Heat Tracing Basics

Heat Tracing Basics

Topics of Discussion

- What is Heat Tracing?
- Why Heat Tracing?
- Fundamentals of Heat Loss and Heat Replenishment
- Rules to Remember in the Heat Tracing business.

Heat Tracing Basics

Heating V/s Heat Tracing

Features of Heating

HIGH Thermal Mass needed
HIGH Rate of Heat Transfer
CHANGE of State of Mass
HIGH Temperature Input

Heating V/s Heat Tracing

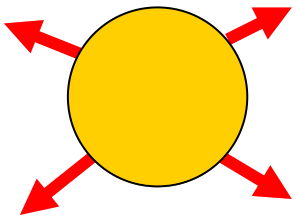
Features of Heat Tracing

LOW Thermal Mass needed
LOW Rate of Heat Transfer
STEADY State of Mass
LOW Temperature inputs

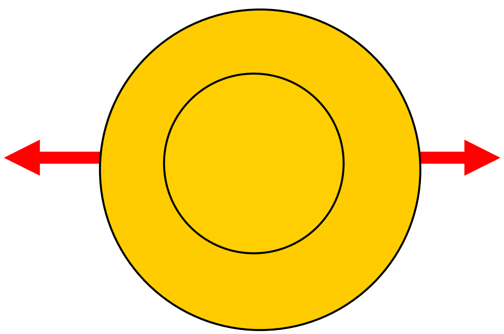
Why Heat Tracing?

- Freeze Protection
- Prevent Solidification
- Maintain Viscosity
- Prevent Condensation (Gases)
- Prevent Moisture (Low Temp.)
- Prevent Moisture (High Temp.)
- Maintain Sterilization

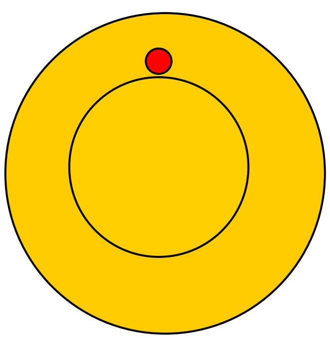
Heat Loss (H/L) Fundamentals



BARE PIPE- 100% H/L

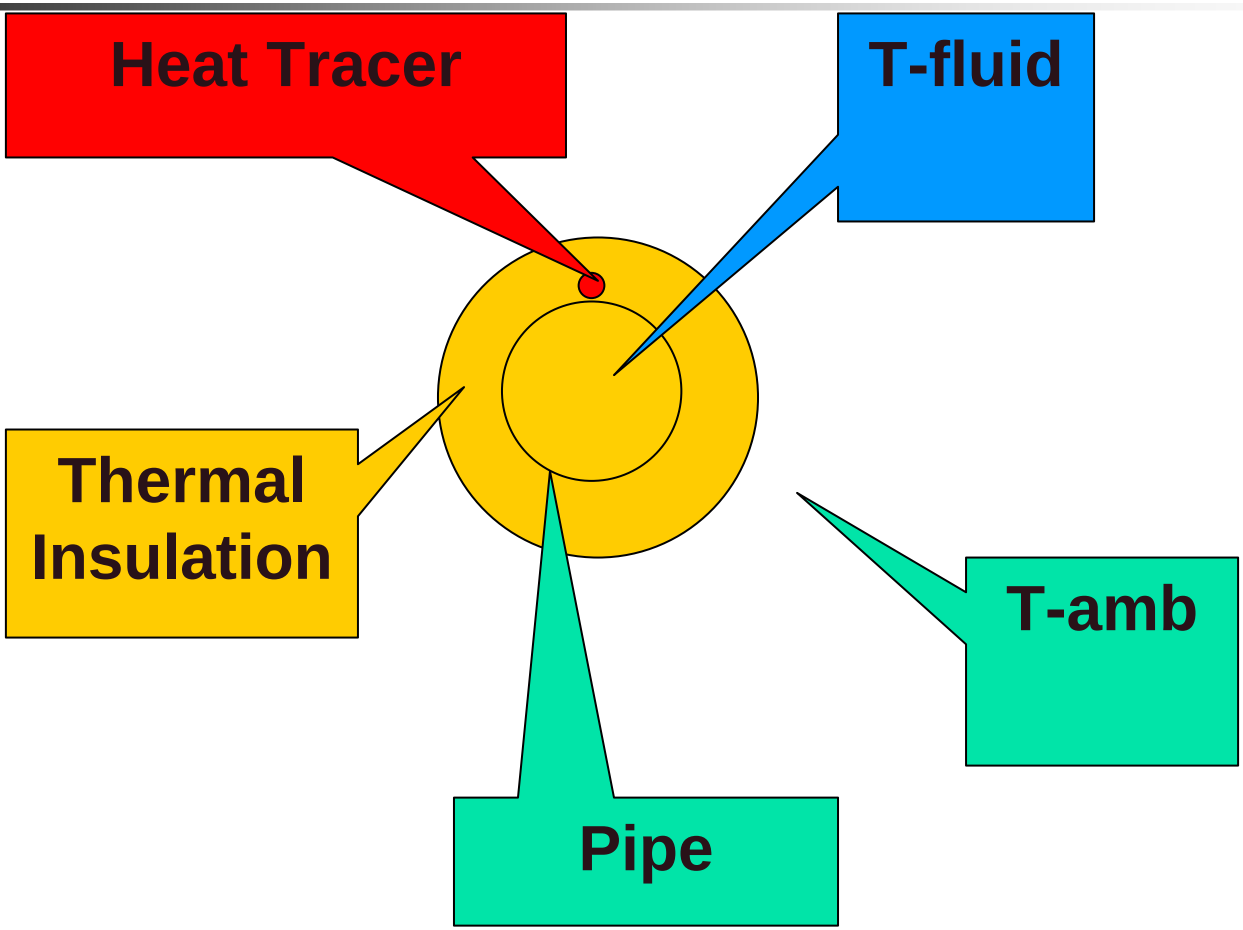


**INSULATED PIPE-
15% H/L**



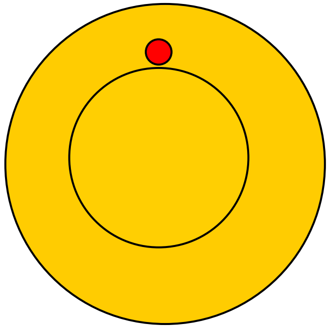
**INSULATED & TRACED
PIPE- 0% H/L**

Heat Loss (H/L) Fundamentals



Heat Loss (H/L) Fundamentals

Differential Temperature (dT)



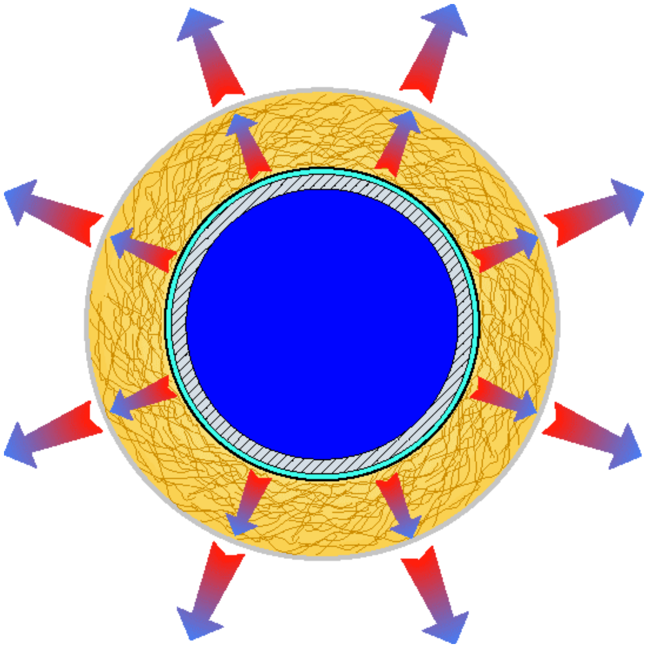
(T-pipe) – (T-ambient) = dT

- **dT α Heat Loss**
- **Higher the T-pipe, Higher the H/L**
- **Lower T-amb. Higher the H/L**

Heat Loss (H/L) Fundamentals

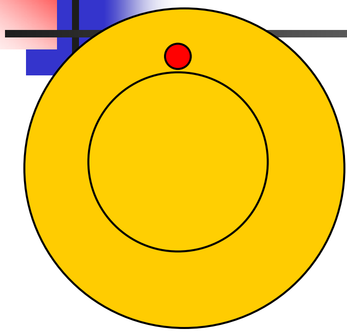
What is Thermal Insulation ?

Thermal insulants are those materials or combination of materials which, when properly applied, retard the flow of heat energy by conduction, convection, and radiation transfer modes.



Heat Loss (H/L) Fundamentals

Thermal Insulation



- **Insulation thickness $^{1}/\alpha$ Heat Loss**
- **Insulation conductivity α Heat Loss**

Heat Loss (H/L) Fundamentals

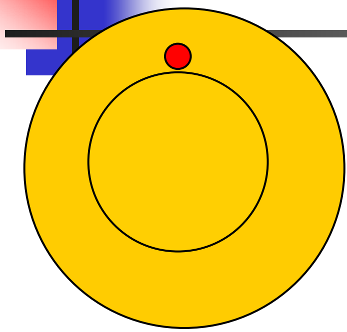
Thermal Insulation

What is Thermal Conductivity?

The rate at which heat flows through any substance after its temperature becomes stationary represents the conductivity of that substance. **Thermal Conductivity is the property of matter by which it transmits heat by conduction and is generally designated by the letter** “k”.

Heat Loss (H/L) Fundamentals

Thermal Insulation



What is Thermal Conductivity?

Materials which transfer heat rapidly such as copper, silver and iron are called good conductors, while those which transfer heat slowly such as fiberglass, rubber or wood are called poor conductors.

Heat Loss (H/L) Fundamentals

What are the Units of Thermal Conductivity?

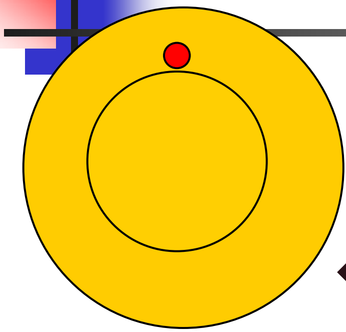
Units commonly used for expressing thermal conductivity (k value) are:

In the SI system, k = W/mK

Mild steel has a thermal conductivity of 45 W/mK while an average k value for fiberglass insulation is 0.036 W/mK.

"k" values will vary somewhat with temperature depending on the substance.

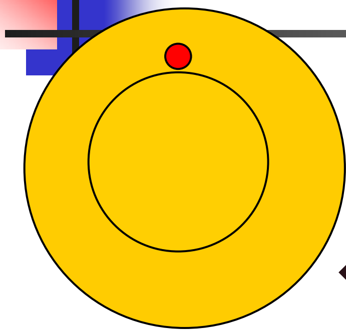
Heat Loss (H/L) Fundamentals



Thermal Design

- **Heat Loss α Energy Loss & Cost**
- **Heat Loss α Heat Tracer Cost**
- **Heat Loss α Cable Cost**
- **Heat Loss α Panel Cost**
- **Heat Loss α Maintenance Cost**

Heat Loss (H/L) Fundamentals



Thermal Design

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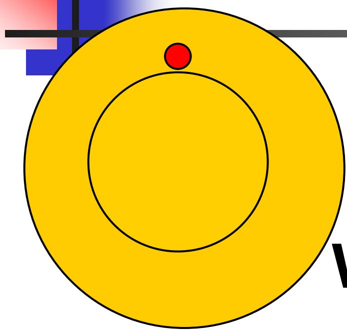
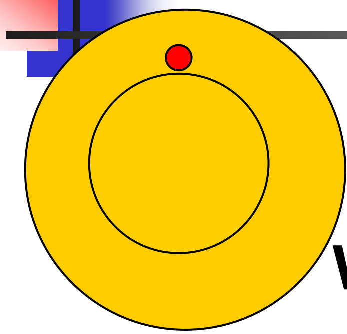
Heat Loss (H/L) Fundamentals



What is the Basic Theory of Heat Tracing?

The theory of maintaining temperature in an insulated line evolves around a very simple heat balance. If the process temperature is to remain constant, **the heat input into the line must be equal to the heat loss (W per meter) through the thermal insulation.**

Heat Loss (H/L) Fundamentals

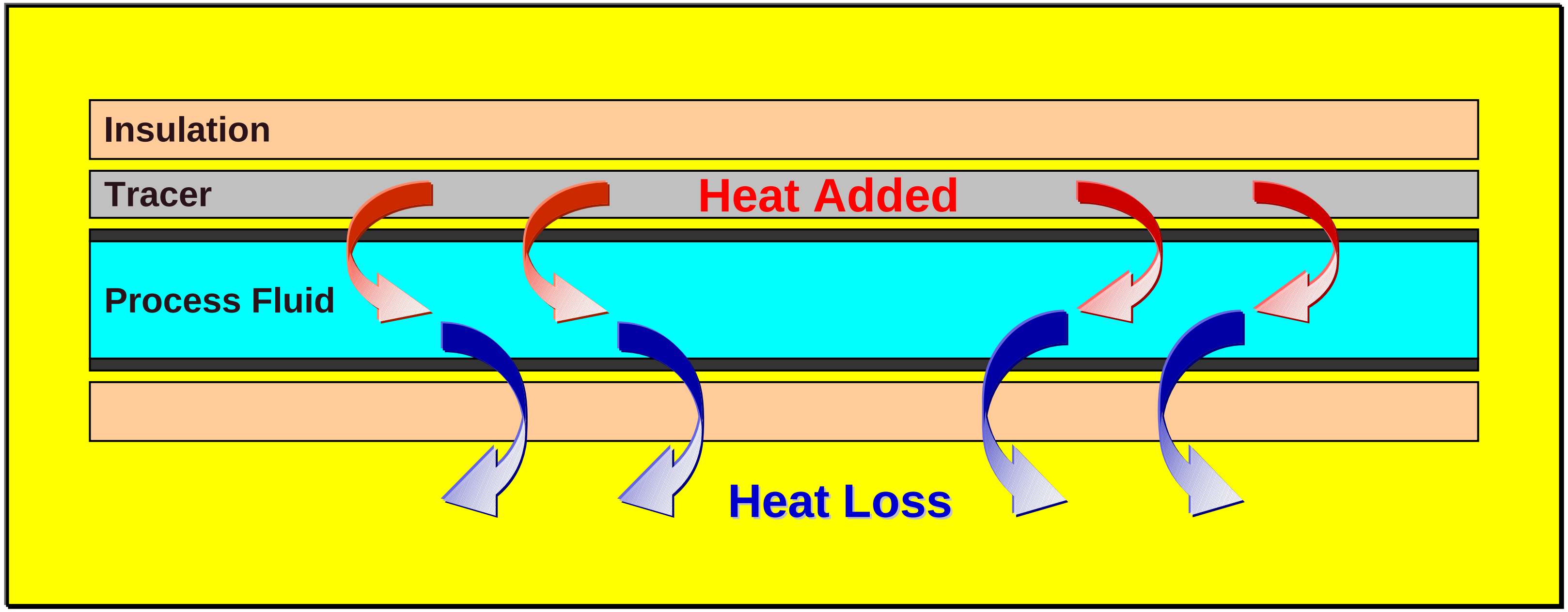


What is the Basic Theory of Heat Tracing?

Selecting the heat tracer type with a **heat output that will most closely match this heat loss** is the key to efficient heat tracing.

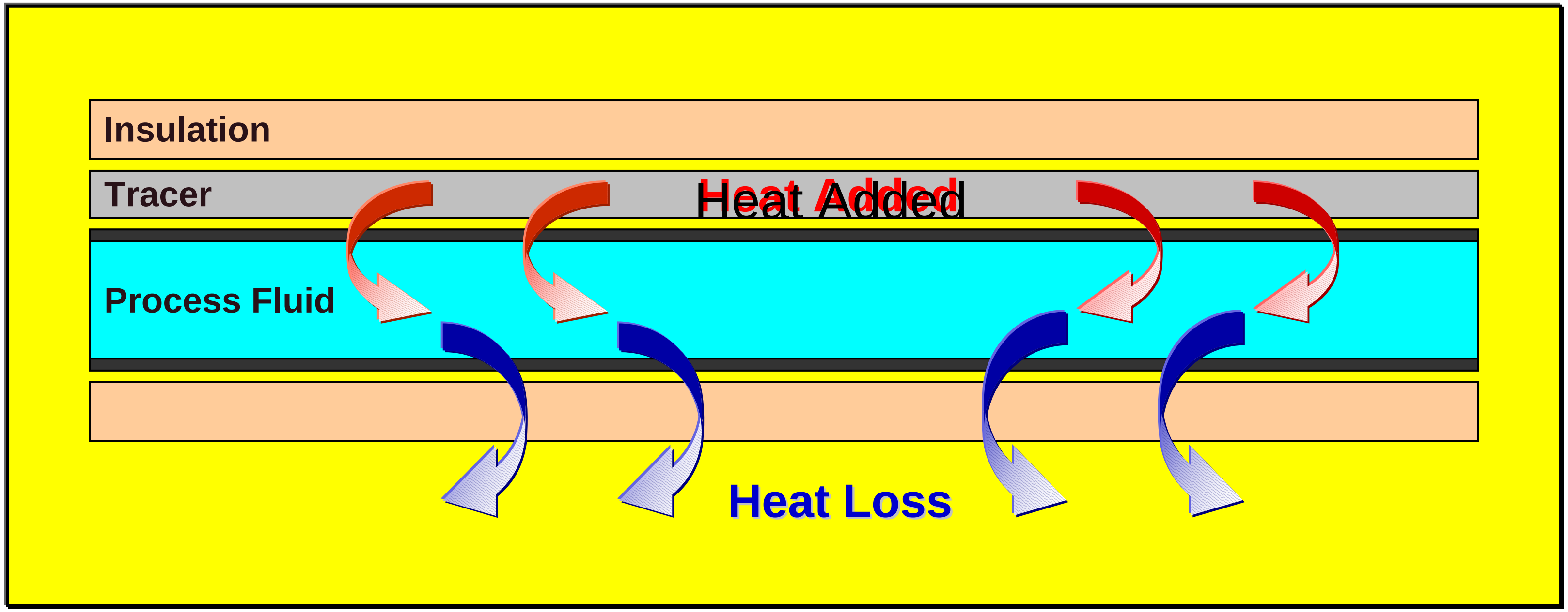
Heat Loss (H/L) Fundamentals

Heat Added by Tracer & Lost Through Insulation



Heat Loss (H/L) Fundamentals

Heat Added by Tracer & Lost Through Insulation



Heat Loss (H/L) Fundamentals

What Happens if Insulation Gets Wet?

The Heat lost through Wet insulation is 12-15 times more than dry insulation.

What are the Steps for Insulation Selection ?

Determine the best type of insulation for the application.

Decide the minimum insulation thickness on economic analysis.

Select a sound weather barrier for the insulation.

Heat Loss (H/L) Fundamentals

Heat Transfer

Heat Loss (H/L) Fundamentals

How is Heat Transferred?

Heat is transferred from one object to another by **conduction, radiation,** and **convection**. In most processes, all three modes of heat transfer are involved, even though one may be the prevalent means of heat transfer in a given process.

How is Heat Transferred by Conduction?

Conduction transfers heat by direct contact. For example, if you put a spoon in a hot cup of tea, you will notice that the spoon will get warm. The ability of different substances to conduct heat varies considerably. Metals (like the spoon) are the best conductors of heat among solids. Such non-metallic objects as wood and rubber are poor conductors and thus good insulators.

Heat Loss (H/L) Fundamentals

How is Heat Transferred by Convection?

When heat is transmitted by **conduction**, no motion of the substance (other than molecular activity) is involved. In the case of **convection** the essential process is the flow of a fluid. **Convection is the transfer of heat from one part of a fluid (liquid or gas) to another by the mixing of the warmer particles of the fluid with the cooler.**

For example, when air is heated, it expands, becomes less dense and moves in an upward direction. Cooler, more dense air moves in a downward direction.

Heat Loss (H/L) Fundamentals

How is Heat Transferred by Radiation?

Radiation is the process by which we receive heat from the sun. Sensible heat, as previously discussed, consists of the vibration of molecules. However, **radiant heat is an electromagnetic vibration or wave, similar to visible light that requires no molecules of matter for its transmission.**

<u>Radiation transfers heat from a hotter object to a colder one without warming the space in between</u> such as the sun warming the earth.

Heat Loss (H/L) Fundamentals

What is Meant by Overall Heat Transfer Coefficient?

The overall heat transfer coefficient represents the summed effect of all the individual resistances (previously described) that restrict the flow of heat in a steam tracing system. Each of these resistances is called a local heat transfer coefficient.

Local heat transfer coefficients are the individual resistances restricting the flow of heat from the steam in the tracer to the process fluid in the pipeline. The resistances that involve a fluid such as air or the process material in the pipeline are called film coefficients or convection coefficients.

Heat Loss (H/L) Fundamentals

Heat Transfer Coefficients Continued

Film coefficients sometimes called convection coefficients which include the effects of both conduction and convection, and are often derived experimentally.

When a fluid is in contact with a retaining wall, a thin film of the fluid will remain relatively stagnant along that wall as a result of friction with the wall, even when the main body of the fluid is in motion. The thickness of this stagnant film is not clearly defined and varies as the degree of turbulence in the main body of the fluid varies. Since heat is transferred through this film largely by conduction rather than convection, the entire process by which heat is transferred from the retaining wall to the main body of fluid is rather complicated.

Heat Loss (H/L) Fundamentals

Heat Transfer Coefficients Continued

The values of film coefficients vary considerably with change in state, impurities, scale deposits, etc. Charts and tables for determining film coefficients are available in various engineering handbooks.

Since most steam tracing applications are for “temperature maintenance only” where the traced pipe is in a steady-state condition (thermal equilibrium), Thermon generally uses a conductance rate which embodies both the overall heat transfer coefficient and the heat transfer area. This conductance rate is derived empirically for all of the tracer types and is used in most steady state calculations including the CompuTrace SteamTrace software.

Heat Loss (H/L) Fundamentals

What is the Basic Heat Transfer Equation?

The total amount of heat transferred in a steam tracing system can be represented by: $Q_T = U_T\ A\ \Delta T$

Where:

Q_T is the amount of heat supplied in W/m

U_T is the overall heat transfer coefficient in W/m^2-°C and is the reciprocal of the overall resistance where, $U_T = 1/R_T$ or $1/U_T = R_T$

A is the effective heat transfer area in m^2

ΔT is the difference in the heat tracer and the process temperature (T_{ht} - T_P) in deg. C for steady state conditions.

Heat Loss (H/L) Fundamentals

The Basic Heat Transfer Equation Cont...

For product heat-up the the temperature difference will be the log-mean temperature difference (LMTD) where:

$$\Delta T = \frac{(T_S - T_1) - (T_S - T_2)}{\ln \dfrac{(T_S - T_1)}{(T_S - T_2)}}$$

Heat Loss (H/L) Fundamentals

Pipe Heat Loss (Q) W/m =

(N.F) x (Differential Temp) deg.C x (k-value) W/m-deg.C x (Design Margin) %

Tank Heat Loss (Q) kW =
[(Area) sq.m] x [(dTemp.) deg.C] x [(k) W/m-deg.C] x [(dM) %] <u>divide</u> by Insulation Thickness ‘t’ in mm