# PRE-INSULATED PIPING

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The face of Indian cities is gradually changing, spurred by the growth of the economy and the demand for bigger buildings with larger floor areas, to house thousands of new IT and BPO workers who are entering the industry every year, shopping malls, hotels, hospitals and airports. Earlier, new building owners talked about floor areas in terms of thousands of square feet but now they talk in terms of lakhs of square feet. HVAC consultants and contractors in earlier years talked about plant capacities in terms of 1000 tons and 2000 tons which were considered large but now they talk in terms of 5000 tons and 10,000 tons.

Such large buildings require extensive chilled water piping to feed dozens of air handling units and remote plant rooms to keep noise and vibration as far as possible from the occupied areas. Huge chilled water headers and mains are needed to feed branches to different parts of the building and run through vertical shafts that are not easy to access and work in.

Building developers insist on tightly compressing completion schedules in order to start earning lease rentals or recover their investments through outright sales as early as possible. Contractors are hard pressed to find adequate skilled labour to complete projects on time or face penalties for delay. While ductwork suppliers have introduced factory prefabricated ductwork manufactured on high speed, special purpose, sheet metal fabrication machines, insulated chilled water piping contractors continue to follow the age-old practice of first installing the pipes, often using

## About the Author

**Sankaran** is a mechanical engineer from Madras University with a post graduate diploma in management. He joined Blue Star Ltd in 1969 as a trainee engineer, worked his way up to vice president of the AC&R Projects division and retired after 37 years of work in the company. The largest project he handled during his tenure with the company was a 36,000 ton water chilling plant for Khammam Chemical Refinery. He has pioneered the manufacture of pre-insulated piping in the company he helped start with a few ex-colleagues after retirement. He is a senior and active member of ISHRAE and an ASHRAE-fellow.

# & ITS ADVANTAGES

*Photo 1 : Typical scene at a site where insulation work is being done. Notice the open flame for melting the bitumen and then hand carrying it to where needed for sticking the insulation to the pipe.*

field fabricated elbows and tees, welding, pressure testing, insulating and cement plastering as the final protective coat. Very, very time consuming and messy work often executed with poor quality.

Pre-insulated piping work with advanced planning and exact measurements carried out in a factory with proper supervision and controlled quality of work is the answer to the dilemma of the consultant and the contractor to deliver a project on time and without subsequent problems of insulation breakdown.

## Pipe Insulation – the Present Scenario

Nitrile rubber insulation in the form of tubes for pipes up to three inch diameter and sheets are now available, manufactured in India by two international companies. For larger sizes the most commonly used economical insulation is expanded polystyrene in moulded half-pipe sections or sheets. This material is generally stuck to pipes using hot bitumen, covered with a plastic sheet vapour barrier, chicken wire mesh and sand- cement plastered for protection from the rains and physical injury. Polyurethane foam insulation is also available in moulded half-pipe sections and sheets but the method of application is the same as in the case of polystyrene.

*Photo 1* shows a common scene at a project site where insulation work is in progress using polystyrene half-pipe sections and hot bitumen for sticking the insulation to the pipe. Notice the crude method of melting the bitumen in an empty drum using discarded packing wood with an open fire and then hand carrying the melted bitumen to various locations. Not only is such work time consuming but also dangerous for the workers and to the property.

## What are Pre-insulated Pipes?

Pre-insulated pipes are similar to prefabricated insulated panels used in the construction of cold storages, where such polyurethane foam (PUF) panels have almost replaced brick masonry wall construction and site insulation using polystyrene. Just like the ingredients of polyurethane foam are injected between two metal sheets forming the outer and inner skins of the cold storage panel, the same procedure is followed by

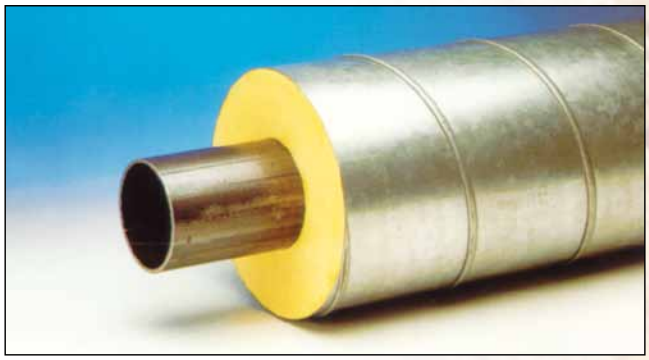

*Photo 2 : Preinsulated steel pipe with spiral wound galvanised outer jacket.*

injecting the chemicals using special-purpose injection machines in the annular space between a leak proof outer jacket and the pipe, which is referred to as the "carrier" pipe. The chemicals combine to form a foam which expands, filling up the entire annular space and on setting forms a homogenous insulation without any breaks or gaps around the carrier pipe. The ready-to-install carrier pipe with insulation and outer protective jacket is called "pre-insulated" pipe,which is easy to transport to the site. See *Photo 2*.

Carrier pipe material is chosen depending on the application. The following are suitable materials: steel, copper, polyethylene, polypropelene, GRP, PVC.

The outer jacket protects the insulation from moisture and external impact and prevents diffusion of water vapour. The location of the installation must be considered when choosing the material of the jacket: polyethylene, PVC, spiral-wound galvanized sheet steel. Underground jackets have to be watertight and corrosion resistant, which makes polyethylene an ideal choice. PVC is sutiable for pipes running in racks or a terrace while metallic jacket can be used inside buildings like in a shaft, corridor etc.

## Common Problems with Field Insulation

A few photographs taken very recently at a job site where traditional insulation work was in progress using expanded polystyrene half-pipe sections and slabs reveal the various practical deficiencies with the present method of application.

The common problem faced is the mismatch between the outer contour of the pipe and the inner contour of the polystyrene pipe section, due to which, gaps ranging from 2mm to 12mm are often noticed as can be seen clearly in *Photo 3*.

All insulation pipe sections also have two continuous longitudinal joints and two circumferential joints for every metre length. Normally these joints also come with gaps. It is good engineering practise to stagger the joints but this is commonly overlooked. See *Photo 4*.

For large size pipes (above 250 mm in the case of polystyrene and above 300 mm in the case of PUF) insulation pipe sections are not generally available and in such cases the insulation is carried out by cutting slabs into small trapezoidal strips and stuck to the pipe with

*Photo 3 : Air gap between pipe & insulation for field applied insulation.*

*Photo 5 : Multiple joints in the insulation for large diameter pipes.*

*Photo 4 : Insulation joints not staggered have large gaps in circumferential joints.*

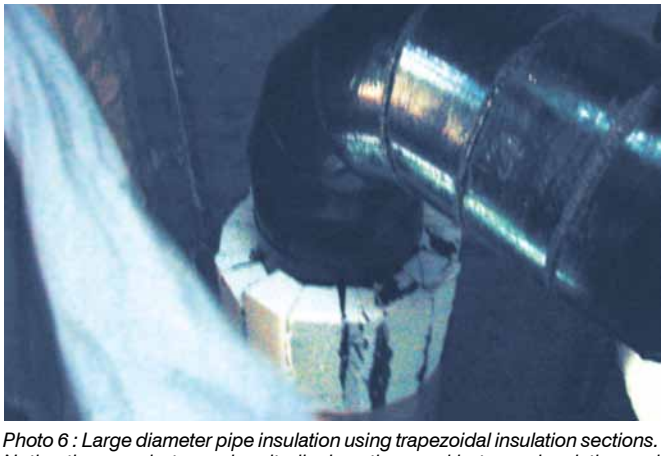

*Photo 6 : Large diameter pipe insulation using trapezoidal insulation sections. Notice the gaps between longitudinal sections and between insulation and pipe.*

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hot bitumen. The number of joints can be observed in *Photo 5*. *Photo 6* shows how manual cutting of trapezoidal sections leaves gaps between two longitudinal sections. Also flat slabs fixed on a pipe of circular contour leave a gap between the insulation and the pipe which eventually gets filled with moisture once the chilled water system starts operating. Refer *Photo 3* again.

## The Ineffectiveness of Insulation with Many Joints

The 'K' value of PUF insulation at laboratory condition is around 0. 02 W/ sq. mt deg. K. This is what is assumed when we calculate and design the insulation thickness for chilled water piping. With all the the discontinuous insulation it is impossible to achieve the above 'K'value for the composite pipe insulation. This insulation 'K'value is also applicable when the insulation is dry,with no moisture penetration.

Large gaps, between pipe and insulation, being inevitable in field insulation, moisture gets trapped in all these gaps. Further, with poor vapour barrier treatment moisture enters through all these gaps on a continuous basis. Moisture, thus trapped, condenses on the pipe. The water thus condensed permeates through the insulation and reaches the outer surface where it either gets evaporated or forms small droplets of water and falls down. This process occurs continuously. It is pertinent to note that the 'K' factor of water is very high 0.58 W/sq. mt. deg. K : thus the entrapped water which permeates through the insulation becomes an excellent conductor, and makes the insulation useless over a period of time. We have come across such insulation failure very frequently and repair of insulation work, while the plant is working is impossible. We have to stop the plant raise the water temperature to ambient condition to avoid sweating; then re do the insulation. Insulation failure and repair is a major headache in continuous process industry as also in applications like hotels, hospitals etc.

*Photo 7 : Pre-insulated pipe lengths with field insulated elbow.*

## Advantages of Pre-insulated Pipes

In the case of pre-insulated pipes there are no such joints at all. Straight pipes are manufactured at the factory with a zero leak outer casing and injecting polyuretherc in the void space between the carrier pipe and outer casing ensuring no break in insulation. Field jointing is done by fixing a standard fabricated outer casing, and field filling with PUF chemicals, which expands, filling up the void and gets integrated with the factory insulation, thus ensuring no breaks in the insulation. *Photo 7* and 8 shows how field insulation is done to ensure integral mass of insulation.

Thus pre-insulated pipes ensure continuous insulation with zero leak, metal/plastic/HDP outer casing which acts as a fool proof vapour barrier making the insulation 'K'value very close to laboratory results.

### *No Premature Pipe Corrosion*

Poor insulation and consequent moisture condensation causes a serious corrosion problem on the external surface of the pipe. *Photo 9* will give an idea of the extent of corrosion that can occur due to poor insulation, there

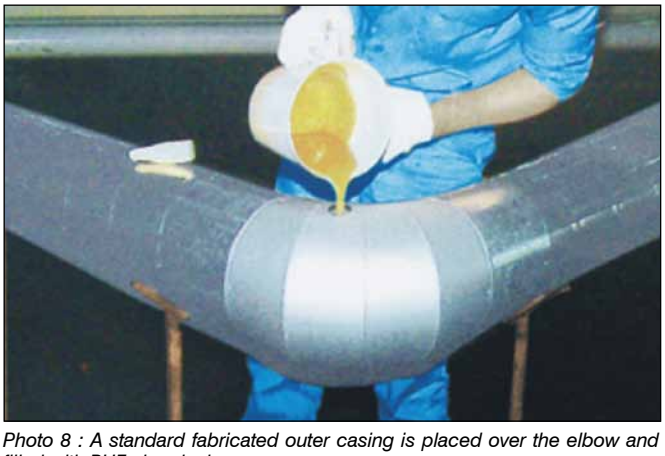

*Photo 8 : A standard fabricated outer casing is placed over the elbow and filled with PUF chemicals.*

*Photo 9 : Corrosion in supply chilled water pipe pipe*

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by reducing the life of entire piping system. Thus, pre-insulated pipe addresses one of the major problems of site insulation, thereby not only saving power due to excellent insulation properties but also ensuring longer life of the piping system.

***Pipe Supporting is Easier and Better***

Site insulated pipes are supported independently either by a wooden support or a high density PUF saddle. These supports are kept below the pipe before insulation is started and this becomes a weak point in the insulation and also breaks the insulation where ever supports are provided. It is a common sight to see a wet patch or water dripping near each support.

No such special supports are required for pre-insulated pipes. They can be supported in the same way as bare pipes except that the width of the saddle on which the pipe rests should be longer to enable a larger area of PUF section to transfer the pipe load to the support.

***Ideal for Shafts***

Service shafts are becoming smaller and smaller due to very high floor space rentals. New buildings under construction have very small service shafts that can barely accommodate the insulated pipe leaving virtually

*Photo 10 : Shaft insulation with pre insulated pipes.*

no working space for carrying out insulation, plastering or welding. In such cases pipes are insulated, then welded at terrace level and lowered down. At a few places,field insulation is done by small boys who can go into the shaft taking risks. Finally the quality suffers. Custom made pre-insulated pipe with *grooved* joints is the only solution for such application.

***Ideal for Underground Runs***

World wide, underground chilled water piping is carried out with pre-insulated pipes with HDP/GRP outer casing. This ensures zero water/moisture penetration, The mechanical strength of the pre-insulated pipe withHDP/GRP outer casing is also very good so that the pipe or the insulation hardly gets damaged while installing under road crossings etc. District cooling jobs, now very popular in the Middle East, where kilometers of pipes are buried underground, use only pre-insulated pipes as this is the only fool-proof way of taking up insulation work for underground applications.

The underground pipe jointing has also been standardized. After completing the normal field jointing, "heat shrink" wrap-around sleeves are placed over the GI casing with proper overlap. The heat shrink sleeve is then heated uniformly with a blow torch, hand pressed without wrinkles, giving a leak proof jointing system.

Another major problem faced by the the facility manager is to locate the leak in underground piping, in the event of leakage taking place due to internal corrosion. Pre-insulated pipes can be provided with built in ERM (electric resistance monitoring) leak detection wires to identify the exact location of leak as and when it happens.

***Withstands Abuse and Remains Neat***

Pre-insulated pipe with metallic jacket, provides an excellent mechanical protection to the insulation. Metallic jacket can take some rough handling, mechanical abuse and impact of falling objects, etc. and will stay good for the full life of the carrier pipe.

Normal specifications in India, call for chicken wire netting above the insulation and two coats of sand cement plaster for mechanical protection. Due to poor workmanship and lack of curing the cement plaster cracks over a period of time; further it cannot withstand any mechanical abuse. With shortage of good masons, cement plastering is more of a hassle at work sites nowadays. Cement plastering is a messy and time consuming operation. Definitely not suitable for our present day fast track completion schedules.

Specifications abroad call for Foster 30-36 coating, which is a white, fire resistive, washable, abrasion resistive chemical. Canvass or glass lagging cloth is dipped in Foster compound and wrapped around the insulation with suitable overlap. Two coats of Foster chemical is brushed on top of this application to make the insulation mechanically strong and weather proof. This is far superior than cement plastering but is as expensive as pre-insulated pipe.

***Reduces Installation Time***

By using pre-insulated pipe, one activity, pipe insulation at the site is eliminated from site activities. Further, if the piping contractor is taught the methodology of field insulation, which is quite simple, the insulation contractor can be removed from the list of subcontactors. For project managers, supervision of site insulation is a

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major headache. With dwindling skilled manpower, the quality suffers heavily. There is no special test possible at the time of installation for approving the quality of insulation work. Only physical inspection is possible, that too while the work is progressing. The outer coat of bitumen and vapour barrier treatment, like cladding will conceal most of the bad workmanship. On a rainy day, insulation will start sweating, spoiling the false ceiling or carpet. It is such a nuisance to repair the insulation work after taking a shut down, draining water etc. Pre-insulated pipe reduces the site supervision considerably: only site jointing has to be inspected which can even be done on a 100% basis.

Custom manufactured pre-insulated pipe with factory drilled tap-off holes and grooves enhances the speed of site work as only *grooved* jointing with a coupling has to be done at site. Since no fit-up or welding is required at site,there will be no wastage of time due to non availability of power, welder or fitter. Further, no skilled persons are required to assemble the piping at site. Trained helpers can comfortably do the job at a much faster speed and the final finished piping quality will be miles ahead of the present quality of site work. It has been practically proved that an installation with pre-insulated pipes, can be completed, particularly for shaft piping, in 1/ 25 th of the time required for field insulation.

***Fire Rated***

Pre-insulated pipes with metal jacket were exposed for 2 hours with the temperature in excess of 1000°C as per ISO-834 "*Fire Resistance Test- Elements of Building Construction*"and it was found that the integrity of the jacket and joints were intact and no flames or smoke escaped from the exposed section of the pipe.

The author's company has had its product tested for fire propagation as per British Standards and obtained Class O certification, which is the highest performance for fire rating.

## Conclusion

Many may wonder why, with all these benefits, this product did not penetrate earlier in India. The only reason was the cost which got artificially hiked due to varied excise tarrif and sales tax. With the present uniform excise tariff for most of the commodities and with VAT regime, the cost of this product is in line with similar site insulation specifications like PUF sections and metal cladding. It is therefore expected that the industry will gradually change over to pre-insulated pipe as it has happened in the case of factory fabricated ductwork.