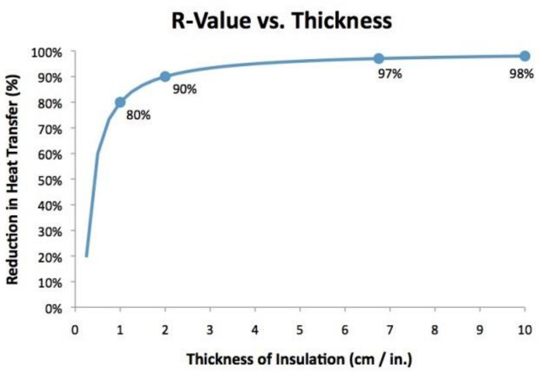
While from an engineering perspective, greater the insulation the better is the performance, one has to acknowledge that this is a financial decision as increased capital increases cost. There is a trade-off which needs to be reckoned with as Insulation vs energy saving follows the laws of diminishing returns.

To understand this better we need to look at the "R" value of the insulation.

Resistance to conduction is measured by R-value (high thermal resistance = high R-value); Resistance to radiative heat transfer is measured by emissivity (high resistance = low emissivity and high reflectance). Conduction is the dominant factor when materials are touching each other; when there is an air gap between materials, radiation becomes important. Convection usually only becomes an issue when significant air pockets are involved.

Because R-values are 1 / conductance (U), doubling the thickness of insulation will not cut heat loss in half. Rather, there is an exponential decay of heat flow, where the difference between no insulation and one inch (or one cm) of a particular insulation may save 80% of heat loss, while going from one inch to two inches of that insulation saves an additional 9%, and going from 9 inches to 10 inches only saves an additional 1%.

Reduction in heat loss does not follow R-values linearly, but in an inverse logarithmic curve.



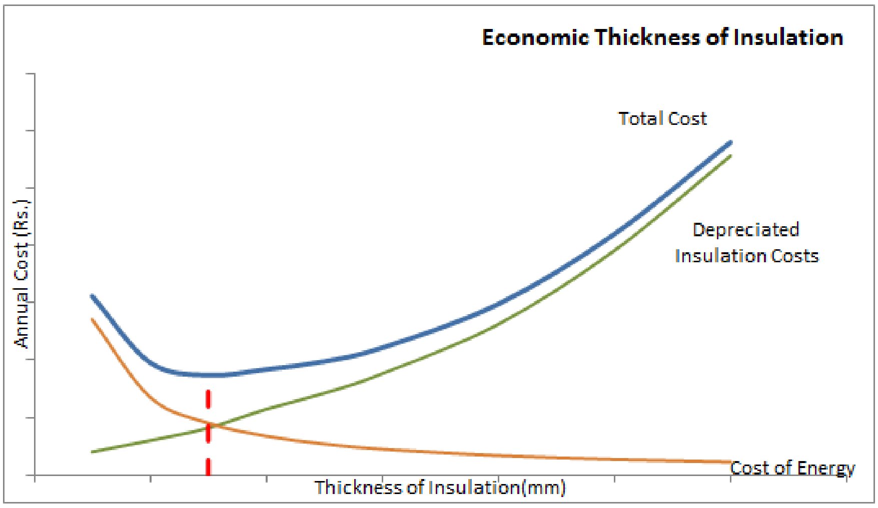
There is a substantial difference between insulation for temperature control and insulation for heat loss control. For instance, the graph (below) shows the heat loss control of the spray-in-place urethane foam insulation. Any insulation will have a similar graph but with thicker amounts of insulation. This graph points out that more insulation is not necessarily cost effective. There is a point where more insulation is pointless from a total heat loss perspective.

However to arrive at what thickness of insulation is economic from a financial perspective, especially when the returns on savings from increased insulation are not commensurate with the increased cost of insulation, we need to take into consideration the a wide range of parameters which include the following:

- Ambient Temperature
- Temp at which the Chamber is proposed to be maintained
- Atmospheric Heat Q (Atmospheric)

- "k" Value of Insulation
- Area Considered
- Energy Cost
- Hours of Operation per Day
- Insulation payback period / Depreciation

Once these elements are factored the following graph can be plotted of Costs Vs. Insulation



The generic graph above shows the energy cost, insulation cost, and total cost used to determine economic thickness for an insulated pipe.

The following three sets of curves are represented in Figure 1:

- A curve (**Orange**) that shows the decreasing lost energy cost for increasing insulation thicknesses
- A curve (**Green**) showing the increasing installed cost for increasing insulation thicknesses (with jumps where the number of layers is increased from one to two, then from two to three layers)
- A Total Cost curve (**Blue**) that shows the sum of the previous two curves (the lowest point of this curve corresponds to the economic thickness).