



## Steel Deck and Fasteners Corrosion on Insulated Roofs

### Executive Overview

Steel decks in Canada have performed particularly well under all insulation boards because of the zinc alloy coating and extensive use of vapour retarders. Proactive roof maintenance programs are beneficial. The mechanisms of steel deck and fastener corrosion and its prevention are discussed. Two cases of deck corrosion with wet, early design phenolic type insulation are reviewed. Differences from current generation phenolics are also defined.

### Background

On commercial and industrial buildings steel decks have the largest volume across Canada. Steel decks in Canada voluntarily conform to ASTM Standard A525M and normally conform to a zinc alloy coating weight of 75 g/m<sup>2</sup> (specified as ZF075 (wipe coat)). This standard requires that the steel be protected to a satisfactory level for the particular type of service. Flat decks are deemed to be installed in an interior environment.

Corrosion of steel is affected by three main variables - liquid moisture, oxygen and temperature. If either moisture or oxygen or both are not present corrosion stops. Corrosion increases with temperature until liquid water evaporates away.

When any two dissimilar metals are in close proximity, and separated by a conductive film of water, an electrolytic charge is set up between the two metals and corrosion results. Consequently it is never a good practice to have say copper and aluminum sheets in contact with each other or with steel sheet or fasteners. (See December 1969 CRCA Technical Bulletin "Corrosion of Metals" for more details).

A thick zinc coating over sheet steel material protects the steel by becoming a sacrificial anode when a conductive film of water is on the deck surface. This means that zinc in an area will continue to be oxidized until it is all consumed before the steel will be oxidized or rusted. Oxidized zinc ("white rust") has a white colour and may appear as a fine powder coating.

Polymeric coatings protect steel sheet and fasteners by keeping moisture from their surfaces. The more abuse resistant and durable the coating the longer the protection. United States roofing practice does not require zinc-coated decks. The major portion of their installed decks have paint primer coatings to protect the steel until it is installed. This paint does not have any significant corrosion inhibiting properties and can be easily scratched and damaged. The surfaces of these decks in contact with insulation become corroded when liquid water through membrane leaks or condensation moisture accumulates in the interface due to the lack of a vapour retarder in the majority of their roof systems.

Moisture films or droplets on steel with salts, acids or bases will accelerate corrosion reactions in proportion to their concentration and strength. Chloride salts such as sodium chloride (table or deicing salt) and calcium chloride (dust suppressant) are particularly bad. Acidic materials such as: sulphur dioxide and nitrogen oxides (acid rain pollution); chloride bleaching or water treatment materials most

strongly accelerate corrosion. Toluene sulphonic acid (catalyst for curing phenolic-type thermoset foams) and other organic acids (e.g. rotting organic material) also accelerate corrosion.

### **Deck Corrosion**

The steel decks under roof insulations which have become saturated due to leaks tend to develop corrosion on all wet surfaces. Leaking water brings small amounts of salts and acids from the roof surface and in some cases from insulation surfaces it has passed over or through. Due to a few cases of corroded decks under saturated (mainly open cell or severely damaged) early design phenolic insulation due to membrane leaks, concerns have been expressed regarding all phenolic type products.

Following extensive cut testing by Canadian phenolic-type insulation manufacturers of roof assemblies with water tight membranes, vapour retarders and galvanized steel decks, no assemblies were found to exhibit corrosion.

Corrosion has been found under all types of insulation following long term membrane leakage. One Canadian deck with open-cell phenolic insulation and long term saturation through leakage was found to be severely corroded. Likewise, NRCA<sup>1</sup> reported severe primer coated deck corrosion under wet phenolic insulation. Water passing through the foam material liberated quantities of acid catalyst.

A film of rust has been found on the bearing flute areas of certain insulated decks with older design phenolic insulation having a standard glass mat facer but no vapour retarder in the assembly. New designs of this phenolic insulation have upper and lower filled glass facers which appear to inhibit corrosion by neutralizing leachate at the foam-steel interface. The effect of such facers in roof leak situations is still being studied at this time.

Extensive corrosion research programs at Surface Science Western (University of Western Ontario), Energy, Mines and Resources Canada, and other laboratories has shown the positive benefit of certain facers and copolymer formulations with low catalyst levels (one manufacturer calls this resol foam) and cell structures with very high percentages of closed cells. The latest generation of all phenolic products currently available in the Canadian marketplace incorporate one or more of these features. Field and laboratory research using certain of these foam insulation materials, without the protection of vapour retarders (commonly used in Canada), have shown corrosivities as low or lower than rigid insulations satisfactorily used on North American roofs over the last thirty years.

Research efforts are continuing to develop a reliable ASTM corrosion test method that is corroborated by field data.

### **Fastener Corrosion**

Factory Mutual requires fastening of at least the bottom layer of insulation or board for steel deck assemblies. The dominant role in USA of the Factory Mutual insurance firms has meant that insulation fastening is present on most conventional membrane (BUR, modified bitumen and adhered membrane designs) roofs. Long term performance of the fasteners and the penetrated deck is necessary to protect the roof from wind uplift failure.

Factory Mutual #4470 Standard for testing (deck penetrated) fasteners under 15 sulphur dioxide-moisture cycles has resulted in only superior coated fasteners being listed by Factory Mutual.

Specification and usage of fasteners conforming to this #4470 Standard is recommended by most insulation manufacturers. Other manufacturers specify fasteners which exceed this requirement and pass up to 30 test cycles.

The presence of adequate insulation on decks during winter prevents condensation at the fastener deck interface by keeping this area above the dew-point temperature. The lack of liquid moisture restricts the amount of deck or fastener corrosion. The presence of a vapour retarder restricts the amount of moisture that can accumulate in a roof assembly during winter. Accumulated moisture is driven from the top of the assembly to lower regions by warmer weather and solar loads. As long as interior and supporting deck temperatures are above the dew point of the assembly air, no condensation occurs. If the temperatures are lower, the condensation occurs on the vapour retarder and not the deck, in the absence of a vapour retarder corrosion is accelerated at the fastener-deck interface or unprotected deck surfaces.

If the roof leaks and moisture accumulates at the deck and fastener interface, corrosion may occur on unprotected surfaces. The presence of salts or acids in this water will accelerate corrosion proportional to their quantity or concentration.

## Conclusions

On the basis of available information, there is no justification for concerns in Canada regarding the use of available insulation. Continued extensive use and CRCA recommendation of vapour retarders and air barriers with all insulations over zinc alloy coated (ZF075) steel decks appears to offer a high probability of satisfactory long term performance. For enhanced corrosion protection, thicker G-60 and G-90 zinc or vinyl deck coatings can be specified. An effective routine maintenance inspection and remedial action program for all membrane and insulation systems will detect and repair leaks before the moisture presence can initiate significant deck corrosion.

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## References

1. Smith, T.I., Carlson, J.D., Walzak, T.I., "Steel Deck Corrosion Associated with Phenolic Roof Insulation: Problem Causes, Prevention, Damage Assessment and Corrective Action", Proceedings of the Tenth Conference on Roofing Technology, 1993, pp.108

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