

Field-to-Lab Correlation of De-Icing Salt-Driven Corrosion in Automotive Materials under Subarctic Exposure Conditions

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Corrosion of automotive materials in cold regions is significantly accelerated by the combined effects of de-icing salts, environmental exposure, and mechanical damage mechanisms. While accelerated laboratory tests are widely used for material qualification, their ability to replicate real-world corrosion behavior - particularly in subarctic environments - remains limited.

This study presents an integrated framework combining long-term field exposure, controlled laboratory testing, and mechanistic evaluation to improve corrosion testing and prediction for automotive applications. Atmospheric exposure of carbon steel coupons was conducted in Anchorage, Alaska, under representative subarctic conditions, incorporating seasonal variability, chloride deposition, and continuous environmental monitoring. Coupons were deployed at 0° and 90° orientations and periodically exposed to sodium chloride brine to simulate roadway de-icing practices. Environmental parameters, including temperature, relative humidity, and time of wetness (TOW), were measured to establish correlations with corrosion rates.

Results indicate that corrosion behavior is strongly dependent on exposure orientation and seasonal effects. Vertically oriented samples exhibited higher corrosion rates during winter due to increased chloride exposure from airborne brine and meltwater runoff, while horizontally oriented surfaces experienced partial shielding from snow accumulation. These findings challenge conventional assumptions used in corrosion testing protocols and highlight the importance of incorporating realistic environmental interactions into predictive models.

Complementary accelerated corrosion testing was performed using cyclic corrosion test chambers (CCTC), incorporating surface damage induced by stone and gravel impingement under chloride-rich conditions. Variations in surface roughness significantly influenced corrosion initiation and propagation, with rougher surfaces exhibiting higher susceptibility.

This work establishes a pathway to improve correlation between field exposure data and laboratory testing, enabling more reliable prediction of automotive material performance in cold-region environments.