A CONSISTENT APPROACH FOR THE ANALYSIS OF BURIED PIPES

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SUMMARY

The site of any nuclear power plant is crossed by an underground net of piping needed for various safety and non-safety related functions. To design against the loss of integrity of these pipes, it is necessary to know not only the effect of loading arising from overburden, soil settlement and thermal expansion, but also, for safety related systems, the effect of seismic wave motion due to an earthquake.

When a pipe is buried, the surrounding soil and pipe interact structurally. As a result, the supportive strength of such a structure depends not only on the pipe's own inherent strength but also on the magnitude and distribution of the load around the pipe and the support from the soil. The latter two influences are in turn dependent on such variables as character of backfill, type of trench, bedding condition, degree of flexibility of pipe and magnitude of surface loads. Past investigations have shown that shallow pipe is significantly affected by line surface load while for deeply buried pipe the effect of soil fill predominates. When such a pipe is subjected to an earthquake disturbance, its response is due not only to the various seismic waves propagating through the soil but also to the differential movement of its anchors. Since transfer of the soil motion due to seismic waves to the pipe is dependent on interface friction, relative displacement between the soil and the pipe results. It thus is seen that optimum design of buried piping can only be achieved if all the variables involved in the pipe-soil-load interaction process are understood and properly accounted for.

This paper presents a systematic and consistent approach to the analysis of buried piping. In particular, methods for checking the adequacy of the pipe wall, for determining the various soil parameters, and for evaluating the response due to surface, overburden, thermal and seismic loading are given. In addition to straight piping, the effects of bends, elbows, supports and other restraints are considered. The given analysis procedure is illustrated with reference to typical piping systems and on the basis of the results obtained, simplifications in the procedure and possible design modifications are discussed. The paper concludes with the presentation of a method of how to properly consider and combine the various separate effects so as to satisfy the allowable limits of the ASME Boiler and Pressure Vessel Code.