GalvInfoNote 4.2

Prepainted Metallic-Coated Steel Sheet for Building Panels – Assuring Good Performance

Rev 1 Jan-09

Introduction

Prepainted metallic-coated steel sheet for buildings has been used very successfully for many years. One indicator of the popularity of this product is the large number of roofs made with prepainted steel in place around North America and other parts of the world. An example of one such application is shown in the photograph below and illustrates how this material can be used in a striking and effective manner.

Source: www.mbma.com

A metal roof lasts 2 to 3 times longer than a non-metal roof (see www.metalroofing.com). Metal buildings comprise almost half of low-rise, non-residential construction, and a high fraction of these buildings use prepainted metallic-coated steel sheet for both the roof and wall panels. It is a cost-effective and long lasting product. Its appearance and longevity has been made even better because steel producers, paint manufactures, coil coaters, panel manufacturers and building producers, when designing and manufacturing these products, have taken into consideration many of the guidelines in this GalvInfoNote.

Prepainted Metallic-Coated Steel Sheet

Prepainted metallic-coated steel sheet products are made using the coil-coating process to apply a heat-cured paint system to the sheet substrate. The two most common types of metallic-coated steel sheet substrates used worldwide today are hot-dip galvanized sheet and hot-dip coated 55% aluminum-zinc alloy coated steel sheet. A third substrate is hot-dip coated zinc-5% aluminum alloy coated steel sheet. Refer to GalvInfoNote 4.1 for an introduction to prepainted products. One important feature of the prepainting process is that it allows the application of thermally cured paint coatings, a process that provides superior paint properties (fade and chalking resistance, for example) compared with most field applied or shop applied air-dry paints. Also, the superior bonding of the paint to the corrosion resistant, zinc-containing layer creates a synergistic total coating system that is the reason for the long product life.

There are many applications today where the proper selection of the paint system (pretreatment, primer and topcoat) is providing painted metallic-coated steel sheet roofs and walls with a life of 20 years and longer. To achieve this long service life, the manufacturers of the prepainted steel sheet and the building constructors, take into consideration issues related to:

- nature of the service environment,
- the metallic-coated steel sheet,
- type of paint system,
- the prepainted coil-coating process,
- panel design and the roll-forming process,
- storage and handling of the roll-formed sheets,
- building design,
- installation practices, and
- field maintenance

Service Environment Considerations

One of the first considerations in the selection of a prepainted metallic-coated steel sheet product is the service environment to which it will be exposed[1]. The environment encompasses both the general climate of the region, and localized effects.

General climatic factors to be taken into account include:

- the amount and intensity of UV radiation
- time of wetness
- acidity of the rain
- presence of chlorides near sea coast locations

The amount and intensity of UV radiation that the product is exposed to is governed by the latitude of the location, the hours per year of sunlight, and the angle of exposure of the prepainted sheet. Obviously, a low angle (flat) roof on a building located in a desert area in the low latitudes requires a primer and top coat system that is very resistant to UV radiation to avoid premature fading, chalking and cracking. On the other hand, UV radiation damage would be of much less concern for vertical wall cladding on a building located in a high-latitude, cloudy climate.

Time of wetness refers to the length of time the cladding on roofs and walls are wet due to rain, high humidity, fog, and condensation. Paint systems are not impervious to moisture. If wet long enough, the moisture will eventually reach the substrate under any paint system, and corrosion will begin. The amount of chemical contaminants, e.g., sulphur dioxide, chlorides, etc., present in the atmosphere will then govern the corrosion rate. Some paint systems are more impervious to moisture than others.

Local or micro-climate effects that need to be taken into account include:

- wind direction
- pollution fallout from industrial plants
- marine environments

The prevailing wind direction should be considered when selecting a coating system. If the building location is downwind from a source of chemical contamination then caution is advised. Gaseous and

particulate exhaust emissions can have a serious effect on paint systems. Within 5 km of heavy industry, corrosivity could range from moderate to heavy depending on wind direction and local weather conditions. Beyond 5 km, the effects associated with pollution fallout from industrial plants are usually reduced.

If prepainted buildings are located close to the sea coast, the effects of salt water can be severe. Within 300 m of a coastline can be critical, while significant effects can be felt up to 5 km inland, and further, depending on offshore winds.

If the corrosiveness of a proposed building site is not obvious, an investigation of the local area can be very helpful. Data from environmental monitoring stations are useful as these data provide information on precipitation, humidity and temperature. Examine unwashed surfaces in protected exposures to learn about particulate fallout from industry, roads, marine salts, etc. Examine the performance of structures in the immediate vicinity. If building materials such as galvanized fences and galvanized or prepainted cladding, roofs, eaves troughs, flashing, etc., are in good shape after 10 to 15 years, the environment is probably not aggressive. If structures show distress after only a few years, a cautious approach is justified.

Paint suppliers have the knowledge and experience to recommend paint systems for specific environments.

Metallic-Coated Sheet Considerations

The thickness of the metallic coating beneath the paint has a significant effect on the life of a prepainted sheet in the field, particularly in the case of galvanize. The thicker the metallic coating, the lower the rate of undercutting corrosion at a sheared edge, at a scratch or any other place where the paint film integrity is lost.

At locations where the paint is cut or damaged and the zinc or zinc-based alloy is exposed, there is lateral undercutting corrosion of the metallic coating. As the coating is consumed by the corrosion reaction, the paint loses adhesion, and peels back or flakes off the surface. The thicker the metallic coating, the slower the rate of undercutting corrosion, and the lower the rate of lateral paint delamination.

In the case of galvanize, the importance of zinc coating thickness, especially for roofing, is one reason that many of the manufacturers of galvanized sheet products recommend a G90 [Z275] coating for most prepainted galvanized sheet applications. For prepainted 55% aluminum-zinc alloy coated the issue of coating thickness is more complex for several reasons. AZ50 [AZM150] is often the recommended coating as it has been shown to be very adequate for long-term performance.

One aspect to keep in mind is that coil coating operations can generally not use metallic-coated sheet that has been passivated with chrome-based chemicals. These chemicals can contaminate the cleaner and pretreatment solutions on a paint line, so the most common practice is to use unpassivated sheet. GalvInfoNote 2.10 on surface treatments describes passivation and its effect on the prepainting process in more detail.

Paint System Considerations

Clearly, one of the most important aspects governing good performance is the paint system used for the job. For example, in areas that receive a lot of sunlight (high UV exposure), it's important to use a topcoat that is very resistant to fading, while in regions where there are high times of wetness it is vital that the pretreatment and topcoat are resistant to moisture penetration. Issues relating to the paint system to be used for a specific application are many and complex, and will not be discussed in this GalvInfoNote. This subject is best covered by the paint manufacturers and coil coated sheet producers, who possess the knowledge needed to make specific recommendations. A document that provides a general review of the

available paints for metallic coated steel sheet products is ASTM Specification A 755/A 755M, Steel Sheet, Metallic Coated by the Hot-Dip Process and Prepainted by the Coil-Coating Process for Exterior Exposed Building Products, available from ASTM at www.astm.org

Prepainted Coil-Coating Process Considerations

An important variable that impacts the life of prepainted products in the field is the manufacture of the prepainted sheet. The prepainted coil-coating process can dramatically affect the field performance. For example, good paint adhesion is important to prevent paint delamination or blistering in the field. Good adhesion requires well controlled coil-coating operating practices. This topic will not be discussed in detail, but remember that the coil-line painting process can influence the field life. Issues involved are:

- Good cleaning practices prior to application of the pretreatment,
- The proper application of a good chemical pretreatment, appropriate for the end use ,
- The application of an adequately thick primer and topcoat, and
- Proper thermal curing of both the primer and paint.

Coil-coating producers that manufacture prepainted sheet for buildings have well-developed quality systems that ensure the above issues are under excellent control. Refer to http://www.coilcoating.org/ for more information on this topic.

Roll Forming and Panel Design Considerations

The importance of panel design, specifically the bend radii along the formed ribs, is another important issue. As noted previously, zinc corrosion occurs at areas where the paint film is damaged. If the panel design is such that the bend radii are small, there is always the tendency for cracks to develop in the paint coating. Typically, these cracks are small, and are often referred to as “micro-cracking”. Nevertheless, the metallic coating is exposed and the potential is present for an increased rate of corrosion along the bend radii on a roll-formed panel.

The potential for micro-cracking at bends does not mean that deep profiles are not possible. But, to accommodate these deep profiles, the design should include as large a bend radius as possible. This aspect of performance involves roll-former design and is well understood by the roll-forming industry.

In addition to the importance of panel and roll-former design, the operation of the roll-former influences the field performance. For example, alignment of the roll sets influences the actual bend radii. If the alignment is not proper, the bends may develop sharp kinks in the profile bends instead of smooth-flowing, gradual bend radii. These “tight” bends may lead to more severe micro-cracking. Also, it is important that the mating rolls do not abrade the paint coating as this degrades the ability of the paint to accommodate the bending operation. Spring-back is another relevant issue that needs to be recognized when roll-forming. The usual way to allow for spring-back is to “over-bend” the panel. This is needed, but over-bending during the roll-forming operation does tend to cause more micro-cracking. Again, the quality control procedures of building panel producers are set up to deal with these issues.

A condition known as “oil canning” or “pocket waves” can sometimes occur on roll formed prepainted steel sheet panels. Panel profiles with wide web or flat areas (architectural profiles) are particularly susceptible. This condition creates an unacceptable wavy appearance when the panels are installed on roofs and walls. While oil canning can be caused by a number of reasons[2], including poor incoming sheet flatness, poor roll former operation and poor installation practices, it can also result from elastic buckling of the sheet during forming because compressive stresses occur in the longitudinal direction of the panel. This elastic buckling results because the steel has a low or zero yield-point-elongation (YPE). YPE is the

strain associated with discontinuous yielding in the stress-strain curve. During roll forming, sheet at the bend tries to thin in the thickness and contract in the longitudinal direction. In steel with low YPE, the non-deformed regions adjacent to the bend prevent contraction longitudinally and are placed in compression. Pocket waves occur in the web areas when the compressive stresses exceed the elastic buckling limit stress. Steel with a high YPE improves roll formability because it thins locally at a bend with little transfer of strain in the longitudinal direction. In general, prepainted steel with YPE greater than 4 percent will roll form satisfactorily. Lower YPE material may roll form without oil canning depending on roll former set-up, steel thickness and panel profile. Oil canning severity decreases as: more stands are used to form a profile, as steel thickness increases, as bend corner radius increases and as web width decreases. If the YPE is higher than 6 percent, fluting may occur during roll forming. Temper rolling the steel sheet at the time of manufacture will control this. Steel manufacturers need to be aware of when they are supplying prepainted sheet for architectural panels so that manufacturing processes can be used that will produce YPE in the acceptable range.

Storage and Handling Considerations

Perhaps, the most important issue related to storage at the jobsite prior to putting the panels onto a building is “keeping the panels dry”. If moisture is allowed to permeate between adjacent panels, either from rainfall or condensation, and the panel surfaces are then not allowed to dry very soon thereafter, several undesirable things can happen. One is that the paint adhesion can be adversely affected. This can lead to the development of small blisters between the paint and the zinc coating even before the panels are placed into service. Needless to say, this behaviour potentially accelerates the loss of paint adhesion in service.

At times, the presence of moisture between the panels at a jobsite can actually cause the formation of white rust (corrosion of the zinc coating) on the panels. This is undesirable aesthetically and may even render the panels unusable.

If the bundle of sheets at a jobsite cannot be stored inside, be sure to wrap the bundles with paper. The paper needs to be applied in a manner that does not allow water to accumulate in the bundle. At a minimum, cover the bundles with a tarp. Keep the tarp covering open at the bottom so that water can flow away freely and so that the bundles can have free airflow to allow the bundles to dry if for some reason condensation does occur.

For further information on this topic refer to National Coil Coaters Association (http://www.coilcoating.org/) publication: Toolkit #1: Preventing Job Site Storage Corrosion of Prepainted Building Panels.

Building Design Considerations

As mentioned previously, corrosion is greatly influenced by the time of wetness. One of the most important design rules, therefore, is to ensure that all rain and melting snow can run off a building[1)]. Water should not be allowed to collect and sit in contact with a building. Following are some other suggestions related to roof and wall design.

Roofs

- Roofs with low slopes are subject to the most severe corrosion conditions. They encounter high levels of ultraviolet (UV) radiation, acid rain, particulate fallout, and wind-borne chemicals. Every effort should be made to avoid water ponding at overlaps, ventilators, air conditioning equipment and other objects. For maintenance traffic, walkways should be provided to prevent damage to the coating.

- Drip edge puddling is a function of roof slope. The greater the slope, the better the corrosion performance at drip edges.

- Dissimilar metals, e.g., steel, aluminum, copper, lead, should be separated electrically to prevent galvanic corrosion. Also, to avoid another source of galvanic corrosion, the runoff path should be directed to prevent water running from one type of material to another.

- Consider using lighter colours on roofs to lessen the damage from UV radiation.

- In areas where the roof of a building experiences heavy accumulation of snow, and the snow is on the roof for long periods, there is the possibility of shortened panel life. If the building design is one where the space immediately beneath the roof panels is warm, the snow next to the sheet may be kept melted all winter long. This continual slow melting leads to a situation where the painted panel is in constant contact with water, i.e., a long time of wetness. As explained earlier, the water eventually permeates the paint film and corrosion can be severe, leading to an abnormally short roof life. If the interior roof is insulated so that the roof panel stays cold on the underside, then the snow in contact with the exterior surface is not constantly melted, and the paint blistering and zinc corrosion associated with long times of wetness are avoided. Also, keep in mind that the thicker the paint system, the longer it is before moisture permeates to the substrate.

Walls

- Vertical side walls receive less exposure to the weather than other parts of a building and suffer less deterioration, with the exception of protected exposures.

- Cladding located in protected exposures, e.g., wall reliefs, overhangs, etc., receives less exposure to sunlight and rainfall. Corrosion is increased in such locations because contaminants are not washed away by rainfall. In addition, wetness due to condensation is not dried due to the absence of direct sunlight. Protected exposures in industrial or marine environments, or close to major thoroughfares, should receive special attention.

- Horizontal portions of wall cladding should be adequately sloped to prevent the accumulation of water and contaminants. This is particularly important for base flashings, as an inadequate slope can allow both it and the cladding resting on it to corrode.

- Dissimilar metals, e.g., steel, aluminum, copper, lead, should be separated electrically to prevent galvanic corrosion.

- As with roofs, corrosion can be an issue for sidewall panels in areas that receive high amounts of snow. If possible, remove the snow from areas adjoining the building, or use good insulation practices so that snow build-up against a building is not continually melting on the panel surface.

- Good insulation practices are helpful for many reasons. Most importantly, do not allow insulation to become wet, and if it does, never let it come in contact with prepainted panels. Once insulation gets wet, it doesn't dry very quickly, if at all. Again, this leads to a situation where the panel is subject to long times of wetness; a condition that will lead to accelerated failure. A common situation in the field is when the insulation at the bottom of sidewall panels gets wet because water sits on the footer. A design that involves the panels overlapping the footer, rather than one where the panel bottom is set directly onto the footer, seems preferable to minimize this potential problem.

- Prepainted Galvalume sheet should not come in direct contact with wet concrete. Concrete's high alkalinity attacks the aluminum, causing the coating to peel[3].

If the application involves the use of fasteners that penetrate through the panels, the fasteners need to be selected so that their life matches the life of the prepainted panel. Today, there are screws/fasteners with an organic coating on their heads that provide corrosion protection and are available in colors to match the roof/wall cladding.

Installation Considerations

Perhaps the two most significant issues relating to field installation, especially when the application is a roof, are the way the panels are moved around on the roof and the impact of the worker's footwear and tools. If the panel edges have any type of burr from the shearing operation, the paint film can be scratched through to the zinc containing coating when panels are slid across one another. As noted previously, at any location where the paint integrity is compromised, the metallic coating begins to corrode more rapidly and the life of the prepainted panel is adversely affected. Similarly, worker's footwear can cause similar scratching damage. It is important that shoes or boots do not allow small stones, steel drillings, etc., to be embedded into the soles.

During the installation, there are often small drillings and/or cuttings (called "swarf") from the fastening and trimming operations. Remember, these contain steel. After the job is done, or even before, the steel will corrode and leave behind a rust discoloration that is objectionable, especially if the paint color is a light tone. Too often, this discoloration is thought to be actual premature degradation of the prepainted panels, and in addition to the aesthetic issue, the building owner needs to be convinced that the building is not failing prematurely. All swarf should be immediately removed from the roof.

If the application involves a low-slope roof, the possibility of water ponding is real. Even though the slope design might be adequate to provide for free drainage, there might be local issues that lead to ponding of water. Small dents caused by workers (walking or placement of tools etc.), can leave behind areas that do not experience free drainage. If free drainage is not allowed, the ponding may lead to paint blistering, then to paint disbondment in larger areas, and then to more aggressive corrosion of the metallic coating beneath the paint. After erection, settling of the building may lead to improper roof drainage.

Maintenance Considerations

Simple maintenance of the prepainted panels on the building involves washing with water from time to time. This is not usually necessary for installations where the panels experience rainfall such as a roof. But, in protected exposure areas, such as the soffit and wall sections beneath eaves, washing every six months is beneficial to remove corrosive salts and debris from the surface of the panels.

Care with washing is needed.

- Do not use strong cleansers as these may damage the paint.
- Do not use scouring powders as these assuredly will damage the paint surface.
- One cup of a mild non-abrasive detergent (one that contains less than 0.5% phosphate) dissolved into five gallons of water is a common cleaning agent.
- If mildew or other fungal growth is present, a recommended cleanser is one gallon of household bleach in five gallons of water along with one cup of mild soap to aid wetting.
- Never use a hard bristle brush; use only a very soft bristle brush or a soft cloth
- After cleaning, wash the surface thoroughly with clean water.

It is recommended that any cleaning be done by first "test cleaning" a small surface area in a location that is not boldly exposed to be certain that satisfactory results are achieved.

Also, for roofing applications, the removal of loose debris such as leaves, dirt or building effluent (dust or other residues around roof vents), etc., is important. Even if these residues do not contain corrosive chemicals, they prevent the quick drying that is vital for a long-life roof.

Another thing to be careful about – don't use a metal bladed shovel to remove snow from roofs. This can cause severe scratching of the paint.

Prepainted metallic-coated steel sheet for buildings is designed to provide many years of problem free service. Eventually, however, all paint coatings will change in appearance, perhaps to a degree that requires repainting. Recommendations for repainting weathered coil-coated building panels are given in GalvInfoNote 4.3.

Summary

Prepainted galvanized steel sheet has been successfully used for decades in various climates for building cladding (roofs and walls). With proper selection of the paint system, careful design of the building, and regular maintenance, long and trouble-free service is achieved.

Source: www.mbma.com

References:
1) "Stelcolour Prefinished Sheet Steel for Building Construction", Technical Bulletin 23/December 1983, published by Stelco Inc.
2) Metal Construction Association, Technical Bulletin #95-1060, Revised 1/03
3) Bethlehem Steel Corporation, Descriptive Data Sheet: SPEC-101, April 2000