average temperature	700°C1290°F		900°C/1650°F	
Maximum temperature	1200°C/2192°F		1200°C/2192°F	
Duration in Hrs/Mins	17hrs		12hrs	
Physical	Height 300mm 11.8 in.	Width 512mm 20.2 in.	Length 735mm 28.9 in.	Weight 36.5kg 80.3 lbs
Suitable logger	TP0106			
Typical product	Sanitaryware			

Roller Hearth Kiln Process

Roller Hearth Kiln Thermocouples

Use type K/N with 1.5-mm/$^{1}/_{16}$-in. diameter mineral insulated cable to ensure flexibility during loading, transport through the kiln and unloading.

Checking the Loading on the Rollers

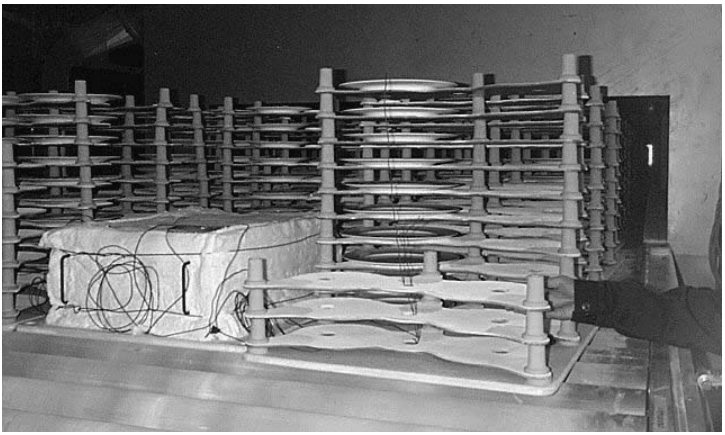
Ensure the weight of the kiln tracker system is distributed evenly over the area of the ceramic fiberboard and therefore over each roller. An estimate of the loading on each roller can be established by dividing the total weight of the Kiln Tracker system plus the weight of any ware traveling on the same rollers by the number of rollers supporting it. This should be compared with the kiln manufacturer's specification to confirm its acceptability. If in doubt consult the kiln manufacturer before using the kiln tracker system.

Establishing Height Restrictions

Having selected the barrier, a dummy load slightly higher should be sent through the kiln to confirm its suitability. This is particularly important for tile kilns, but less so for tableware, roof tile and sanitary ware applications where clearance is not normally a problem.

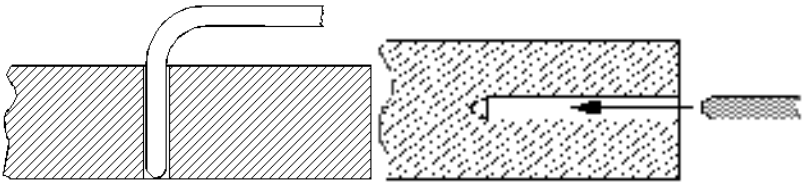
Prepare the dummy load by cutting green unfired unglazed tiles into strips about 50 mm/2 in. wide and stacking them on the front end of a ceramic batt, making a pile slightly higher than the height of the thermal barrier. Run the dummy load through the kiln ensuring any detectors and air blowers are lifted clear. After the run examine the pile of tiles, if they are undisturbed the barrier is suitable. If not contact Datapaq for advice.

Installing the Thermocouples



Thermocouple attached to test pieces ready for a trial run.

Thermocouples are normally 1.5 mm/$^{1}/_{16}$ in. diameter. If you are positioning the thermocouple into the tiles, drill a hole into the green (unfired) tile 1.6mm/$^{1}/_{16}$ in. in diameter and 15 mm/0.5 in. deep and place the hot junction of the probe into this (see the diagram below).



Measuring the tile's base temperature via a hole drilled through the tile.

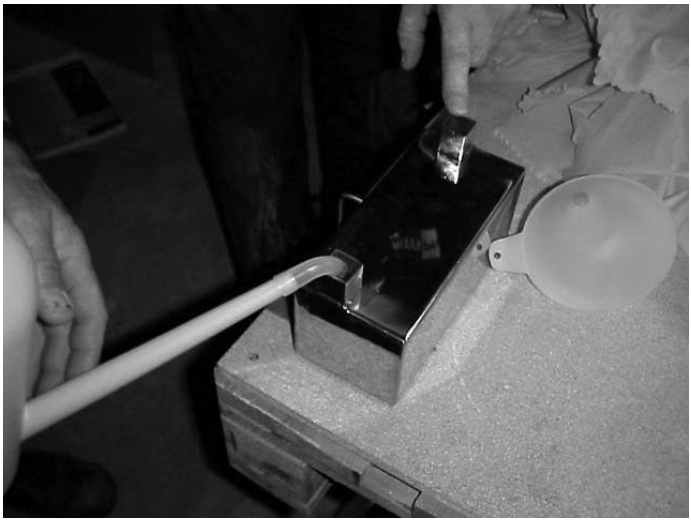
Measuring the tile's inner temperature via a hole drilled in the edge.

If you are placing thermocouples into an actual sanitaryware piece, drill a hole 3 mm/$^{1}/_{8}$ in. diameter in the green ware and place the hot junction of the probe into this. Hold the thermocouple in position by placing some "slip" around it and leaving this to dry out.

Type R or S thermocouples may be used in some sanitary ware roller hearth kiln applications.

Assembling the System

Filling the Thermal Barrier with Water



Filling the thermal barrier before a trial.

Before the trial commences it is essential to fill the thermal barrier with water so that the evaporation process can take place during its passage through the kiln. This can easily be done by connecting a short length of plastic hose to the inlet port of the thermal barrier and filling with cold water, or by using a suitable watering can (see above picture). Fill until the water spills out of the overflow port.

A Brief Word about Data Loggers

Data loggers suitable for kiln operation include variants of the Tpaq21 which are available for use with type B, K, R and S thermocouples.

Data Logger selection is based on:

- Process characteristics.
- The number and type of thermocouples required.
- The sampling interval required.
- The accuracy and resolution required.

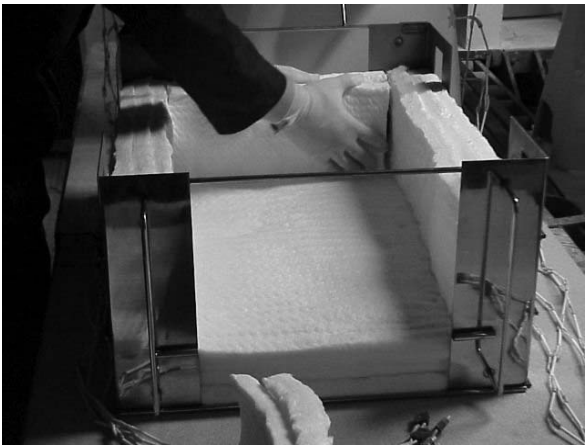
Please refer to your dedicated logger manual for further details.

Programming the Data Logger

To prepare the data logger, please refer to the dedicated logger manual, and the Insight software on line help.

Preparing the Thermal Barrier and Installing the Data Logger

The following photographs show the basic stages in the thermal barrier preparation.



Assembling the insulation layers.

The photograph above shows the basic assembly of the insulation layers inside the barrier cage. Note that you must wear gloves to protect your hands from the fibers.

Placing the thermal barrier within the insulation layers.

The thermal barrier is then placed within the insulation layers. Note that in this illustration cardboard inserts have been used to assist in this process. This makes it easier to squeeze the barrier in, as well as protecting the insulation. When the barrier is in position, simply pull out the cardboard inserts.

Spraying on a rigidizer.

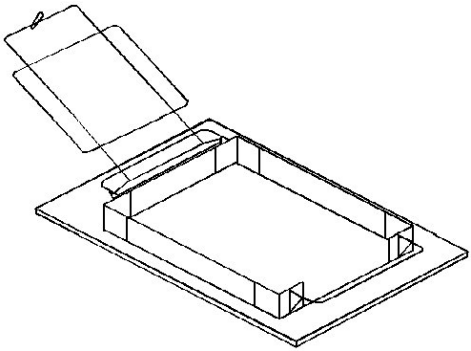
Fibers from the thermal blanket can become detached during your process and contaminate the product leading to unacceptable rejects. To prevent this spray on a rigidizer, which will bind the outer fiber blanket layer and prevent contamination.

WARNING

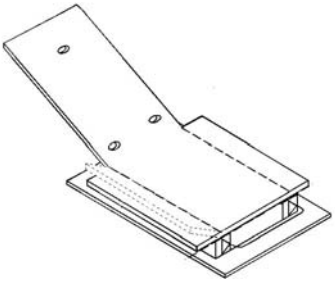
The performance of the insulation material deteriorates with use at the temperatures experienced in roller hearth kilns and must be replaced after every fourth run through the kiln.

Two types of thermal barrier are available for roller hearth kiln applications these are the TB3020 and TB's 3031, 3036 and 3038. The following diagrams show the assembly procedures.

TB3020 Barrier

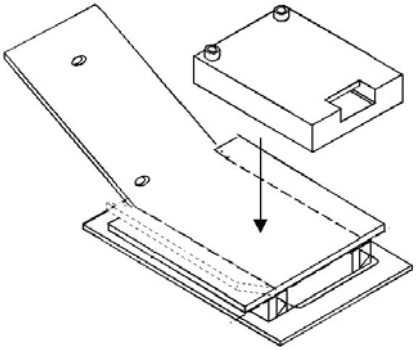


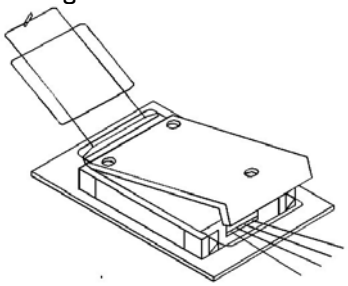
Place insulation cage on fiberboard, remove locking pin and open the lid.



Aligning insulation with the rear of the cage. Fold flaps up to fit

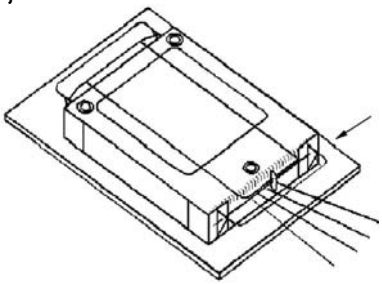
into cage.





Fill main water jacket and fit into insulation.

Place the data logger into the water jacket, fit rear water jacket.



Ensure there are no gaps in the insulation, replace the cage's lid.

Replace the locking pin.

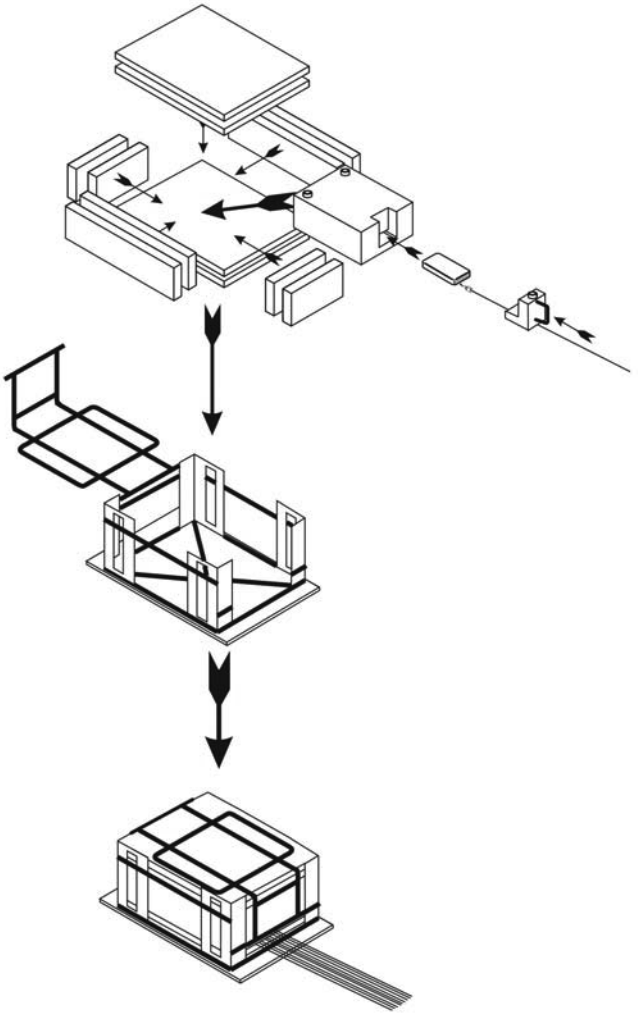
TB3031, TB3036 and TB3038 Barriers

These barriers utilize outer insulation sets as described below

- TB3031: Single layer 25 mm/1 in. thick
- TB3036: Double layer 50 mm/2 in. thick
- TB3038: Triple layer 75 mm/3 in. thick

For simplicity the diagram shown shows a typical installation using a double layer. You should modify your installation according to the specific barrier for your application.

The following flow diagram shows the process of assembly:



1. Place the insulation cage onto the ceramic batt.
2. Place the insulation blocks (two in this example) into the cage.
3. Place the insulation blocks (two in this example) at the sides and at the end.
4. Program the data logger and plug the thermocouples in.
5. Fill the main water tank and place on the insulation.
6. Fit the data logger.
7. Fill the rear water tank and fit into the main water tank.
8. Place the remaining insulation blocks to the side and the end.
9. Place the insulation panels on top (two in this example) and close the cage lid and lock.

Placing the System in the Kiln

Tracker system entering the kiln.

In tile kiln applications, support the system on the fiber board batt provided in your Tracker system (i.e. Datapaq supplied). For sanitaryware and whiteware roller hearth kiln applications support the system on the batts provided for the ware (i.e. customer supplied).

Safety Considerations

We strongly recommend that you discuss the application of the Tracker System with your Health and Safety Officer.

Loading the System

As the ware is normally automatically loaded into roller hearth kilns the time taken to manually load each element of the tracker system, and the ware it monitors, requires a relatively large gap in the spacing of the ware on the rollers.

TIP

When loading a tile system onto the kiln the ware (tiles) are fast moving and there may be little time to load the barrier and insert the thermocouples into the green tiles. If possible, place the system and test tiles on the top layer of the product accumulator so that it can be released by indexing it down when everything is in position.

WARNING

Running the system through the kiln with empty or partially empty water tanks is likely to result in severe damage. Both main and rear water jackets must be completely filled with water to ensure adequate protection.

The water in the roller hearth kiln barrier boils aggressively during the test causing evaporation. To avoid scalding by steam or boiling water handle the barrier and water tanks carefully when recovering the system. Remove the water tanks, keeping them horizontal, and place them on a suitable surface for cooling.

Recovering the System – Roller Hearth Kilns

Dismantling the System

With the help of an assistant lift the system and tiles or other ware from the moving rollers. Ensure the system is kept level to avoid spilling the boiling water contained in the water jackets, place it on the floor. Remove the batt, handling it with care to avoid damage.

Thermocouple Probes

Remove the thermocouples from the ware, if the product is tiles, then it may be necessary to break the tile by hitting it close to the thermocouples with a small hammer.

Data Logger

Remove the locking pin, open the lid and lift the insulation. Carefully remove the front water box keeping it horizontal to ensure the water does not spill.

Holding the thermocouple cables withdraw the data logger from the main water jacket. Disconnect thermocouples from the data logger, coil them ensuring the diameter of the coil is at least 400mm (16") and store them in a safe place.

Leave the water jackets to cool before emptying the water.

Downloading Data

To download data, please refer to the dedicated logger manual, and the Insight software on line help.

Care and Maintenance

Thermal Barriers

Cooling

Stand the hot thermal barrier on spacers, a ceramic fiber blanket or refractory material to ensure uniform cooling. Placing a hot thermal barrier directly onto a cold surface will cause the barrier to distort due to the different cooling rates of the surfaces.

The heat absorbed by the thermal barrier will continue to affect the temperature of the data logger, so remove it from the thermal barrier as soon as the test is completed. Leave in the open to cool before further use, or re-fill with cold water if another trial is soon required.

Always replace the fiber insulation panels after two or three runs as they will deteriorate with handling and this will affect the thermal capacity of the barriers.

Thermocouple Probes

Examine cables, and replace any found to have damaged insulation.

When coiling cables, ensure the diameter of the coil is not less than 400 mm (16").

Thermocouple Plugs

If your system has thermocouple plugs fixed together as part of an internal wiring harness, it may be necessary to use a **small** amount of electrical lubricant on the plugs if they become difficult to remove.

Datapaq Service Department

If you cannot resolve your problems, please contact the Service Department at Datapaq (see title page for contact details).

Troubleshooting

Hardware

Thermocouple Probe Faults

Although thermocouple probes are generally reliable they can be damaged by inappropriate use or handling, and as a result, produce erroneous readings. Datapaq Tracker software detects open circuit probes and attaches a warning to their data identifying it as invalid.

Probe Faults	Symptom	Action
Open Circuit	Permanent open circuit probes are marked *OC.	Check plug connections.
	Intermittent open circuit probes produce spiky, erratic profiles. Use View Data to check measurements.	Check plug connections.
Short Circuit	Reading inconsistent with other probes	Refer to your dedicated data logger manual on testing the data logger.

To minimize probe problems refer to Care and Maintenance, Thermocouple Probes page 61.

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