NEW REALM OF POSSIBILITIES FOR PEX PIPES

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PEX (cross-linked Polyethylene) pipes have been traditionally used for indoor applications such as underfloor heating, hot and cold water pipelines and district heating pipelines. Recently these pipes are being used in mainly industrial applications, water mains and gas lines.

The success of PEX pipes in these and similar applications is based on the special qualities of the PEX material, some more known than others.

- Excellent resistance to slow crack growth – SCG
- Excellent longevity
- Excellent abrasion resistance
- Immunity to scratches and point loading

These last two issues will be discussed in this paper. I will also discuss a study we have conducted on PEX electrofusion couplers.
ABRASION RESISTANCE OF PEX PIPES

PE pipes are frequently used for the transportation of fish food to the marine cages where fish are raised. The fish food is very abrasive and while PE is very resistant to abrasion, in this severe application the PE pipes are soon worn out.

Several fish raising companies have tried PEX pipes, including Chilean and Israeli companies. One Israeli company had found out that the PE pipes were able to transport 300 tons of fish food before they were finished, while the PEX pipes transported over 1000 tons – a threefold increase.

In the gold mines of South Africa, the ores are fed back into the mine to serve as supporting columns. This is called “back fill”. The feeding is done by gravity. The line velocity is enormous, 6-8 mtrs/second (20 – 26 fps) with very little abrasion. PEXGOL pipes were tested as a replacement for PE pipes. The test was commissioned by “Western Deep Levels” which is the deepest gold mine owned by the Anglo America. The test was done by the consulting company, “Patterson & Cooke” (Report no. WPR-018.R13 from August 1994). The results were that PEXGOL pipes were 3 times better in abrasion resistance compared to HDPE. The difference is more pronounced at higher velocities.
In a comparative abrasion test carried out by the raw material supplier, Basell, PE and PEX pipes were tested. In this test, which was carried out at relatively slow velocities, the PEX pipes were 1.8 to 2 time better in abrasion resistance than PE pipes. This is in accordance to the previous observation that the difference in abrasion resistance between PE and PEX pipes is more pronounced at high velocities.

In the Dead Sea area, there was a problem of large salt crystals growing from the seabed. These crystals were an obstacle to the harvesting operation of the potash from the Dead Sea ponds – which is the heart and core of the business of
the “Dead Sea Works”. These crystals had to be disposed of. Special dredges were brought by two companies to cut, grind, and transport them to the seashore by pipes. One of the 2 companies, ordered PN10 450mm PEX pipes for dredging. The other company ordered from the USA special HMW – PE abrasion resistant pipes. The HMW PE pipes served for 2 months before being abraded and replaced by PEX pipes. After completing the dredge project, the PEX pipes were resold to another company for a different dredging operation and the pipes performed as if they were new. PEX pipes obviously are the perfect solution to abrasion!

POINT LOADING AND SAND BEDDING

What happens if you do not use sand, but rather the native soil as a cover for the pipes? Point loading is the result of compacting sand that contains stones in it. These stones create tensile stresses at the inner layer of the pipe. The result is failure by the slow crack growth (SCG) mechanism and brittle failures. Since this is a SCG mode of failure, the scientists tried to correlate the failure of point loading to the failure in SCG tests, line the FNCT for example.

In FNCT, the specimen is a square rod bar made of the pipe material. A sharp notch is made in the centre of the specimen, and it is put under tensile stress of 4MPa inside detergent in 80 degrees C. This test was conducted by the German company of Dr. Hessel. The time to failure of PEX pipes is naturally the maximum as compared to various PE resins. When correlating the FNCT test with the point loading times to failure, the result was a very good correlation. Since there is much data regarding FNCT, it was possible to analyze it and to conclude that it is possible to use PEX pipes without sand embedding.
ASSESSMENT OF THE LONG TERM PROPERTIES OF HOT WATER ELECTROFUSION FITTINGS

The long term properties of electrofusion fittings depend on the raw material properties. This is true for any type of fittings as it is true for any type of pipe. But there are other significant factors which have a significant effect on the lifetime of the fitting and these factors are usually not looked at in the case of a pipe. One factor is the fitting design. In the case of a pipe, this is actually the SDR value of the pipe. In case of a fitting, in addition to that, the shape of the fitting creates additional stresses. It is obvious that the stress regime in a T piece is not the same stress as that of a straight coupler or an elbow. The result is a 3 dimensional stress tensor which has to be carefully looked at.

One common stress concentration factor in all electrofusion couplers is the central cold zone. Other places are the corners of a T or elbow fittings, which
tend to become straight at high stresses. In our study, we tested PEX electrofusion fittings. The raw material was TUX 100 by Solvay.

The fittings which were tested were:
- Straight couplers
- Tees
- Elbows

In previous tests, the straight couplers having SDR 7.4 were approved as equivalent to SDR 11 PEX pipes (according to ISO 15875 part 3 and 5). The test purpose was to see whether it is possible to use these fittings without pre-crosslinking them. The fittings were tested at a pressure of 9.9 bars. According to the regression curves of TUX 100, this is the “working pressure” of this fitting. The result was that the fitting failed after only 282 hours. Another fitting of the same production was first pre-crosslinked in a hot water bath with no pressure. Then it was put to test at a higher test pressure of 13.4 bars. The fitting failed after 1130 hours.

In both cases, the failure was in the sharp corner between the central outlet and the side outlet.

Conclusions:
- The fittings should be pre-crosslinked in order to increase their lifetime
- The fitting should be redesigned in order to reduce the stress-concentration factor
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