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ANALYSIS OF CONDITIONS CAUSING INITIATION AND PROPAGATION OF CORROSION CRACKS IN ZONES OF CIRCUMFERENTIAL JOINTS ON MAIN GAS PIPELINES

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The paper deals with conditions causing formation of corrosion cracks within the zones of circumferential field and longitudinal factory welded joints on main gas pipelines. Described is the case study of force conditions and resistance of material to initiation and propagation of stress corrosion cracks up to a spontaneous fracture.

Keywords: *welded main gas pipelines, circumferential welded joints, initiation and propagation of corrosion cracks, crack resistance diagram, nominal stresses, stress concentration, stress intensity factors*

The most dangerous defects in welded main gas pipelines are corrosion cracks, which are relatively difficult to detect by using the in-pipe diagnostic method. Initiation and propagation of such defects up to critical sizes, when a spontaneous fracture takes place, are determined by a number of factors:

- fracture of corrosion-preventing insulation on the pipeline surface and, hence, formation of contact with the environment (soil);
- time of dwelling of the pipe wall, Δt_c, under stress corrosion conditions;
- degree of aggressiveness of the environment (humidity of soil, its chemical composition, etc.);
- level of tensile stresses in the pipeline wall, and presence of stress concentration zones;
- ability of the pipeline wall material to resist initiation and growth of corrosion cracks.

The presence of the above factors is a precondition for initiation and propagation of corrosion cracks. However, each of them is not sufficient for formation of the given type of defects.

As a rule, the time of reliable operation of a protective coating on a pipeline is markedly shorter than the specified and actual life time of the pipeline itself. Here the probability of fracture (separation) of the coating depends upon its type, deposition and service conditions. The zone of field welded joints may be very vulnerable, depending upon the coating deposition conditions.

Time Δt_c of dwelling of the pipeline wall with a fractured coating in the stress corrosion conditions is hard to estimate by deterministic calculations. Estimation of this value greatly depends upon the periodicity of monitoring of the state of insulation (or re-insulation) on the pipeline, duration of shutdowns of the pipeline, changes in aggressiveness of the environment, etc. A sufficiently conservative estimate of Δt_c made by the reliable methods of monitoring of the state of the insulation coating is an interval between regular inspections (about 2--5 years), providing that they are combined in time with the in-pipe diagnostics of the state of the pipeline wall. It is very important that during time Δt_c the corrosion cracks, allowing for their initiation and growth (coalescence), do not reach their critical sizes, at which the spontaneous fracture takes place.

The degree of aggressiveness of the environment for main gas pipelines is determined primarily by properties of those soils wherein the pipelines are laid down (the issue of corrosion damages on the internal surfaces, which is characteristic of oil pipelines [1], is not considered in this study). In this case, of high importance is the degree of humidity of the soil caused by periodic or continuous inflow of moisture.

As shown by the results of investigations conducted by the E.O. Paton Electric Welding Institute, in the case of periodic moistening of the soil, when it dries out, a film of corrosion products appears on the crack surface. Fracture of this film after an intensive moisture inflow takes some time, this having a marked effect on average values of the rate of crack growth through thickness of the wall at constant stresses induced by a force load. Constant and rather high humidity of the aggressive environment is characteristic of main pipelines laid down in marshland, on the bottom of lakes, rivers and seas. When they are laid down into the firm soil, a high humidity associated with atmospheric precipitates is of a periodic character. Considering the above circumstances, experimental studies of the kinetics of growth of corrosion cracks under laboratory conditions at a constant high humidity (water solutions of extracts of corresponding soils [2]) yield conservative data, which at the given stage of investigation of the problem are fully acceptable to predict remaining safe service life of pipelines.

The level of nominal tensile stresses in the pipe wall is determined by an internal pressure of gas in a pipe, as well as by bending deformations associated most often with subsidence of the soil under the pipe and bending moments due to the dead weight of the pipe and backfilling material. Local geometric peculiarities (e.g. zones of welded joints) causing the con-