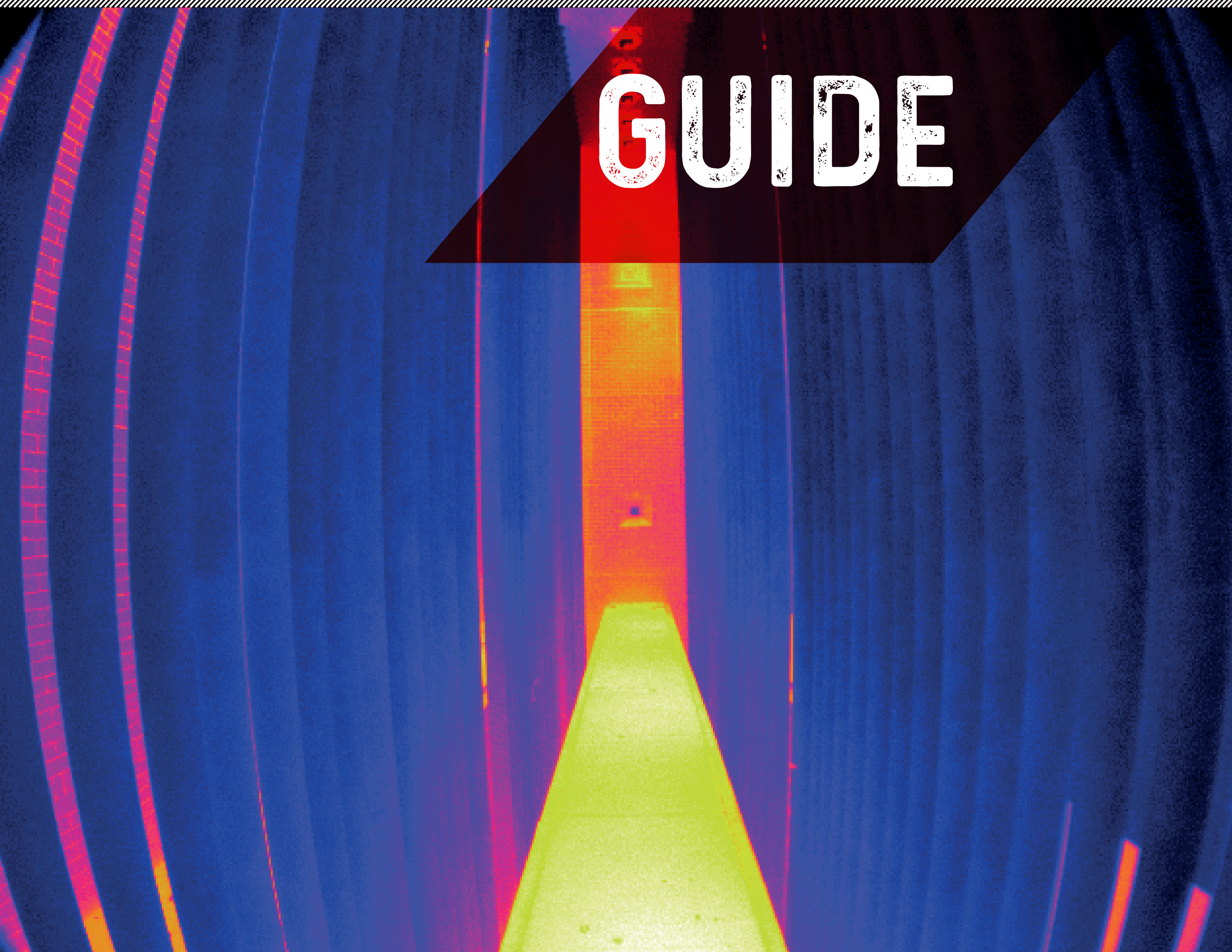
STEAM REFORMER TUBE WALL TEMPERATURE MEASUREMENT

GUIDE



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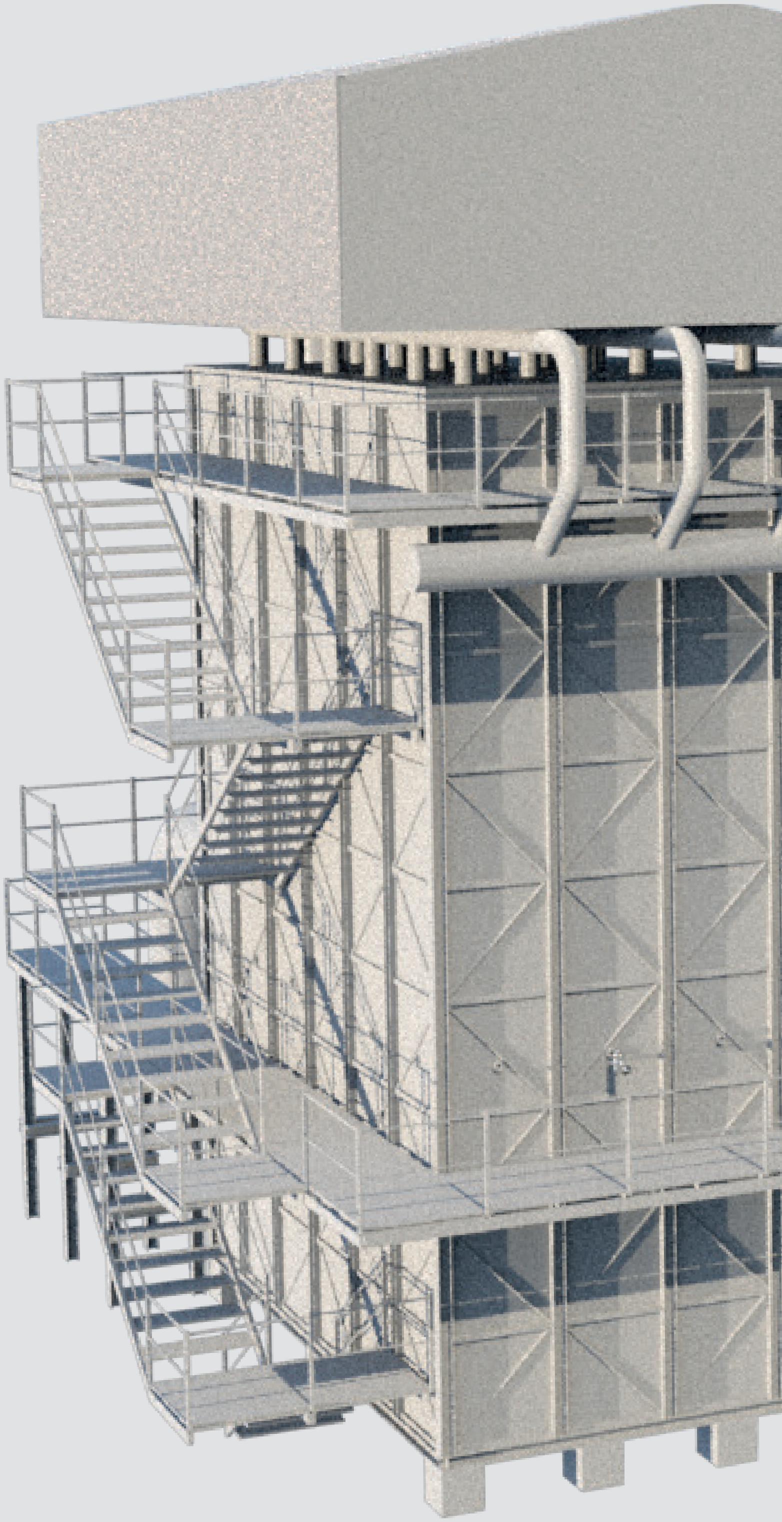

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WELCOME

Welcome to AMETEK Land's expert guide to the temperature measurement of tube walls in steam reformers.

Steam reforming is widely used in the hydrocarbon processing industries for the production of important gases, particularly hydrogen, methanol and ammonia.

The steam reforming process uses a huge furnace which heats a large number of tubes containing a catalyst. When steam and natural gas are passed through the tubes, over the catalyst, a catalytic reaction occurs that produces the synthetic gas (syngas) made up of hydrogen and carbon monoxide. This syngas is used to produce the desired product.

Understanding the temperatures of the tube walls is critical to controlling the reforming reaction. It also significantly affects the lifespan of the tubes, since this can be rapidly diminished by overheating.

Finding a balanced temperature that does not place undue stress on the tubes, while being high enough to deliver the most efficient process, is critical, and can have a significant impact on the profitability of a plant.

The best method for meeting the demands of improved safety and production is to implement regular temperature monitoring. This guide covers three technologies that are used to meet this requirement: infrared pyrometers, thermal imaging borescopes, and the Gold Cup.

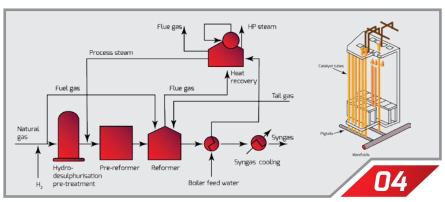
Each of these methods use a non-contact temperature measurement technique which, while providing highly accurate and repeatable temperature data, requires an understanding of this challenging application.

Inexpensive, easy-to-use handheld pyrometers have traditionally been the industry standard for steam reformer tube measurements. Although they need to compensate for emissivity and reflected radiation, they deliver precise results at high speed.

A method to verify the portable pyrometer readings is to use the Gold Cup pyrometer, which is held against the tube surface to eliminate background, sight path, and emissivity effects.

Thermal imaging technology can now be housed in water-cooled jackets which mean reformers can be monitored continuously, patterns can be observed, and alarms can be set to automatically detect concerning temperature rises and falls.

In this guide, we look at how tube wall temperature (TWT) measurements can benefit your applications, the technology behind the measurements, and a range of solutions that help reformer operators achieve safer, more efficient production.



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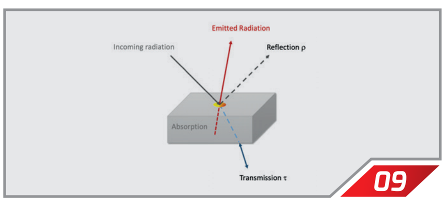
STEAM REFORMING



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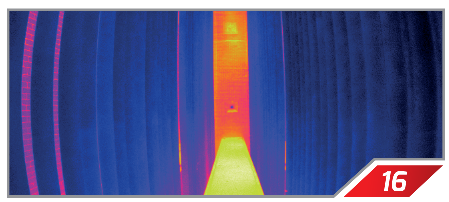
NON-CONTACT INFRARED MEASUREMENTS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THERMAL IMAGING

TEMPERATURE (ºC/ºF)	MEAN TUBE LIFE
860/1580	10 YEARS
880/1616	5 YEARS
900/1652	2.5 YEARS

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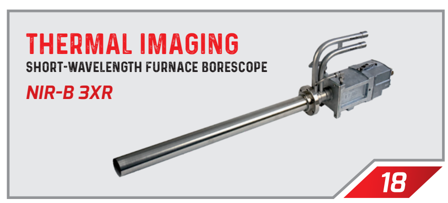
USING PORTABLE HANDHELD PYROMETERS



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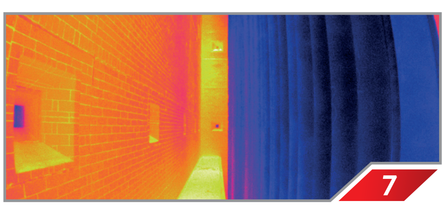
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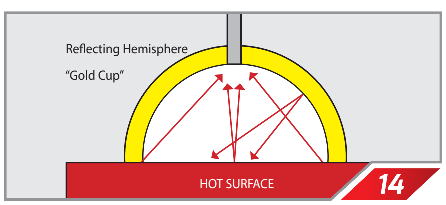
BENEFITS OF ACCURATE TEMPERATURE MEASUREMENTS



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GOLD CUP REFERENCE MEASUREMENTS

DISCOVER OUR PRODUCT SOLUTIONS ON PAGE 18

STEAM REFORMING

Steam reformers are primarily used for the industrial production of hydrogen, syngas and carbon dioxide from hydrocarbon fuels. Hydrogen produced from steam reformer plants is sometimes created as the first stage of an ammonia or methanol production process.

Steam methane reforming of natural gas is the least expensive and most commonly used method for hydrogen generation. In the United States, for example, it accounts for 95% of all the hydrogen produced.

The process uses readily available and inexpensive methane and water. Natural gas is combined with steam and heated at high temperature (between 700 to 1000 °C/1292 to 1832 °F) under pressure in the presence of a catalyst (typically nickel).

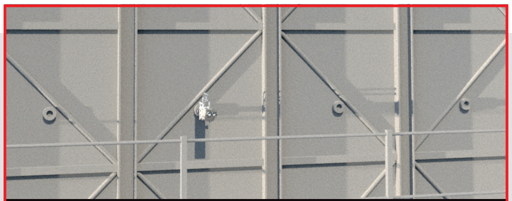
This produces carbon monoxide (CO), hydrogen (H_2) and a small amount of carbon dioxide (CO_2).

Next, CO from the reforming reaction interacts with steam, again using a catalyst, producing additional H_2. Any CO_2 is then removed to leave pure H_2. Throughout this process, the heat resulting from the combustion of fuel gas in a furnace box is transferred to catalyst tubes by radiation.

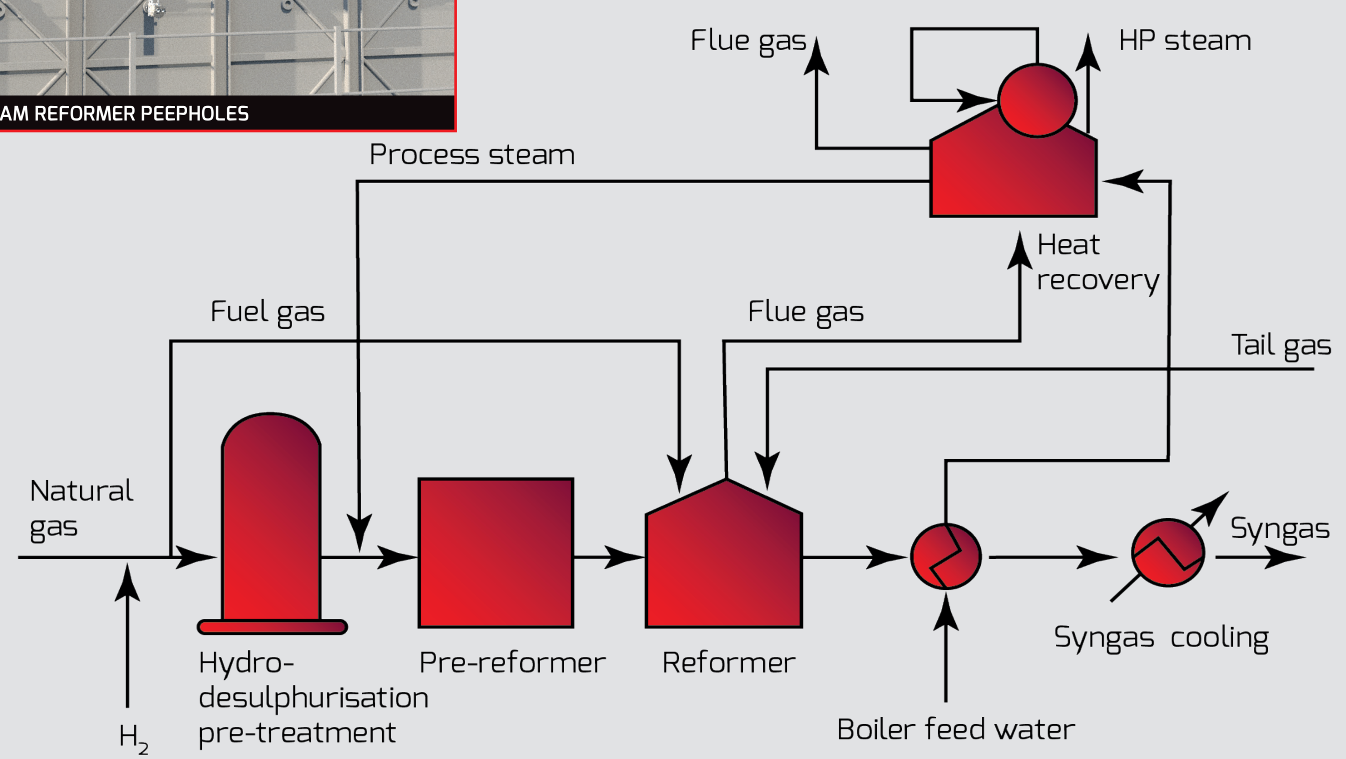
Furnaces typically hold large numbers of tubes, arranged into rows, which contain the catalyst. The tubes vary in size, but are typically around 100 mm (3.9 in.) in internal diameter, with a heated length of approximately 13 m (42.7 ft.).

These catalyst tubes continually degrade due to the harsh, high-temperature environment of the furnace. They have a design temperature which governs the upper limit of the tube temperature. Exceeding this temperature causes damage which can significantly curtail the life of the tube, requiring the added expense of early tube replacement and associated downtime. But operating significantly below design temperature reduces capacity and increases methane slip. Even a small reduction in methane slip in the primary reformer can produce huge annual savings due to significantly improved carbon efficiency in the methanol synthesis loop, meaning more production from the same volume of feedstock.

Operators need to have an in-depth understanding of the way a reformer behaves. They also have to be able to analyse data and make quick decisions in the shadow of catastrophic failure.



STEAM REFORMER PEEPHOLES

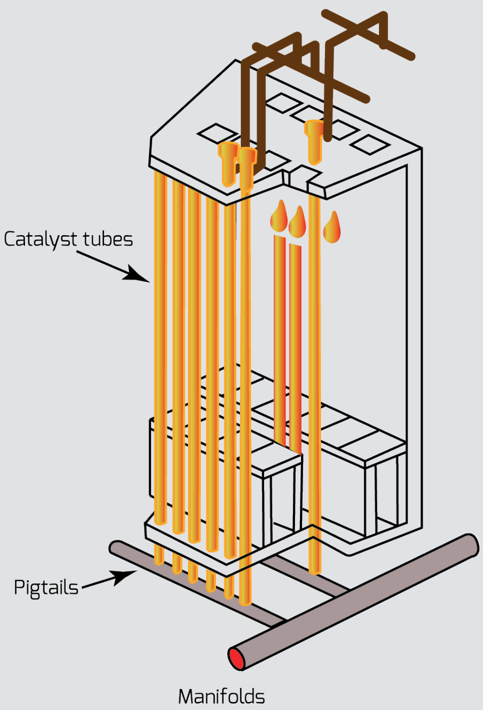


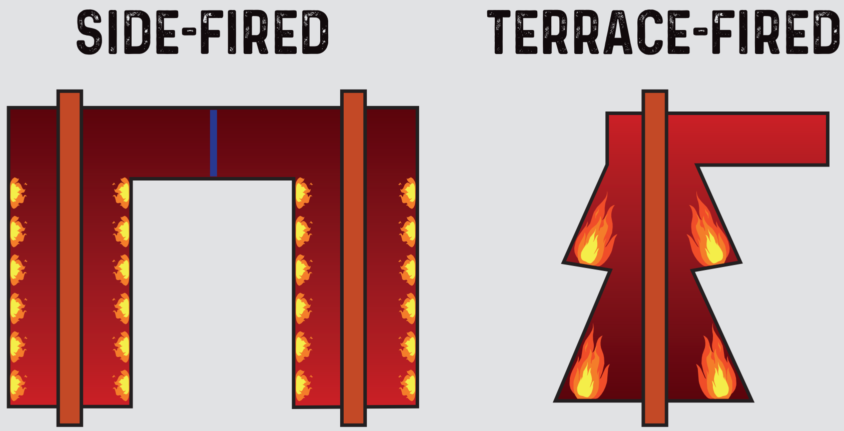
HYDROGEN PRODUCTION PROCESS USING A TOP-FIRED STEAM REFORMER

Significant experience is needed to fully understand basic reformer construction, process flow, heat transfer principles, background radiation, emissivity, and the cooling effects that occur whenever the furnace peephole is opened.

Most overheating can be traced back to human error. With increasing plant reliability, there is a longer gap between serious problems, so operators are often unfamiliar with how to spot developing issues and deal with them.

An increased data supply and accurate, continuous monitoring can support these operators, helping to enhance plant safety, while improving productivity, lowering energy consumption and extending tube life.





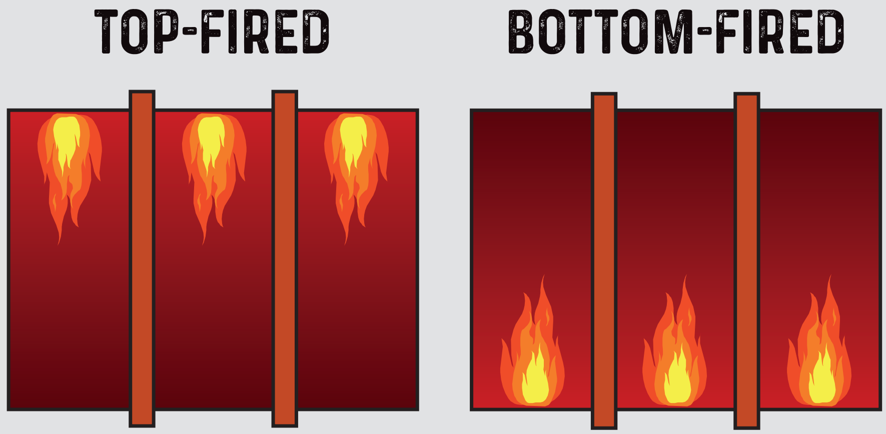
STEAM REFORMER DESIGNS

While the reactions involved are straightforward, steam reformers are complex and energy-intensive designs. Tubular steam reformers are commonly divided into four varieties, depending upon where the burners are located.

For top-fired and bottom-fired reformers, the catalyst tubes are arranged in parallel rows with burners between each row. The top or bottom of the furnace box is heated to temperatures between 1000 to 1100 °C (1832 to 2012 °F).

In side-fired and terrace-fired reformers, the tubes are arranged in single rows between opposing furnace walls. The reaction occurs through the tubes at approximately 900 °C (1652 °F), exiting at the bottom of the reformer.

Accurate temperature measurement will prove challenging in any reformer, but it is particularly difficult in those with tubes arranged in multiple parallel rows.



BENEFITS OF TWT MEASUREMENTS

Monitoring tube wall temperatures (TWT) provides the maximum level of catalyst tube life to ensure energy efficiency and productivity. High temperatures inside the furnace can cause expansion of the tubes, or even catastrophic tube failure, along with creep damage, coke formation and process flow problems.

The cost of not properly managing TWT can be extremely high, since the effect on tube life can be significant. At levels of as little as 20 °C (36 °F) above the design temperature, the lifetime of the tube may be halved, with higher temperatures having an even more dramatic impact (see Table 1).

TEMPERATURE (ºC/ºF)	MEAN TUBE LIFE
860/1580	10 YEARS
880/1616	5 YEARS
900/1652	2.5 YEARS
925/1697	11 MONTHS
950/1742	4.5 MONTHS
975/1787	2 MONTHS
1000/1832	4 WEEKS
1050/1922	5.5 DAYS
1100/2012	1 DAY

TABLE 1: THE EFFECT OF TEMPERATURE ON TUBE LIFETIME

Having to rebuild a 400-tube reformer can cost millions in materials alone, while the impact of lost production can also be significant. Current data places a typical rebuild cost at more than £7 million ($9.2 million), or £14 million ($18.4 million) when labour and lost production is taken into consideration.

Unsurprisingly, many plants err on the side of safety when setting operating temperatures, to reduce the risk of this expensive tube damage. However, if the plant is run too conservatively in order to prevent tube overheating, it will not achieve full efficiency.

At low TWT levels, the production output is decreased. A reduction of 10 °C (18 °F) below the design temperature, for example, results in a 1% productivity efficiency loss that may translate to millions of dollars in sales. It is, therefore, critical to find and maintain the optimum temperature to deliver production efficiency while preventing damage to the tubes.

TWT measurements can also be used to ensure balanced firing within the furnace, with all tubes running to the same exit conditions. Obtaining TWTs presents a number of measurement challenges. The conditions are extremely hot and hazardous, with flue gases at the outer tube surfaces reaching approximately 960 °C (1760 °F). Inner-surface process gases can range from 450 to 900 °C (842 to 1652 °F).

For non-contact measurements, the emissivity of the tube wall surface is an important factor in temperature accuracy. General industry practice recommends an assumed tube wall emissivity of 0.85 for 1 µm pyrometers and 0.82 for 3.9 µm, but this can be affected by the condition of the tubes, which may be 0.9 when new, but will decrease with use as they shed their thick oxide layer.

In addition, within the reformer environment, many items may reflect off the surface, which can be incorrectly interpreted as real data. The presence of soot may also interfere with measurements, particularly by infrared spot pyrometers.

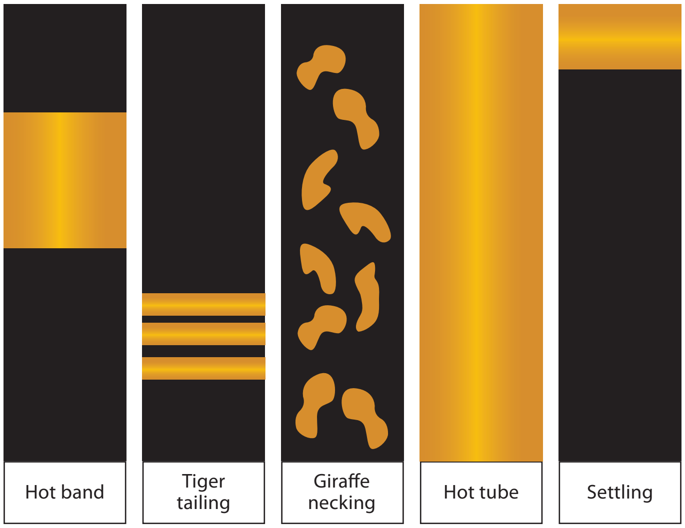
Despite these challenges, it is critically important to improve monitoring and temperature measurement of the tube walls, obtaining an accurate reading and applying a suitable correction method to get the true TWT. A continuous and accurate monitoring solution delivers more data certainty, increasing the uniformity of heat through the furnace and homogeneity of tube temperature. This data allows temperatures to be increased safely, leading to a growth in productivity.

Temperature monitoring helps extend the life of both the tube and catalyst, while also providing early warning of any temperature increases. During start-ups and shutdowns infrared thermal imaging allows the operator to easily identify hot and cold areas, unbalanced burners and the gas mix, allowing better optimisation. Three main areas of measurement can support better performance in the reformer: linear tube measurements, interior temperature measurements, and burner flame monitoring. A thermal imaging solution is the most effective way to monitor all three of these areas.

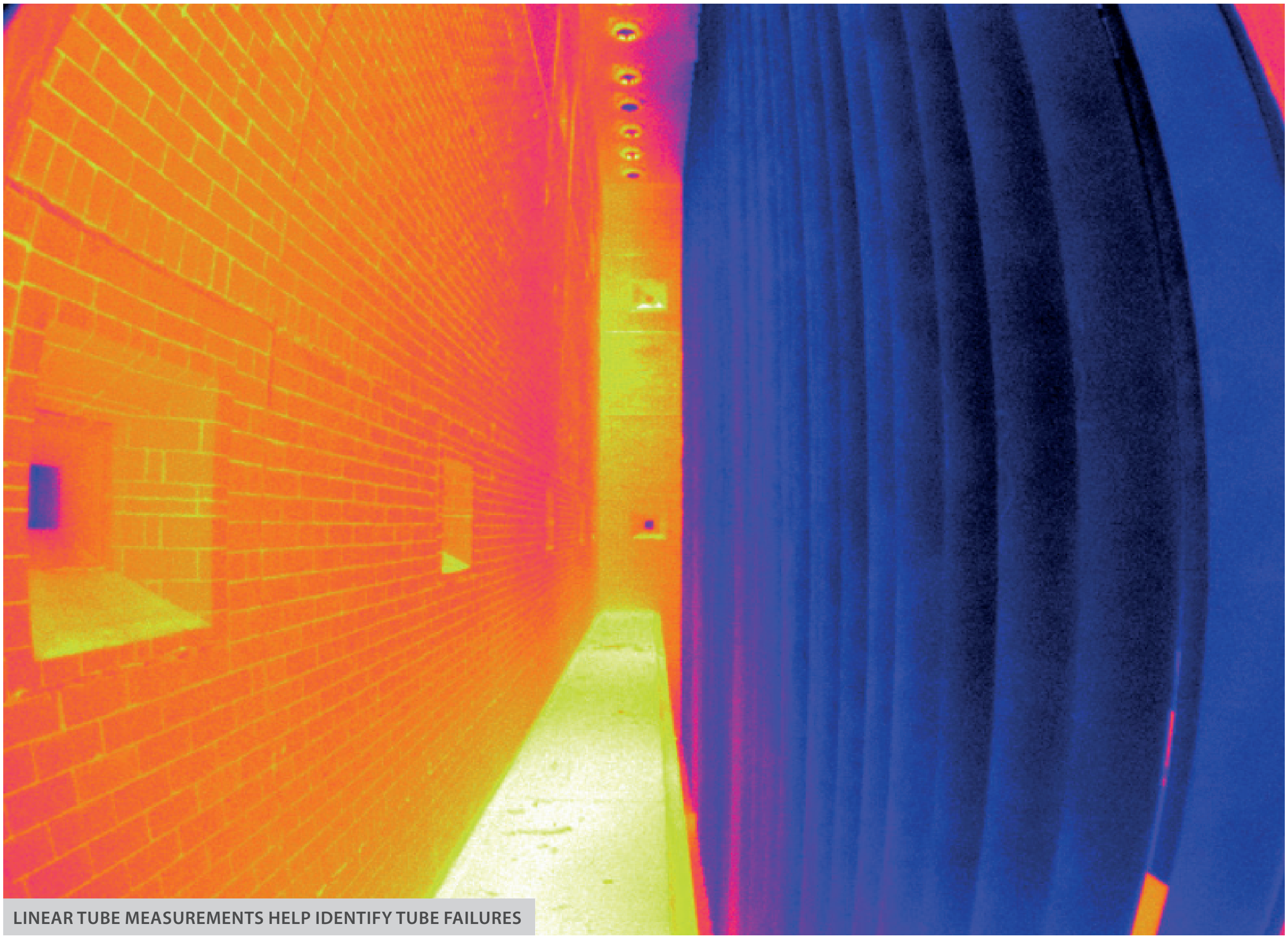
BENEFITS OF ACCURATE TEMPERATURE MEASUREMENTS

LINEAR TUBE MEASUREMENTS:

- Help identify tube failures
- Help indirectly determine catalyst performance
- Help identify carbon formation
- Help determine over-firing and heat flux
- Can compare heat flux and maldistribution within the tube grid
- Can identify fluid flows within the reformer
- Can assist with burner control
- Help improve approach to equilibrium with better knowledge of TWT
- Provide better quantification of exit temperature at the bottom of the tube



REFORMER TUBE APPEARANCE



LINEAR TUBE MEASUREMENTS HELP IDENTIFY TUBE FAILURES

BENEFITS OF ACCURATE TEMPERATURE MEASUREMENTS

INTERIOR TEMPERATURE MEASUREMENTS:

- Help optimise reformer temperature uniformity
- Help prevent burner flame impingement
- Help prevent catastrophic damage to reformer refractory, tubes and catalyst
- Help with fuel trimming
- Help with fire balancing between rows and exterior walls
- Help balance temperatures between rows to limit tube bending
- Help identify refractory wear
- Help map out temperature gradients within the reformer
- Help identify hot/cold zones for better fuel management
- Easily identify critical temperatures throughout reformer
- Help identify port-related failures and collapsed tunnels
- Help identify hot bands on wall tubes due to port openings
- Identify wall temperatures to identify leaks and refractory failure
- Improve heat/mass balance calculations with better air leak estimations
- Help with proper start-up procedures
- Balance pressure and temperature for maximum tube life and asset protection
- Enable true tube temperature measurement over initial stages of start-up
- Help balance firing and feed rates within the reformer to maximise production while minimising overheating, premature creep failure and methane slip
- Help identify and/or prevent carbon formation along the tubes
- Help with proper linear control, which can in turn help mitigate sintering and catalyst deactivation
- Help correlate TWT against catalyst age to better identify catalyst lifetime

WHY IS ACCURACY IMPORTANT?

~7 Million USD/Year Lost Production

NON-CONTACT INFRARED MEASUREMENTS

Non-contact measurements are advantageous because they provide a non-destructive technique that doesn't interfere with the process.

Typical instruments used to make these measurements include infrared spot pyrometers, linescanners, and process thermal imagers. These all operate by detecting the infrared radiation emitted by the target object.

A direct measurement of the target object can be achieved within milliseconds, even if the object is moving fast.

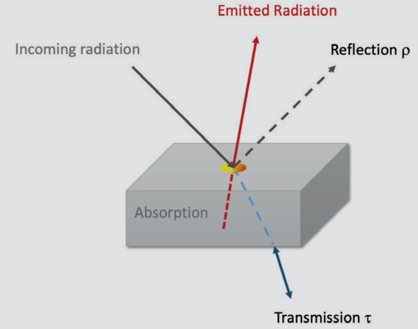
Every object with a temperature above absolute zero (-273 °C or -459.4 °F) contains heat. Part of this contained energy is emitted through radiation, and most of this emitted radiation energy is within the infrared part of the spectrum.

According to Kirchhoff's law of radiation, the sum of all radiation for an object at any time is the sum of the absorbed radiation, the reflection, and the transmission. Transmission is the radiation that passes through an object, and in most metals this value for infrared radiation is zero.

Further, Kirchhoff determined that the absorbed radiation is equal to the emitted radiation, so:

EMISSIVITY + REFLECTION + TRANSMISSION = 1 (OR 100%)

Thus, to measure the temperature of a metal at high accuracy, with a reasonable signal to noise ratio, the emissivity should be as large as possible, while the reflection should be as low as possible.



HOW A BODY ABSORBS AND REFLECTS RADIATION

EMISSIVITY

The emissivity of a material's surface is a measure of its effectiveness in emitting energy as thermal radiation. It is typically defined as the ratio between the thermal radiation of a surface and that of a perfect black body at the same temperature. It is therefore quantified either as a percentage or, more commonly, a number between 0 and 1, where 1 is perfect emissivity.

THERMAL IMAGE OF TUBES WITHIN STEAM METHANE REFORMER.

NON-CONTACT INFRARED MEASUREMENTS

As the object temperature increases, there is an increase in the radiation power and a shift towards shorter wavelengths. This means that cooler objects need to be measured at longer wavelengths.

The Stefan-Boltzmann Law describes the emitted radiation power P by a black body with the surface A and an absolute temperature T (σ is the Stefan-Boltzmann constant and ε is the emissivity):

$$P = \varepsilon \sigma A T^4$$

The temperature in this equation appears at the fourth degree, which means doubling the temperature has an effect with a factor of 16. So, if a cool object is being measured in a hotter furnace, the hotter background will reflect on the object surface – the lower the emissivity of the surface, the higher the reflectivity.

If, for example, the furnace temperature is twice that of the object, the intensity of the background radiation is 16 times that emitted by the object – this can create a huge influence on the measurement.

So, for an object at 100 °C, with an emissivity of 0.2, in a furnace at 1000 °C, a pyrometer or thermal imager would measure a complete radiation signal of:

Object radiation power x Object emissivity + Refractory background radiation power x the Object surface reflection (0.8) x 10,000

This is an influence on the temperature measurement for the object.

HOW TEMPERATURE AFFECTS RADIATION POWER

BODY TEMPERATURE (°C/°F)	TEMPERATURE ENVIRONMENT (°C/°F)	RADIATION POWER RATIO
20/68	30/86	X 5
20/68	100/212	X 625
100/212	500/932	X 625
100/212	1000/1832	X 10,000
100/212	2000/3632	X 160,000

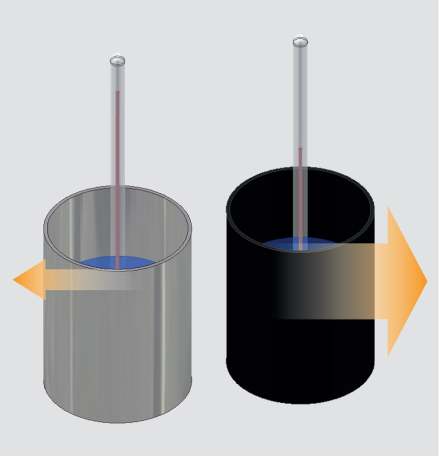
Accurate measurement requires adjustment for emissivity, which itself depends on the material type, surface condition, temperature and wavelength. This adjustment is made by multiplying the signal response by 1/ε .

So, for example if the temperature reading is 747 °C (1376.6 °F) and the emissivity is known to be 0.83, the true temperature will be (747 x 1/0.83), which is 900 °C (1652 °F).

If the emissivity value used for the adjustment is incorrect, it will impart a temperature measurement error. Continuing the previous example, if the emissivity adjustment was wrongly set to 0.84, the temperature given will be (747 x 1/0.84), which is 890 °C (1634 °F), a 10% error.

Fortunately, materials and surface conditions have been studied for decades, and so emissivity values are well known.

Emissivity usually remains unchanged by temperature over a specific wavelength. In addition, short-wavelength thermal imaging minimises any emissivity errors, since the spectral response is at a specific, or narrow-range, wavelength.



EXAMPLES OF DIFFERENT EMISSIVITIES

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USING PORTABLE HANDHELD PYROMETERS

Until recently, every steam reformer operation relied on operators taking TWT readings with handheld pyrometers, usually on a limited schedule.

Used in combination with a suitable correction method to allow for background radiation, this remains a reliable and accurate technique for TWT measurements.

Handheld pyrometers only provide a spot measurement – the operator may not find the hottest area of the tube, leading to overheating.

So, to obtain the best temperature measurements for the application, there are a number of recommended practices to take into consideration.

Firstly, the emissivity setting on the pyrometer should be positioned at 1.0. An emissivity correction factor of 0.85 can then be applied manually. If the emissivity setting is at a value other than 1.0, the measured temperature will exceed the true TWT, inflating the measured readings and so imposing an artificial limit on the plant.

Suitable background measurements must be made for every tube from which a temperature reading is taken. These background readings ought to include all the hotter surfaces that are visible to the tube and so likely to radiate to the optical pyrometer. Example surfaces include the side and end wall refractory, furnace roof and flue gas extraction tunnels. For an accurate TWT correction, between 10 and 15 background readings are required.

The number of correction readings taken should be scaled so as to replicate reality. For example, when taking bottom temperature correction readings for a top-fired furnace, more readings should be taken for the flue gas extraction tunnels, as these will contribute more background heat to the TWT than the end walls.

When the bottom peephole is below the tunnel tops, then the background readings should be taken from the tunnel walls and furnace floor. When the hole is above the tunnel tops, then the top of the tunnels should be measured at a ratio of four top measurements to every one taken of the furnace floor, since the floor also contributes to the radiation measured by the pyrometer.

It is, of course, important to avoid picking up any flame temperatures when making either TWT or background temperature measurements, as these will result in much higher readings.

Where possible, any temperature readings should be taken at a 90º angle to the tube wall. This minimises the path length, which in turn minimises the effect of the radiation emitted by the flue gas. The pyrometer should also be placed as close as possible to the peephole, to reduce the effects of the ambient surroundings, and must be held in a constant position to obtain a uniform reading.

The time for which the peephole door is open for measurements should be as short as possible, to ensure that the temperature within the furnace does not fall during the measurement shoot. In addition, only one peephole should be opened at a time, to prevent the possibility of a draught circulation effect.

AMETEK LAND'S CYCLOPS HANDHELD PYROMETER

USING PORTABLE HAND

Whenever a peephole is first opened, personnel should stand to one side for several seconds, since pockets of higher pressure within the furnace may cause flames to be emitted through the peephole.

Measurement distances should be kept in mind during any temperature shoot session. Generally, optical pyrometers have measuring angles of 33°, and so typically cannot see a whole single tube at distances greater than about 5 m, as neighbouring tubes will obscure it. Radiation from neighbouring tubes will be detected by the pyrometer, masking the true temperature of the target tube. In addition, the viewing angle of a handheld pyrometer is between 7° and 9°, so at distances of greater than a metre, more than one tube will be in the field of view. This makes it difficult for the operator to target the correct tube. At distances above 10 m, it becomes almost impossible to target individual tubes adequately.

Temperature readings should be made from all the available peepholes in order to obtain the most accurate representation of the furnace operation. The distance for temperature readings should be minimised to reduce any slight path effects resulting from hotter furnace gases, and to avoid interference from neighbouring tubes. For top-fired furnaces, this requires TWT measurements from both ends of the furnace.

Finally, it is important to conduct all TWT measurement shoots in a systematic, methodical way to minimise the impact of different people taking the measurements.

A PEEPHOLE IN A STEAM REFORMER FURNACE

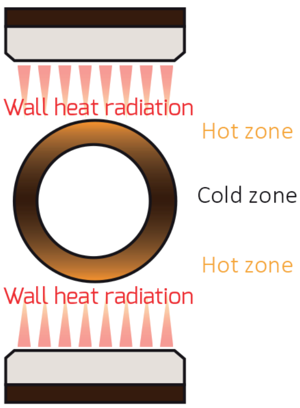
SAFETY CONSIDERATIONS

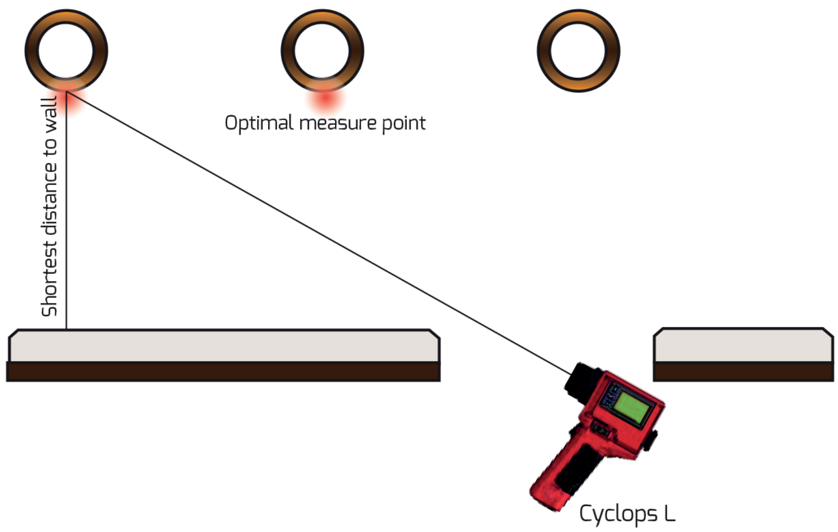
Since these TWT and background measurements are taken manually in environments with high ambient temperatures, it is vital to ensure that all appropriate precautions are taken to safeguard the pyrometer operator.

Fire-resistant clothing is recommended where possible. Heat-resistant gloves are a minimum requirement, since regular cotton gloves are typically not sufficient to prevent burns to the hands from radiated heat while making measurements.

Green-shaded Infrared (IR) furnace glasses should be used to protect against potential eye damage from looking at the inside of a reformer tube for an extended period of time. These glasses also assist the user by making hot bands stand out from the normal tubes. An adequate supply of water should be available, to prevent dehydration, and regular breaks should be taken during the temperature measurement session.

In confined areas with minimal throughflow of air, time spent in the area should be minimised to reduce the chance of thermal fatigue.





MEASURING TWT USING A PORTABLE PYROMETER

COMPARING 1.0 µm AND 3.9 µm PYROMETERS

The two most common operating wavelengths used for pyrometers that measure reformer tube walls are 1.0 µm and 3.9 µm.

Introduced to the industry in the 1990s, the longer (3.9 µm) wavelength shows lower sensitivity to uncertainties in background reformer temperature and tube wall emissivity.

However, this is only the case where the background temperature is higher than the target TWT, which is usually the situation within reformers. If, on the other hand, the background temperature is lower than the TWT, the 1.0 µm wavelength shows the best sensitivity.

Although showing less sensitivity to uncertainties in the reformer, 3.9 µm pyrometers have been shown to give less accurate TWT measurements in studies. They consistently measured higher temperatures after correction than thermocouples, and returned readings that were higher than those predicted by reformer simulations.

In contrast, 1.0 µm pyrometers were found to measure target temperatures in agreement with thermocouples, and were consistent with simulation predictions. The high sensitivity, however, makes it less straightforward to use.

The 3.9 µm pyrometer is a more conservative solution, since it returns higher temperature readings that generally ensure reformer adjustments do not exceed tube design limits.

However, with proper user training, 1.0 µm pyrometers can deliver a more accurate and precise measurement, particularly for clean-fuelled applications. This is because a clean, blue flame is not visible at 1.0 µm, so does not obscure the temperature reading – a yellow flame, from dirty fuel, is still visible at this wavelength, and so causes the apparent temperature to increase.

GOLD CUP REFERENCE MEASUREMENTS

AMETEK Land's unique pyrometer for reformer tubes, the Gold Cup pyrometer creates black body conditions at the measurement point to deliver a repeatable, reliable reference temperature.

Non-contact infrared measurements of TWT are affected by the emissivity of the target surface, and require a way to compensate for reflections from the hotter surrounding environment of the furnace. In addition, depending on the furnace firing method, there may be interference to these measurements caused by dirty furnace atmospheres.

By using a hemispherical reflector (the 'gold cup' which gives the instrument its name), a measurement area is produced which is independent of emissivity. This is ideal when dealing with tubes of unknown emissivity.

The Gold Cup has a narrow protective edge suitable for tube contact. This edge prevents reflected radiation from the hotter surroundings from entering the cavity formed between the tube and the cup.

The gold reflective hemisphere integrates the emitted and reflected radiation, producing black body conditions. This enhanced energy escapes through a small aperture in the back of the hemisphere, where it is measured by the pyrometer module's InGaAs (indium gallium arsenide) detector. The pyrometer module then transmits the temperature signal to the display unit.

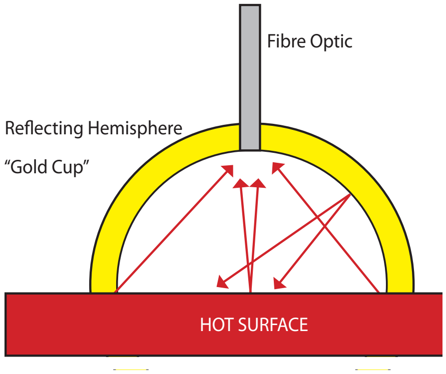
The Gold Cup is designed for portable operation, with a battery-powered display unit that also powers the pyrometer. Once connected to its water-cooling supply, the reflector is inserted into the furnace through a port, before the tube can cool, allowing readings to be taken when convenient, without disrupting the process.

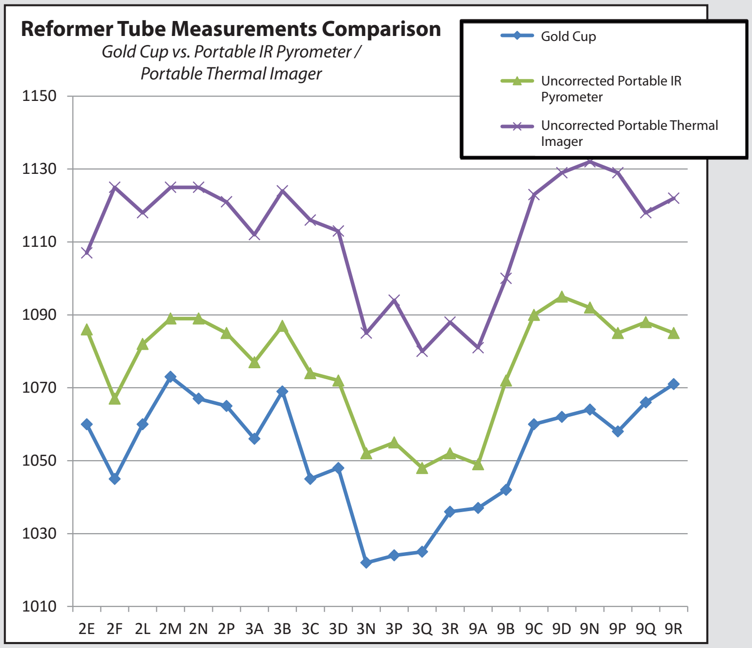
However, the Gold Cup is a large device and, once filled with cooling water, becomes very heavy. There is also a limit to the distance that it can be inserted into the furnace.

For these reasons, along with its relatively high price, it is not practical enough to use for regular measurements, nor is it intended to do so. It provides a periodic reference reading that can be used to increase the accuracy of non-contact devices.

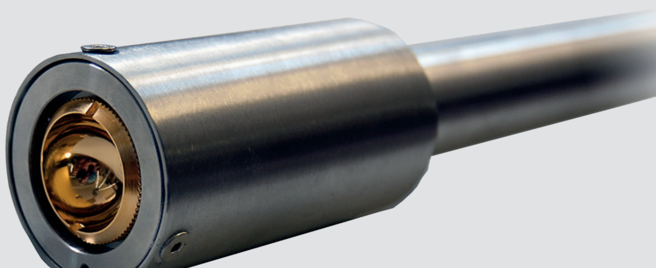
The information from the Gold Cup can be used to eliminate inherent errors and modify infrared thermal imagers and pyrometers. This ensures these non-contact measurements are more accurate, which leads to increased tube life and an improved product yield.

HOW DOES IT WORK?





THE GOLD CUP PYROMETER



HOW IS IT USED?

To obtain highly accurate reference temperature measurements, we must identify any errors caused by three key process variables: tube emissivity, background radiation, and sight path effects.

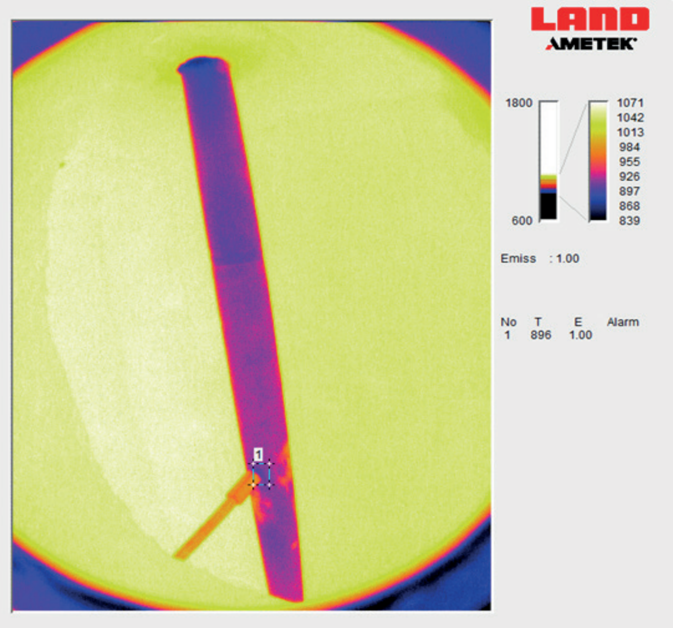
The Gold Cup achieves this by creating near blackbody conditions against the surface of the tube. Therefore the measured temperature is considered to be the true surface temperature, and the portable pyrometer's settings are compensated accordingly.

The device consists of a three-metre-long water-cooled probe which is held against the tube surface. A fibre optic cable connects the Gold Cup to the battery powered digital display which displays the temperature. A thermocouple in the tip of the probe indicates the temperature of the Gold Cup to prevent overheating/damage to the instrument.

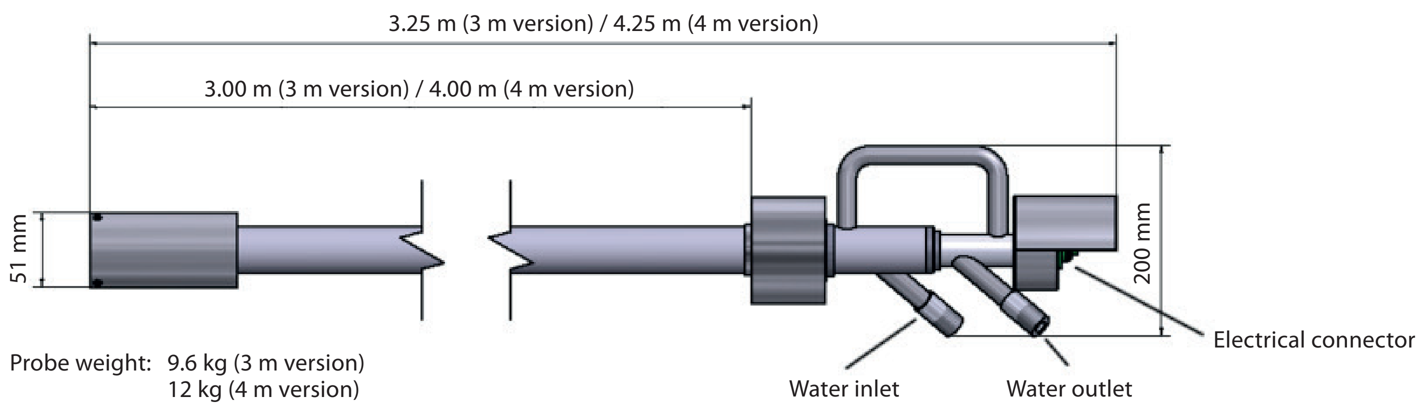
In practice, the Gold Cup probe requires a minimum of two operators. It is carefully inserted through the peephole and the hemisphere is rested against the tube, eliminating sight path effects from hot furnace gases and incident radiation from nearby tubes and refractory surfaces. The temperature reading must be taken straightaway before the measured tube begins to cool down due to being sheltered by the cup.

The Gold Cup must also be applied squarely against surface of the tube. If it is not applied squarely, and if there is a gap between the tube and hemisphere, the reading will include radiation absorbed from refractory, nearby tubes, or CO_2 and H_2O in the furnace: the black body affect is no longer achieved and temperature readings will be artificially high.

The instrument has a measurable range of 625 to 1200 °C (1160 to 2190 °F) and is calibrated in a black body furnace from a ISO 17025 accredited infrared calibration laboratory. The Gold Cup is an industry standard instrument shown to have nearly completely eliminated the effect of surface emissivity on temperature values.



A THERMAL IMAGE OF THE GOLD CUP IN OPERATION



GOLD CUP PROBE DIMENSIONS

DOWNLOAD THE BROCHURE:
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THERMAL IMAGING

To operate within an integrity operating window, there is a need for close, continuous TWT monitoring.

Fixed thermal imaging provides a reliable method of optimising TWT to ensure long tube life. It provides an accurate, repeatable result independent of operator expertise, which improves efficiency and minimises the risk of catastrophic failure.

Emissivity is an important factor in temperature accuracy, so the optimal solution is a thermal imaging camera capable of temperature correction, installed within the reformer for 24/7 operation.

The use of a short wavelength minimises the errors associated with varying emissivity. A thermal imager using a 1.0 µm wavelength provides the most accurate measurement and is more sensitive to both emissivity and background temperature impact.

Thermal imaging delivers a high-resolution image which identifies, in real-time, the temperature measurements of the tube skin and refractory surface. Intelligent installation and a wide field of view should allow for multiple parallel tubes to be viewed simultaneously.

This image allows for easy identification of hot and cold areas within the furnace, making uneven heating immediately visible. When compared with a traditional tube thermocouple, the response time of the thermal imager (0.14 seconds for the AMETEK Land solution) is faster by a factor of 40. This rapid response allows alarms to be triggered when there is a sudden temperature rise, allowing operators to react almost instantly to alleviate a potentially catastrophic event.

In addition, advanced software enables highly accurate processing of the TWT profile data, allowing emissivity adjustments to be made on each tube, or for each area.

The continuous operation of thermal imaging is its key advantage over alternative measurement solutions. Alongside providing accurate, real-time temperature measurements to extend tube and catalyst life, it allows automated or remote operator-controlled temperature monitoring for early warning of rising heat levels.

The real-time measurements enable balancing of the reformer during general operation, and at critical start-up and shutdown stages. It also allows data trending across weeks or months of operation, providing a greater understanding of the reformer process.

By removing the requirement for an operator to make regular handheld spot measurements of the TWT, it also increases safety.

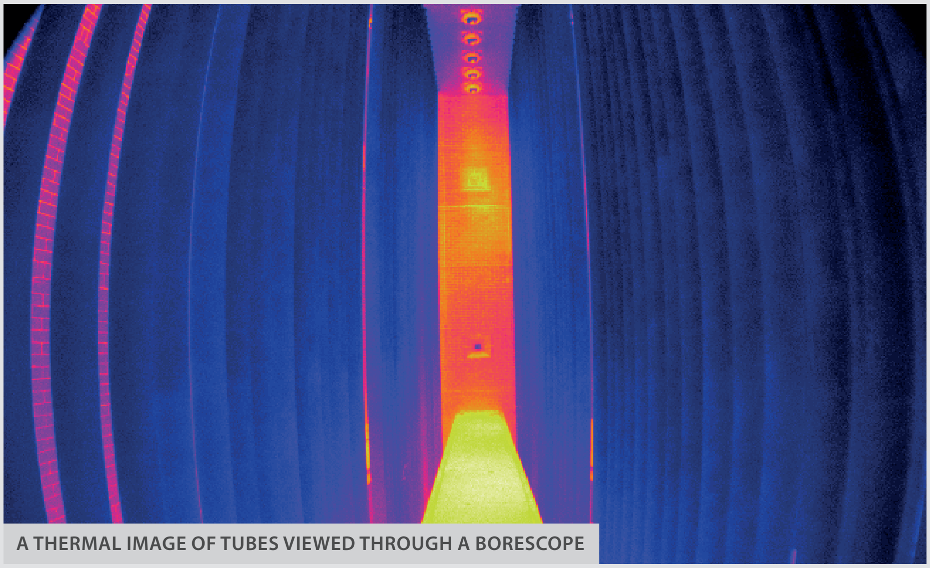
USING BORESCOPE IMAGING

Spot measurements are typically made through peepholes, openings in the reformer housing that allow the interior to be viewed.

Opening these peepholes to take measurements has a cooling effect on the tubes, affecting the accuracy of the TWT measurement. It can also place enormous stress on the tubes, both from a cooling standpoint and from moving/bowing of the tubes.

As the tube cools on the side towards the peep door, the tube will bend towards the higher temperatures, causing stresses that can damage the tube wall.

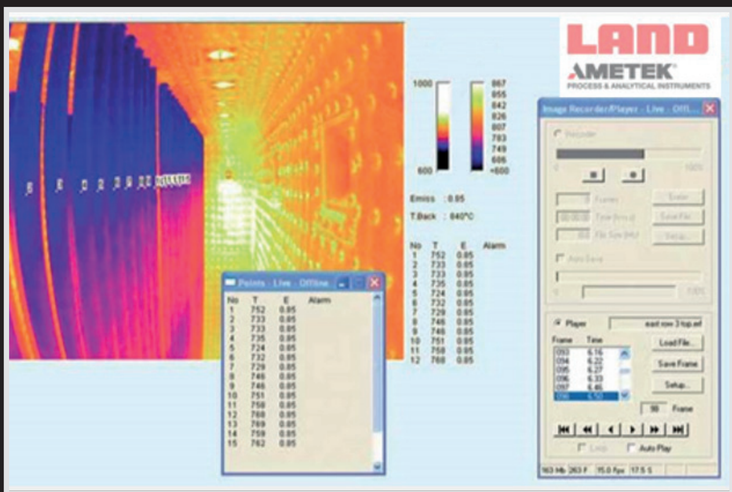
A thermal imager using a borescope can take measurements through a small hole in the furnace wall, which causes much less interference with the process than opening up a peephole. Combined with a wide-angle field of view, this allows multiple reformer tubes to be imaged and measured simultaneously, providing a real-time, high-resolution image with tens of thousands of individual temperature measurement points.



A THERMAL IMAGE OF TUBES VIEWED THROUGH A BORESCOPE

ADVANTAGES OF THERMAL IMAGING

24/7 TUBE WALL TEMPERATURE MONITORING



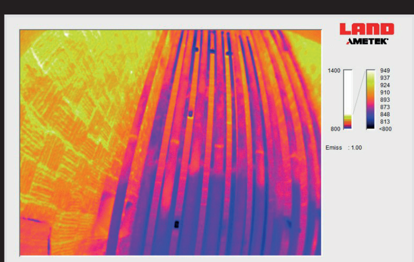
Predictive maintenance can be implemented by monitoring temperature patterns over time.

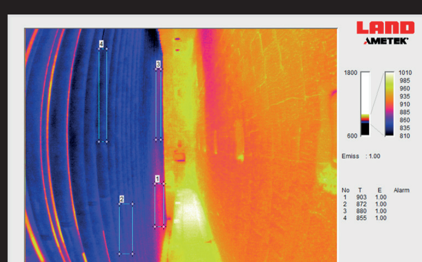
Accurate thermal imaging revolutionises tube wall temperature monitoring because of the huge amount of continuous data it provides versus spot measurements.

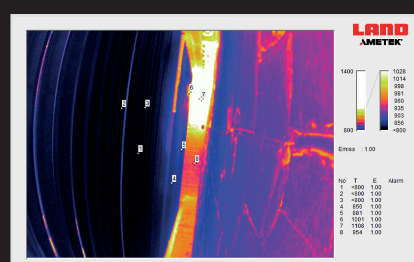
Decisions relating to shutdown intervals and plant capacity can be made based on highly accurate comprehensive sets of data, resulting in significant gains in uptime and plant profitability.

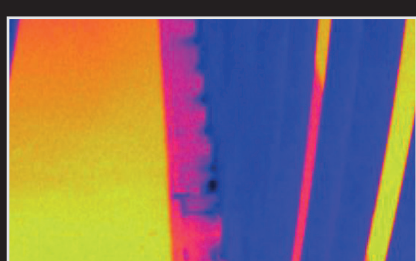
REFORMER OPTIMISATION

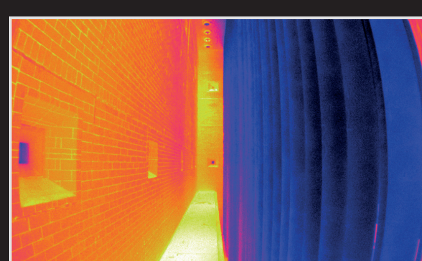
These thermal images show issues relating to reformer temperature balance, flame impingement, hot spots/band, and catalyst damage, and with associated temperature data help inform maintenance decisions.











AMETEK LAND SOLUTIONS

THERMAL IMAGING

SHORT-WAVELENGTH FURNACE BORESCOPE

NIR-B 3XR

PROCESS IMAGING

An infrared thermal imaging solution offering continuous, short-wavelength, 24/7 temperature monitoring for steam reformer and ethylene cracker tube furnaces.

AMETEK Land's short-wavelength radiometric infrared borescope imaging camera has been specifically designed for steam reformer and cracker tube measurements.

It provides a high-resolution thermal image with continuous, highly accurate temperature measurements of both the tube wall and refractory wall surface.

The NIR-B 3XR measures temperatures from 600 to 800 °C (1122 to 3272 °F), utilising the latest wide dynamic range imaging technology. This is ideal for applications with a high differential temperature in the field of view, such as tube and furnace walls.

With a wide-angle, 90° field of view, the imager is able to view and measure multiple tubes simultaneously, producing real-time thermal data from 307,200 points across the image.

It connects to a PC running dedicated image processing software for accurate data analysis and long-term trending.

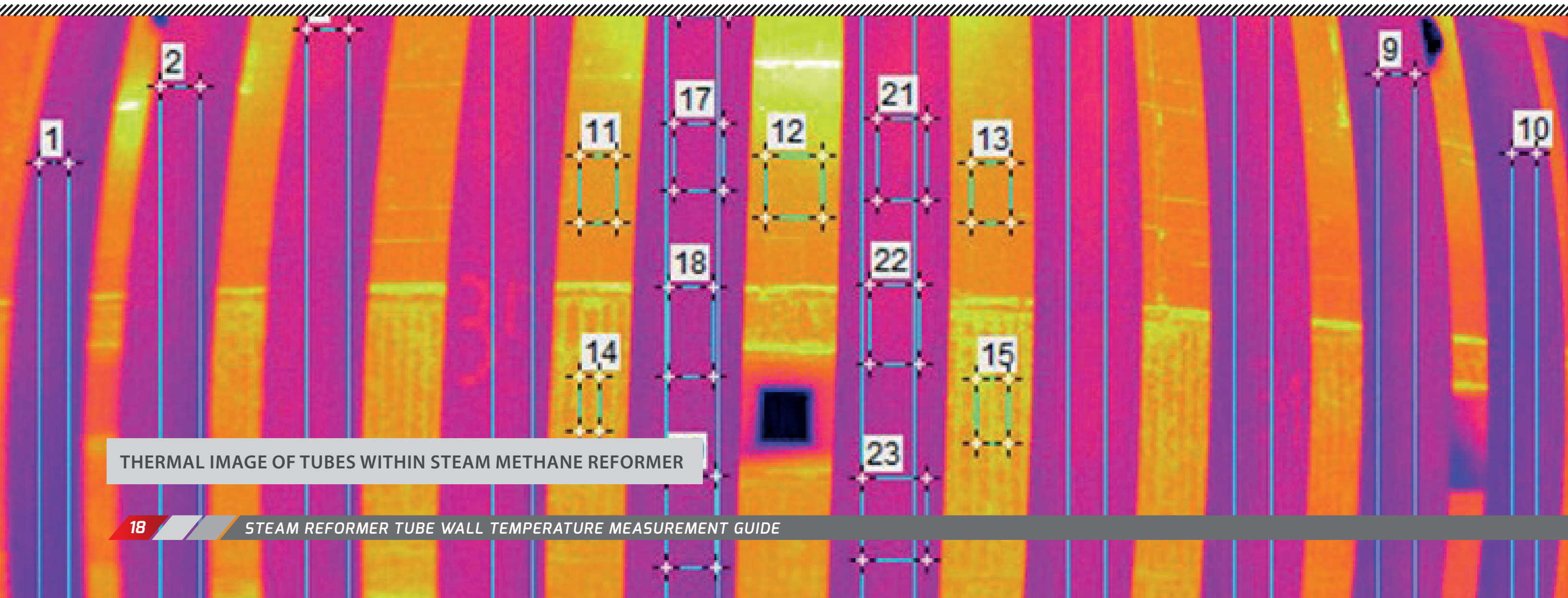
The NIR-B 3XR is ATEX and IECEx approved to Ex nA IIC T4 Gc for use in Zone 2 gas atmospheres, and is CSA Certified for the US and Canada to Class I, Division 2, Groups A, B, C, D T4.

FEATURES

- High-temperature measurement accuracy
- Real-time thermal data
- Short-wavelength sensor
- Continuous 24/7 monitoring

BENEFITS

- Optimum process control
- Rapid response to temperature changes
- Low sensitivity to emissivity changes
- Accurate, reliable data with no blind time



THERMAL IMAGE OF TUBES WITHIN STEAM METHANE REFORMER

FOR THIS APPLICATION

PORTABLE, HAND-HELD

NON-CONTACT TEMPERATURE MEASUREMENT

CYCLOPS L

PORTABLES

Portable, hand-held, non-contact spot pyrometers enabling easy and accurate point-and-measure temperature readings.

The industry standard for handheld portable TWT measurements, the Cyclops range of pyrometers provides accurate non-contact temperature readings on the move.

Four trigger-operated modes are available, with expanded onboard data-logging to store the readings. These consist of:

- **SINGLE MODE** – logs a measurement for each trigger release
- **LATCH MODE** – logs continuous, average, peak and valley readings at a user-defined rate
- **BURST MODE** – logs a stream of measurements while the trigger is pressed, at approximately 30 readings per second
- **ROUTE MODE** – allows the precise execution of pre-configured routes for consistent, long-term readings, using either the instrument alone or with increased functionality through the mobile software

The Cyclops offers enhanced connectivity, including Bluetooth and USB, allowing data to be downloaded periodically to a PC, or live-streamed to a mobile device for analysis and trending.

FEATURES

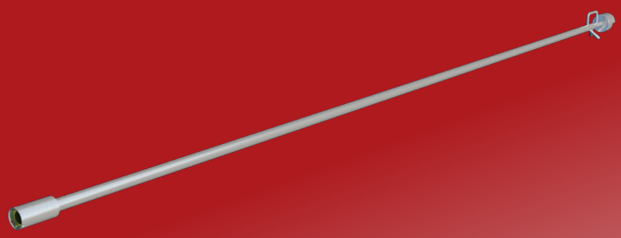
- Rugged instrument casing
- Data-logging software
- Bluetooth and USB connectivity
- Calibrated and traceable to National Standards

BENEFITS

- Highly portable, single-handed use
- Simple, through the lens sighting
- Wireless operation
- Ergonomic trigger control

GOLD CUP PYROMETER

The AMETEK Land Gold Cup pyrometer is the only instrument that can provide a repeatable, reliable reference temperature. It cancels out all the inherent errors typically found within other infrared pyrometer devices. This instrument consists of a gold cup hemispherical reflector. This Gold cup reflector produces a measurement area which is emissivity-independent when placed upon the surface, making it ideal for unknown emissivity tubes.



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A GUIDE TO STEAM REFORMER TUBE WALL TEMPERATURE MEASUREMENT

LAND AMETEK® PROCESS & ANALYTICAL INSTRUMENTS

THERMAL SURVEY SERVICE CONTRACTS:

AMETEK Land has a fleet of Cyclops, NIR-B, and Gold Cup instruments which are used to provide reformer operators with highly accurate, comprehensive temperature data. Typically 2-3 days per reformer is required to produce a detailed report that contributes toward reformer optimisation.

FOR OUR FULL RANGE OF PRODUCTS VISIT: WWW.AMETEK-LAND.COM

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