

Conduit construction for a steamy situation

Finding a conduit structure which is both economical and capable of withstanding the many adverse effects of steam underground has been a problem for many years. Here's the solution

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A SERIOUS problem which has plagued our underground telephone system in New York City for many years is subsurface steam.

Steam supplied by the Consolidated Edison Co. is the energy source that provides heating and air conditioning services for most of New York City's large buildings. This subsurface steam network consists of large steel pipes encased in concrete with steam pulsating through the system usually at 150 psi and approximately 350°F. Fluctuation in the pressure produces a corresponding change in temperature. The usual operating range of temperatures may vary from 300°F to 400°F within the steam main itself.

This distribution system is concentrated in a heavily congested area of Manhattan in New York City from 59th Street, south to the Battery, and in many cases runs in close proximity to conduit and manholes. A minimum of 6 in. separation is required, but any damage to this system usually results in steam leaks.

Steam leaks and poorly insulated steam lines coming in contact with water causes high temperature conditions in the subsurface which have resulted in both cable and conduit damage. Water from any source coming in contact with a pipe carrying superheated steam creates an external steam condition which transmits heat through the soil to our underground plant. All indications are that the 212°F temperature range is seldom surpassed in our conduits and manholes, but if a high pressure steam line causes a direct leak onto conduit plant the temperature could exceed 212°F.

All steamed up

Exposure to these high temperatures for long periods of time can have devastating effects on cable and PVC conduit. Evidence indicates that temperatures exceeding 140°F may exist for months, even years. High temperatures rupture plastic sheath cable (polyethylene sheathing used in Stalpeth cable splits under pressure at about 175°F). Residual moisture on pulp insulated cable is released and then condenses at a bend or cool spot in the cable, thus lowering the dielectric strength of paper and pulp insulation. Excessive temperature in lead cable causing transmission troubles. Conduit structures also are affected by subsurface steam conditions; polyvinyl chloride (PVC) conduit will deform and begin to fail at 170°F.

This is the problem, and it has existed for many years. The solution is complex and can be approached in two ways. First, by developing a cable that can tolerate the hostile environment created by a steam leak. Secondly, by developing an economical conduit structure capable of surviving the high temperatures.

The development of the Steampeth cable by Bell Laboratories and Western Electric Co. has significantly helped in coping with steam underground. We at Empire City Subway Co. have concentrated our efforts in the area of obtaining a conduit structure that is economical in both material and installation costs and capable of providing adequate protection in a steam condition. In pursuit of this goal many avenues of investigation were undertaken. Various materials were evaluated for their effectiveness in the hostile environment of the underground and some significant findings were made.

Many conduit materials are available that meet the required temperature limitations, such as steel pipe conduit, concrete conduit and asbestos-cement conduit as well as fiberglass conduit. Of all these materials only two provide a practical structure for our needs—steel and fiberglass.

Steel pipe conduit has been used extensively throughout the Bell System for conduit structures in steam conditions. It provides an adequate system, but it is very costly in both material and installation. Steel is a conductor of heat and

acts as a heat reservoir when exposed to high temperatures. Most metals will experience oxidation or corrosion when subjected to the atmosphere or high humidity as encountered underground; the corrosion and oxidation will result in bubbles or flakes on the inside of the pipe, which in turn can inflict damage to the jacket of cables when pulled-in or removed.

FRE® conduit

An alternative to steel is fiberglass conduit. In the past, fiberglass conduit was as costly as steel and was difficult to adapt to underground communication conduit systems. A fiberglass reinforced epoxy (FRE®) conduit system has been developed. It is a complete system of cable ducting (duct, fittings and adapters) designed to provide a carrier for underground, above ground and underwater electrical and telecommunications cables.

Fiberglass reinforced epoxy conduit is a plastic and is influenced by temperatures. Epoxy, when mixed with a curing (hardening) agent becomes a thermoset composite, and when completely polymerized obtains its ultimate strength. Thermosetting plastics require heat to cure and harden, contrasted with thermoplastics which must be cooled in order to do so, and are non-meltable after being hardened. At high temperatures there is a drop in modulus (stiffness) and at low temperatures the modulus increases. The recommended limit for FRE® duct is 266°F as the maximum continuous operating temperature because of the elastomeric seal in the watertight duct. Except for this elastomeric seal in the watertight system, much higher temperatures can be tolerated.

One factor under consideration was the effects of heat as it relates to cable and conduit fusion during high temperature exposure. Simulated tests conducted in a controlled environment were performed at Empire City Subway Co. facilities to provide comparative data on two types of plastic conduits: (1) type B polyvinyl chloride (PVC) and, (2) fiberglass reinforced epoxy (FRE®).

The testing consisted of placing a section of Stalpeth jacketed cable in each sample conduit and exposing the samples to intense heat.

The first section tested was the type B polyvinyl chloride (PVC) conduit. The conduit was exposed to 250°F heat for ten minutes. This heat melted both the PVC conduit and the Stalpeth sheath of the cable. The two plastic materials fused together making it extremely difficult to remove the cable from the conduit.

The fiberglass reinforced epoxy (FRE®) conduit with a Stalpeth jacketed cable was subjected to the same conditions, i.e., 250°F for ten minutes. The results were that the Stalpeth sheathed cable melted; the FRE® conduit did not melt or distort and retained its tubular shape without fusing to the jacket of the cable. This permitted the removal of the cable without any difficulty.

This property of FRE® conduit is extremely valuable because it eliminates the necessity of conduit repairs or reinforcements on steam damages as well as the possibility of obstructions due to melted cables on such damages.

Our main interest in FRE® conduit is its use in an underground steam environment as it exists in Manhattan. One of the physical characteristics which makes FRE® attractive to our needs is that it can withstand temperatures exceeding 266°F without any significant strength loss.

Double trouble

The fact that fiberglass conduit can withstand high temperatures is not enough to conclude it will work well in a steam environment. With steam there exists not only high temperature but also high humidity. The combination of the two may have an effect on FRE®, but to what extent is not completely clear. Additional testing was conducted to evaluate the effects of direct steam exposure on the conduit, i.e. high temperature with high humidity. The sample used in this test was standard specification duct, 4 in. diameter, 0.068 in. wall thickness and 12 in. long.

The specimen was placed in a container and subjected to low pressure steam at 5 to 10 psig. at 220°F to 230°F, for a total time of 652 hours during which the sample was removed periodically for compression testing.

The results of this testing were very favorable and indicated no observable change in surface gloss, shape of the sample, or its ability to recover to its original diameter after removal of a compressive load of 200 pounds.

Based on various testing results, FRE[®] conduit demonstrates properties which make it very suitable for use in subsurface steam conditions.

The real thing

Test data obtained during controlled situations in a laboratory environment serves many useful functions and answers several pertinent questions, but cannot substitute for actual field conditions. To obtain actual field conditions, a series of field trials was conducted in Manhattan by Empire City Subway Co. construction forces. The prime objective of these trials was to test the effectiveness of fiberglass reinforced epoxy (FRE[®]) duct as a heat-resistant conduit system that could be placed in a steam condition and afford adequate protection of the conduit structure at a substantially lower cost than steel pipe. The field trials consisted of installing several sections of FRE[®] duct at various underground locations in Manhattan that have known steam conditions, as well as using FRE[®] duct to repair and replace damaged PVC conduit caused by steam leaks.

The field trials were not fabricated testing sites, but real work operations under normal conditions which frequently are encountered. The installation of the FRE[®] conduit proved to be very productive and yielded a productivity increase of 30% to 50% over steel conduit depending upon the amount of bends required. Bending of steel pipe conduit sharply decreases productivity, whereas FRE[®] duct is available with bends and associated fittings. Its light weight (less than PVC) and ease of joining using a bell and spigot push-fit system allow for quick and easy installation which has a marked increase on productivity.

Along with an increase in installation production over the use of steel conduit, there is also a cost effective advantage that yields a savings of approximately 50% on the cost of material.

Looking at all these factors combined, the use of fiberglass reinforced epoxy conduit in subsurface steam conditions appears to be a viable solution to the present problem of obtaining a conduit structure that is economical in both material and installation costs and capable of withstanding the adverse effects of a steam condition.

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