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Testing Laboratory OBRC SPEC S.A. in Warsaw

Quality Assessment of Joint Sleeves for Preinsulated Pipes

Joint Sleeves are the most critical part of burried distict heating pipelines concerning quality assurance and longevity. Different types of joint sleeves are used in the industry for this application. The District Heating Research and Development Center of Warsaw District Heating Enterprise is conducting regular quality tests, e. g. sandbox tests and water impermeability tests, to verify the quality of joints technical solution.

In Laboratory of District Heating Research and Development Center of Warsaw Municipal Heating Company (OBRC SPEC S.A.) a complex research programme concerning preinsulated components is conducted. The fact that the company affiliates to the biggest power industry enterprise in Poland is advantageous for both sides. The company gets the possibility to monitor the quality of the products applied in Warsaw district heating system. The employees of the research laboratory have the possibility to participate in works concerning assembly and operating process of pipelines mounted directly in the ground, as well as their failure causes. This allows gaining complex, practical knowledge concerning the building and functioning of preinsulated district heating pipe systems.

Since 2003 OBRC Laboratory owns the accreditation certificate of Polish Centre for Accreditation (AB414), which is available on PCA Website www.pca.gov.pl, and has the licence to use the ILAC-MRA symbol. Accreditation of laboratory confirms the high quality of tests carried out, competence as well as the prove for setting up, implementing and maintaining a management system proper for laboratory activity range, guaranteeing honesty, reliability, impartiality and independence.

OBRC Laboratory conducts the research for home company SPEC S.A., but also for district heating companies from the whole country, preinsulated pipe manufacturers and producers of tube joint sleeves and muffs for insulation protection in welding connection of preinsulated pipes.

Ground Load for Preinsulated Pipe Joints (Sandbox Test and Water Impermeability Test)

Sandbox tests and water impermeability tests are one of the most important research carry out in the laboratory, because it verifies the quality of joints technical solution. After the ground load test (*figure 1*), joints are put on leak proof test by immersing in water (*figure 2*). Properly mounted joints should be tight after ground load test in case filled with sand and after water impermeable test.

Figures 3 to 9 show different joints after tests in case filled with sand or after water impermeable test.

Figures 3, 4 and 5 show radiational cross-linked tube joint sleeves after tests in case filled with sand. From ten joints tested in the laboratory, with tube joint sleeves radiational cross-linked with glue or with glue and mastic gum at the products ends, with melted-in plugs, after ground load tests, in conditions fulfilling (100 cycles – 3 joints) or considerably exceeding (>500 cycles – 2 joints, 1000 cycles – 7 joints) the requirements of EN 489:2003 [1] Standard, none of them was deformed during tests and all were 100 % tight. *Figure 3* presents a tube joint sleeve radiational cross-linked with glue at the ends after 1,000 cycles test.

Figure 4 presents a tube joint sleeve radiational cross-linked with additional thermo-shrinkable bands, as the second tube sleeve insulation. After the test carried out in case filled with sand (100 cycles), because of improper technical parameters of thermo-shrinkable material (poly-isobutylene PIB) mastic gum without adhesive glue, the bands were destroyed. But apart from that fact the joint after the water impermeable test was tight. It should be added that thermo-shrinkable bands, applied for tube joint sleeve ends insulation, were produced by the leader of thermo-shrinkable market. However, according to information obtained in internet, they did not pass the tests in case filled with sand performed according to the method valid in EN 489 Standard dated on 2005. It is very significant information for both preinsulated pipe producers, who sell joint casings with additional insulation made of thermo-shrinkable bands, and for investors, who use thermo-shrinkable bands for preinsulated pipe insulation.

The necessity of application of glue at the ends of tube joint sleeves radiational cross-linked justifies *figure 5*. Self-shrinking of tube joint sleeves on casing pipe does not provide the proper quality for the joint. To assure the joint will not deform and will be waterproof, the application of glue and mastic gum at the ends of tube joint sleeves is necessary. During operation of pipeline, the glue undergoes ageing process and that is why an additional protection against moisture penetration into the joint, particularly in case of preinsulated pipes mounted in waterlogged grounds, is sealing mastic gum.

Joints with electrically welded casings (*figures 6, 7, 8* and *9*) are always subject to smaller or bigger deformation at the sleeve ends (*figures 6, 7* and *8*), during tests, and just like presented in *figure 9* – muff made of polyethylene, the deformation is also visible at the casing's edge beyond the welding area. The deformation of electrically welded

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Figure 1. *Sand box*

Figure 2. *Water tank*

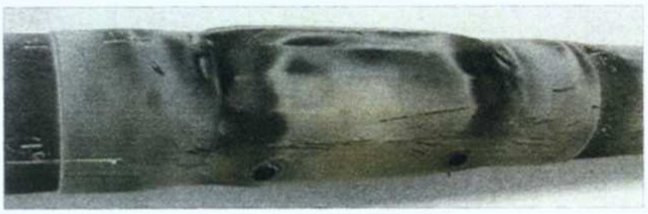

Figure 3. *Tube joint sleeve radiational cross-linked, 1000 cycles, tight after test*

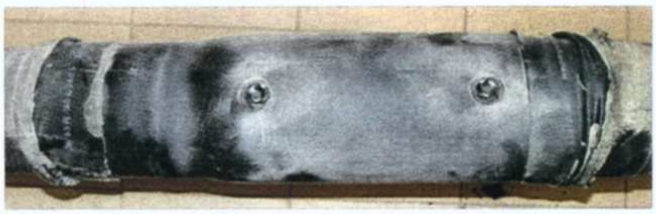

Figure 4. *Thermo-shrinkable tube joint sleeve radiational cross-linked with thermo-shrinkable bands, 100 cycles, tight after test*

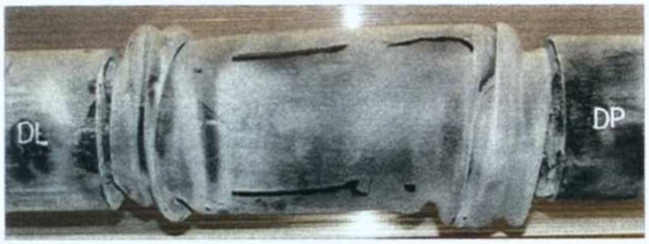

Figure 5. *Thermo-shrinkable tube joint sleeve radiational cross-linked, without glue at the product ends, 1000 cycles*

Figure 6. *Tube joint sleeve electrically welded, 100 cycles, tight after test*

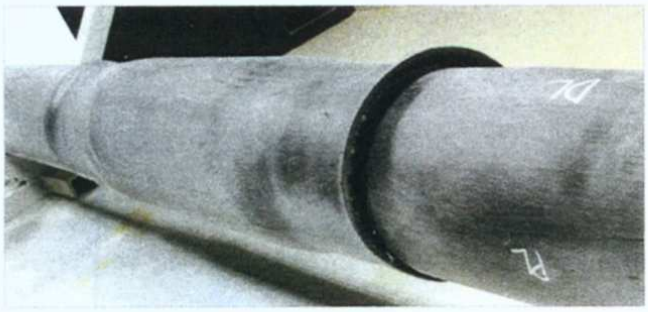

Figure 7. *Tube joint sleeve electrically welded, 100 cycles, tight after test*

Figure 8. *Tube jointing sleeve electrically welded, 1000 cycles. After water impermeable test, ground load test, signs of moisture were noticed in joint*

muffs/sleeves does not always lead to leakage, but the fact that it takes place, confirms the necessity of performing the welding process strictly according to joints producer guidelines – the right time duration, with right casing pressure to the polyethylene screen, usage of current with proper parameters. The figures prove that not every joint withstand a ground load test.

The research concerning joints performed in the laboratory are done in order not to admit the joints with doubtful quality to assembly in preinsulated networks, because as it is well known, the joint is the place where failure occur most often concerning the pipelines mounted directly in the ground.

The matter concerning joint's tightness during pipeline operating process is decided by a few factors, from which the most important is the quality of joint proved by positive result after tests performed in the case filled with sand and the

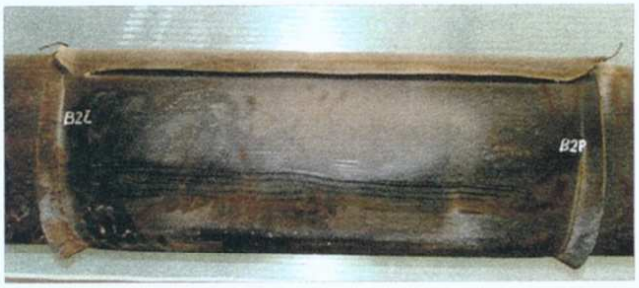

Figure 9. *Muff electrically welded, 100 cycles, tight after test*

Figure 10. *Thermo-shrinkable tube joint sleeve not cross-linked with thermo-shrinkable bands*

Figure 11. *Joint sleve set – supply (in the front), return with not cross-linked, thermo-shrinkable sleeves*

Figure 12. *Welded plug (melted-in)*

Figure 13. *Destroyed insulation (supply, welded connection, caused by water penetration to the joint presented at figure 11*

Figure 14. *Pipe with corrosion under destroyed insulation from figure 11*

producer's honesty. The application of materials with proper quality as well as right joint execution on site by trained employees is very important.

Figure 10 shows a thermo-shrinkable tube joint sleeve not cross-linked with thermo-shrinkable bands, on the supply pipeline located in water logged area, after 4 years of operating. The pit was done, because the alarm system detected the leakage in the joint. In that case the cause of underground water penetration to the joint might have been the application of improper material for thermo-shrinkable bands (compare with *figure 4* after ground load tests) or improper shrinkage of not cross-linked thermo-shrinkable sleeves at casing pipe or bad protection of assembly openings in casing.

Figure 11 presents a unit of joints disassembled after 4 years of operation and handed over to the laboratory in November 2009 from a Polish district heating company for examination. The technical state of the DN 80 joints disassembled from supply and return pipeline was very bad – both were uptight, which was the cause of occurring few factors including

- improper assembly of joints,
- bad sealed assembly openings in sleeves,
- application for sleeve ends insulation, thermo-shrinkable band with insulating mastic gum without glue, which does not prevent moisture penetration to joints,
- application at inner area of not cross-linked thermo-shrinkable sleeves, a thermo-fusible glue with improper quality, which was not able to bear the loads during functioning of pipeline and was not a durable insulation.

The most important point of each insulation casing in welding con-

nection – apart its edges – are assembly holes. The experience indicates that the most durable protection of assembly holes against moisture penetration to the joint are melted-in polyethylene (PE) plugs – *figure 12*. The application of thermo-shrinkable patches and plugs drove, screwed in or glued in, in most cases do not bring expected results, as were proven by test performed by different users of district heating system. By improper protected assembly holes as well as by badly shrunk or welded sleeves/muffs, ground water may penetrate to the joint, which can cause moisture and after some time insulation degradation (*figure 13*) and corrosion of pipelines (*figure 14*).

In Warsaw district heating system at preinsulated pipelines located directly in the ground DN 32 to 300, as well as in many other cities, sleeves/muffs with welded in plugs (melted in) radiational cross-linked are applied and at connections of pipelines DN ≥ 350 sleeves/muffs electrically welded.

Conductivity Coefficient of Insulation from Preinsulated Pipes after Operation

In 2006 a research project concerning testing the thermal conductivity coefficient of insulation, foamed with different porophors made of preinsulated pipes, disassembled from pipelines operated different period, started in OBRC Testing Laboratory.

In 2006, 2007 and 2008 tests concerning 10 samples – insulation made of preinsulated pipes, foamed with carbon dioxide, disassembled from Warsaw district heating system, were carried out. The results of performed tests allow to make a statement that the mean value of thermal conductivity coefficient of insulation foamed with carbon dioxide varies of about 23 % after 5 years of operation in supply pipeline, and 19 % in return pipeline. After 10 years of operation the values vary about 29 % in supply pipeline, and about 27 % in return pipeline.

In 2008 the same tests begun concerning the samples made of operated preinsulated pipes foamed with cyclopenthane. The samples were delivered from other district heating companies.

Preliminary results, concerning tests performed in 2008 and 2009, show that samples foamed with cyclopenthane have better thermal characteristics after some time of operation than samples foamed with carbon dioxide. They change after about 6 years in supply pipeline of around 16 %, after 11 years in supply pipeline of around 17 % and in return pipeline after around 6 years of around 14 %, in supply pipeline of around 22 %.

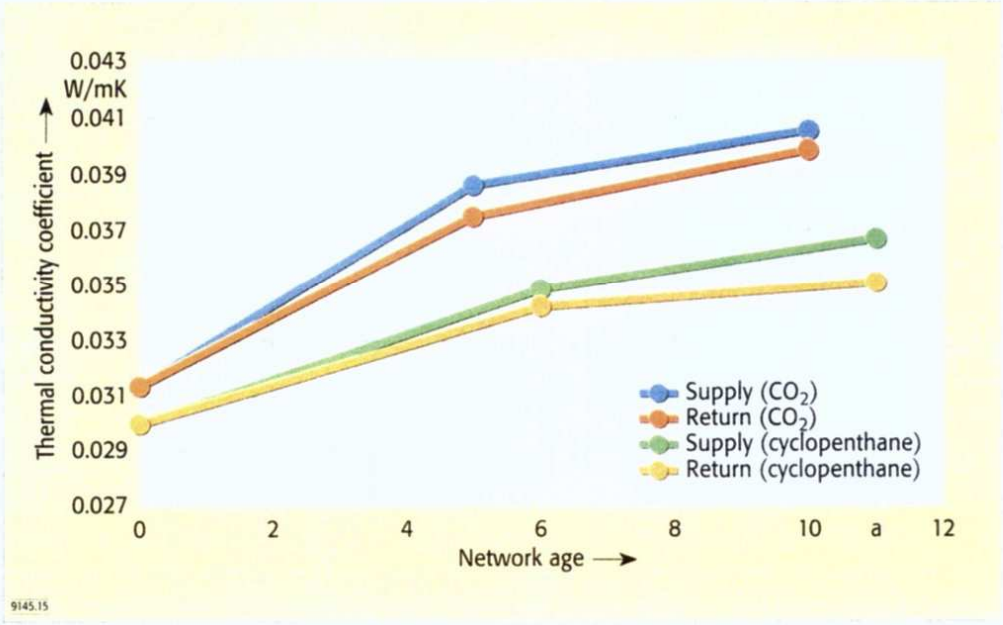

Figure 15. *Dependence between thermal conductivity coefficient for preinsulated pipes insulation and also functioning of preinsulated pipeline*

Figure 15 shows the dependence between the value of thermal conductivity coefficient for insulation made of preinsulated pipes and the time of preinsulated pipeline operation – top two lines: PUR foam expanded with CO_2, bottom two lines: PUR foam expanded with cyclopenthane.

The test results confirmed that in case of failure – joint leakage and water penetration inside the foam, deterioration of thermal parameters of insulation occur in shorter time. Wet foam from preinsulated pipeline after around 4 years of operation has a little bit worse thermal parameters than dry foam after 6 years of operation.

References

[1] EN 489:2003: District heating systems – Preinsulated combined pipes for water district heating systems mounted directly in ground – A set of joint of steel pipelines with thermal insulation made of polyurethanes and polyethylene casing.

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[3] EN 253:2009 District heating systems – Preinsulated combined pipes for water district heating systems mounted directly in ground – Pipe set made of steel pipe, thermal insulation made of polyurethanes and polyethylene casing.

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[5] *Larsen, Ch.T.*: Heating and cooling pipe systems to meet the demands of the future. Hot Cool 2 2009 ■

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