Inquiries at the GalvInfo Center about Construction and Appliance Applications of Zinc-Containing Coated Steel Sheet – Trends and Implications

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INTRODUCTION

The GalvInfo Center is a resource for technical information on the use and performance of zinc-containing metallic-coated steel sheet products. The Center was established in 1999 to serve both current and potential users of these coated sheet products. The core activity of the Center is to provide technical information and support to direct inquiries received from all sources. The Center has both a toll-free number, and a website on which is published GalvInfoNotes, a series of technical bulletins that cover the most frequently asked questions. Over 40 percent of the queries received by the GalvInfo Center in 2003 had to do with the use of zinc-containing coated sheet in construction and appliance end uses. This paper analyzes the trends in these inquiries as they relate to the need for future development of properties of coated steel sheet. Specific information that has helped users with materials selection is discussed.

INQUIRIES

The GalvInfo Center receives 30-35 inquiries per month related to metallic-coated steel sheet. During 2003, 42% of these were questions specifically about construction and appliance applications of these products. Of these two end use categories, over 80% of the questions were construction related. Table I shows a summary of the question topics. Most of the calls and e-mails originate from the continental USA and Canada, although a significant number of inquiries came from South America and the Far East.

As Table I illustrates, of the inquiries related to construction applications, almost one-half deal with corrosion issues, with most of these about product service life. This is the dominant question asked of the GalvInfo Center – how long will a particular coating last. Environments asked about include atmospheric, indoors, in contact with treated wood, in contact with concrete, and buried in soil, to name the most frequent. Another popular question is about zinc-based coatings in contact with other metals; copper, lead, stainless steel, etc. Quite a few questions were received about how the salt spray test is conducted and the performance of various

coatings in this test. Many of the corrosion queries were about white rust (storage stain). Callers wanted to know how to remove it and how harmful it is to the life expectancy.

A significant number of questions in the construction area have been received about appearance issues, particularly phosphatized galvanize – what is it, what is it used for, can it be used as-is on exterior building panels, and even how to solder it. On a related note, the Center has even received calls asking how to dull the metallic sheen on newly installed galvanized roofs and gutters, both as a preparation for painting, and to leave unpainted. A few questions have been about the painting of aged (and sometimes rusted) buildings clad with galvanized sheet. Another concern voiced is how to prevent and/or remove the black marks that sometimes occur on Galvalume roofs during construction.

The weldability of metallic-coated steel sheet was another topic that came up frequently. Questions were related to spot welding, MIG welding and soldering.

Table I GalvInfo Center Inquiry Topics

<table>
<tr><th colspan="4">Topics and Percentage of Construction/Appliance Inquiries</th></tr>
<tr><td rowspan="5">Construction
83%</td><td rowspan="2">Corrosion
47%</td><td>Service Life
35%</td><td>In the atmosphere – 9%
In buildings – 8%
With treated wood – 8%
In concrete – 4%
Galvanic contact – 4%
In soil – 2%</td></tr>
<tr><td>Various
12%</td><td>Storage stain – 6%
Salt spray resistance – 4%
Zinc runoff – 2%</td></tr>
<tr><td>Appearance
20%</td><td colspan="2">Phosphatizing – 6%
Painting issues – 6%
Dulling – 4%
Other – 4%</td></tr>
<tr><td>Weldability
11%</td><td colspan="2">General – 4%
Galvalume – 2%
Phosphatized – 2%
To stainless – 2%
Of galvanneal – 1%</td></tr>
<tr><td>General
6%</td><td colspan="2">Coating thickness – 4%
Fire ratings – 2%</td></tr>
<tr><td rowspan="2">Appliance
17%</td><td>Coatings
11%</td><td colspan="2">Salt spray testing – 2.5%
Hot-dip galvanize vs. electrogalvanize vs. Galvalume – 2.5%
Coating weight versus performance – 2%
Heat resistance – 2%
Prepaint – 2%</td></tr>
<tr><td colspan="3">Formability – 2%
Specifications – 2%
Passivation – 2%</td></tr>
</table>

The questions related to appliance applications of coated sheet were mostly about the testing and performance of available coatings. Performance issues covered topics such as service life and heat resistance. Formability of coated sheet for appliance parts also came up.

Corrosion Inquiries

The predominate question being asked of the GalvInfo Center by users of metallic-coated steel sheet is how long will the material last in service. The service environments asked about included both indoor and outdoor atmospheric, aqueous, in concrete, in soil, in contact with treated wood, and animal containment structures.

Atmospheric service life

The Center has received a number of questions about the use of metallic-coated sheet for lightweight steel framing (LSF). Most of these inquiries involved the misapplication of material. In one case the interior walls of a school were constructed using G40 for the framing members instead of the specified G60. The architect was facing a possible tear down and rebuild situation. The GalvInfo Center provided information that showed the corrosion rate of zinc in a clean indoor atmosphere is typically below 0.1 microns per year.[1] The documentation included the information that a G40 coating has a minimum thickness of 9.5 microns of zinc on each surface. The life expectancy of this material would therefore be at least 95 years (compared to 140 years for the G60 coating). This information was sufficient for the architect to convince the state engineer that the building construction using the G40 was not in jeopardy and a costly situation was avoided.

A similar inquiry involved a school where a contractor incorrectly used G60 for LSF instead of the specified G90. Using the 0.1 micron per year indoor corrosion rate for zinc, a 21 micron G90 coating would last a minimum of 210 years compared to 140 years for G60. Again, this information was sufficient to convince the building authority to allow the LSF made from G60 to remain in place. In similar vein, an architectural firm called when a building inspector wanted to reject and remove the LSF in a highway rest stop because they were made from 55% aluminum-zinc alloy-coated instead of the specified galvanize. After learning that ASTM specification A 1003/A 1003M, Steel Sheet, Carbon, Metallic and Nonmetallic-Coated for Cold-Formed Framing Members allows the use of 55% aluminum-zinc alloy-coated, AZ50 (the thinnest produced), along with galvanize coatings G60 for structural members and G40 for non-structural members, the architect said there would be no problem in convincing the inspector that the structure was satisfactory.

A manufacturer of stone and tile-clad prefabricated wall units, which use G90 galvanized steel for their internal frames, called after an architect requested proof that the steel would not rust if condensation occurred inside the wall. It is difficult to provide data to answer such questions, because aside from the above mentioned corrosion rate data, there are few studies published on the service life and condition of galvanized steel in buildings in various North American climates. Along with a letter explaining the reasons for the 200 year plus life expectancy of G90 in such end uses, the caller was advised to emphasize any of their design features that prevent condensation, and use the 40 year trouble-free history of the wall units as evidence of the soundness of their product and freedom from damaging corrosion.

A caller representing a construction company asked what A40 and A60 galvanize was and whether they could be substituted for G90 that was specified for door frames. After explaining they were zinc-iron alloy coatings, one-half and two-thirds as thick as G90, the caller was advised that if the frames were for indoor use and were to be painted, there would be very little risk of corrosion. While G90 is advised for exterior door frames, it is more than is required for indoor frames. Of course, approval would have to be obtained from the specifier.

As the concern with rust is likely to continue being an issue, the types of questions discussed above will continue to be asked by regulating authorities, designers and builders using galvanize in buildings. If such is the case, and as an aid to increasing knowledge about using galvanize for LSF, a database of the actual corrosion rates and condition of LSF in buildings across the continent should be started and continually updated. The data could be obtained by studying LSF that is easily accessible in buildings, or during renovations, or after demolition. The results could be part of a program to educate users about these products. For instance, relative humidity up to 70% has little effect on the indoor corrosion of zinc.[2] Thus, there appears

to be little need for G90 to be specified for LSF, except in exceptional circumstances. With an expected life of at least 210 years, it would appear to be a case of over-specifying for most indoor service environments. Cost savings could result from not over-specifying coating weights for LSF. The results of the building surveys would serve as proof of the longevity of this product.

A very useful aid to predict the life of zinc coatings in various atmospheric environments does exist on the internet now. It is sponsored bys ILZRO and can be found at: http://213.193.160.172:8080/zclp/index.html . The prediction calculations are based on models developed using statistical calculations and a worldwide corrosion database. Corrosion rates cannot be predicted with certainty however.

Publication of widely available guides to coating weights for LSF based on actual experience would help users balance the service environment and required service life against cost and at the same time offer assurance that the required product life would be achieved. One such guide has recently become available and deals with the corrosion protection for cold-formed steel framing in coastal areas.[3] Also; the AISI has programs in place that includes durability testing, in their goal to increase the use of LSF. Guides and information covering all environments, based on actual product life data, would instil added confidence in the user community about applying galvanize for framing members.

A few calls have been received from appliance manufacturers asking about substituting lighter coatings for G90. One manufacturer used G90 for brackets in appliances. He was advised that the service environment for each type of appliance would have to be looked at, but unless if was severe from a wetness or chemical standpoint, G60 would probably be more than sufficient in most cases, and G40 might be suitable for some. The caller was, of course, looking for cost savings and this approach certainly offers that opportunity. If it was decided to make a switch, it would probably be necessary to modify some of the qualification testing. A maker of computer server cabinets was having problems with the visibility of blue ink stencilling on G60 parts due to the metallic sheen. He was told that changing to A40 would provide adequate corrosion protection and most likely the stencil would show up better. It would also be slightly less expensive. A more expensive option would be to use temper-passed G60, which has a matte finish.

Service life in concrete

Another question asked of the GalvInfo Center is the life of galvanize in concrete. Specifically, a caller was introducing a new method in North America for constructing concrete buildings, wherein the forms are made from expanded galvanize sheet and remain imbedded in the concrete. It allows concrete structures to be built faster and cheaper than with the traditional method. The imbedded galvanize is not in contact with the atmosphere after completion. They received an argument from an engineer in Miami, claiming that in that region's environment, the imbedded galvanize will prematurely rust due to the chloride atmosphere. The Center provided information that the corrosion rate of zinc imbedded in concrete is less than 0.1 micron per year if the water/cement ratio of the concrete when made is less than 0.6 and the chloride content is kept below 1%.[4] A high water/cement ratio results in concrete with a high permeability, allowing moisture to more easily reach the metal. The caller was also referred to the American Galvanizers Association website where a case study showed that a concrete bridge in the Florida Keys, constructed using galvanized rebar, is in excellent condition after almost 30 years.

Another call was received about the expected life of galvanize serving as the underside of a concrete floor deck over an enclosed porch 40 feet from the ocean in Santa Cruz, CA. Information was provided showing that the corrosion rate of fully exposed zinc near this location is 1.2 microns per year.[5] At the time no information was readily available about unvented enclosures close to the ocean. Given that the coating weight involved was G90, the caller was advised that it was most likely a safe application, in conjunction with controlling the concrete quality. In another instance of wrong material being used, a call from an engineering consultant asked about the

expected life of G60 (versus the specified G90) for an outdoor walkway concrete floor deck. The location was in Texas, 40 miles from the Gulf. As no exact data was available, only an estimate could be provided along with the comment that the time to first rusting would to be one-third less than if it was G90. As the concrete had not yet been poured, the caller was again advised to closely monitor its quality in terms of water/cement ratio and chloride level.

While it is generally known that galvanize performs well when in contact with or imbedded in concrete, it is not widely known that the chemistry of the concrete can play a role in the life expectancy of galvanize. This information needs to be more widely available to the marketplace. It is perhaps worthy as a topic for a future GalvInfoNote on the Center's website. Again, a data base of successful galvanize applications in, or in contact with, concrete would be very useful.

Calls have been received about using 55% aluminum-zinc alloy-coated in contact with concrete. As is done by all the producers of this product, the GalvInfo Center strongly advises callers not to use it where it is imbedded in or directly touches concrete.

Service life in contact with treated wood

Changes in the preservative-treated wood industry have created concerns about corrosion affecting zinc-coated metal connectors, anchors, and fasteners. Effective December 31, 2003, the preservative treated wood industry voluntarily transitioned from Chromated Copper Arsenate (CCA-C) used in residential applications to alternative treatments. These new treatments include Alkaline Copper Quat (ACQ-C), ACQ-D (carbonate), and Copper Azole (CBA-A, CA-B). Accelerated testing has shown that these new treatments are more corrosive to zinc than CCA-C; as much as 2.1 times for the ACQ-D and CA-B types.[6] The copper content of these new treatments are in some cases as high a 96% compared to 18% for CCA-A, creating a more aggressive dissimilar metal corrosion situation.[7] In the past the connector industry successfully used G60 and G90 for its products. These coating weights may now not be robust enough to withstand the corrosiveness of the new treatments. There has been a move to order G185 as the coating weight of choice, or use stainless steel. The GalvInfo Center has received numerous calls from users concerned with this situation. As G185 is not obtainable in as wide a range of sheet thicknesses as G90, and is more expensive, solutions other than switching to stainless steel are being sought. The possibility of using inhibitors in the new wood treatments has been raised by the GalvInfo Center. If successful, this could allow the continued use of G90 for pressure treated wood connectors. A project that would include this and other solutions is being developed under the leadership of ILZRO. Hopefully a successful resolution will be reached. If not, the cost of building treated wood structures will increase and the portion of the connectors that cannot be made with a G185 coating will be lost to the continuous galvanizing industry.

Service life with dissimilar metal contact

Questions continue to be received about the service life of galvanize that is in contact with other metals. This is a very difficult question to answer in most cases. While there is much data in the literature on this subject, it is not easy to translate it into service life as there are so many variables. Generally the answer given is to avoid having galvanized steel come in contact with other metals whenever possible. When it must occur, the usual response is to supply callers with corrosion rate data for the most common metals and various environments, then allow them to come to their own decision. The example of the type of data supplied is shown in Table II.

Table II Galvanic Corrosion Rates of Zinc Coupled to Other Common Metals[8]

Coupled Alloy	Galvanic corrosion rate (μm/yr)		
	Rural	Urban	Marine
Zinc freely exposed	0.5	2.4	1.3
Mild steel	3.0	3.3	3.9
Stainless steel	1.1	1.8	2.0
Copper	2.2	2.0	3.2
Aluminum	0.4	1.1	1.1

While this information is generic, it gives users an indication of what common situations to avoid and which metals are the least aggressive towards zinc. In one case, a comment was received from the manufacturer of connectors for wood structures that it is better to use stainless steel nails with galvanized connectors than to use galvanized steel nails with stainless connectors. The Center agreed with their assessment, as the zinc on a nail shaft and head would likely corrode faster than the zinc coating on a connector surrounding a stainless nail shaft and head.

One caller asked if the cut edges of 12 gauge still needed to be protected if certain types of saw blades were used. It was explained that for galvanized sheet, the steel exposed on any cut edge is galvanically protected in most environments for thicknesses up to about 1/8". This is the case when the sheet is sheared and therefore a smooth saw cut would not be any different. Early edge corrosion could occur if a saw cut was ragged and left burrs or protrusions that extended out from the sheet. Blades that leave a smooth cut are preferred.

Callers have asked about having dissimilar metals on the exterior of buildings when these metals or coatings are not in electrical contact with galvanize. In these cases they have been advised to be sure that rainwater cannot run off other metal building parts onto galvanize parts. If this occurs it can accelerate the corrosion of the zinc coating, sometimes significantly.

Service life in soil and marine environments

Questions have been asked about the service life of galvanize in soil, and occasionally in marine environments (in or just above the water). With regard to soil, it differs greatly from other natural environments. It has a much wider range of chemical and physical properties and is highly inhomogeneous. While there is much data available in the literature, there have been few systematic studies of the corrosion of zinc in soil. The most recent investigations were conducted by the U.S. National Bureau of Standards and ended in 1955. As soil is so inhomogeneous, both microscopically and macroscopically, it is probably unrealistic to expect data to exist for all situations. The GalvInfo Center attempts to answer questions with the data available and sometimes directs callers to the American Galvanizers Association because the products involve after-fabrication galvanizing.

A greenhouse builder in Florida has found that G60 and G90 support tubing has corrosion problems where it goes into the soil. The interior of greenhouses can be wet for long periods and there is an increased level of plant chemicals near and in the ground. Post hot-dipped galvanized greenhouse structures with their heavier coatings are known to last much longer and the caller had been offered tubing made from G210 and asked if would be equivalent to post hot-dipped of the same coating weight. He was told that it definitely would be, as the corrosion resistance of zinc is directly related to its thickness, and not to how it is applied. Also, G90 would most likely be satisfactory higher up in the greenhouse structure, but G60 should be avoided.

Most of the questions about marine applications, e.g., boat lifters, are concerned about the life of coatings such as G210 and G235. Again, there are many variables that make it difficult to predict product life in saltwater environments. For instance, corrosion rates just above the water are much different than if the coating is submerged in the tidal erosion zone and different again in deeper water. For these applications it is usually a

case of obtaining as heavy a coating as possible, including going to after-fabrication coating. Sometimes data is readily available for the location the caller is interested in and this is passed along

Storage stain and salt spray testing

Questions are routinely received about storage stain (white rust) problems on galvanized sheet. One such query involved over 2000 roll formed panels that had been stored outside for months before being used. All were badly stained with the typical white corrosion product. The caller wanted to know what would remove the stain and restore the sheets to their original sheen. While it is sometimes possible to remove most of the stain with mild solutions of phosphoric acid and good rinsing, it has unfortunately never been possible to restore the metallic sheen. The only known cure for this problem is prevention of the conditions that cause it. Prevention is covered in GalvInfoNote #7 on the Center's website; www.galvinfo.com. Storage stain removal deserves investigation, because if a method could be found to clean and even partially restore the original appearance, it would prevent the rejection of many tons of galvanized sheet that is discarded for mostly aesthetic reasons. Other calls have been received from building authorities concerned about storage stain visible on galvanized framing members already installed. They were advised that if the stain is of the white form, the corrosion protection properties of the coating have not been compromised. Black or red stains mean the coating has been damaged. One call was from an insurance broker who wanted to know what white rust was, as he had denied a claim for it.

Numerous calls have been received on salt spray testing. The center has posted GalvInfoNote #15, The Salt Spray Test, on its website that answers most of the frequently asked questions. New questions continue to come in. A maker of metal cabinets wanted to switch from EG G30 to HD G30 and asked if it would perform the same in salt spray testing. He was told that the time to first rusting is related to the zinc thickness, not the method of application. A caller wanted data on the salt spray resistance of 55% aluminum-zinc alloy-coated versus stainless steel. Note #15 provides information on the former, but unfortunately the Center could not provide any data on stainless steel. Another caller wanted information on what coating would be required to pass a 500 hour salt spray test without corrosion on 0.6 mm sheet for refrigerators. As the information on Note #15 shows, the only coatings that will provide that performance are AZ150, 55% aluminum-zinc alloy-coated, and perhaps ZGF275, zinc-5% aluminum alloy-coated. A galvanized coating thick enough (~Z700) to give this performance is unavailable on 0.6 mm sheet.

Zinc runoff

An inquiry was received from an architect as to how to respond to the concerns of a client in the Pacific Northwest about 55% aluminum-zinc alloy-coated steel roofs being considered pollution generating surfaces due the elevated zinc content of the runoff water. At the time it was not possible to provide information to completely defend the use of these products, although the option of using a prepainted was pointed out. A copy of the American Iron and Steel Institute 2000 position paper on this issue was also provided[9]. This bulletin emphasized that zinc is an essential element for sustaining life, has always been present in the environment, but that more research on its effects is needed, and the results need to be interpreted properly and adopted in a reasonable manner. Since that time the first study has been completed in the Pacific Northwest and the results are being presented at this conference. Indications are that the results are positive for the galvanizing industry. If more studies are necessary, they should be undertaken quickly.

Appearance Inquiries

Numerous calls were received asking about bonderized (phosphatized) galvanize. Some simply asked what is it and how is it meant to be used. The response, of course, is that is intended to be painted since the phosphate crystals serve as an excellent base to paint over and achieve superior adhesion. On the other hand, several discussions were held with users who clad buildings with it and leave it as is. In some areas of Texas, roofs are clad with it and left unpainted. An architect in Oakland had used unpainted phosphated galvanize for exterior

wall panels, even though it is not guaranteed for this end use. The reason he called was that he liked the look of unpainted galvanneal even better and wanted to know if it was an acceptable product for exposed panels. He was advised very strongly not to use galvanneal. There does appear to be a market for the "phosphatized look" (low gloss, matte grey). Perhaps paint suppliers should look at developing such a finish using prepainted steel. The appearance would be more consistent and it would have superior corrosion resistance. Cost would be an issue though, as phosphated sheet has lower cost as one of its benefits.

Calls have been received from building owners asking how to dull the shine on new galvanized roofs and eaves troughs. In the case of the roof query, the reason for asking was not to prepare it for painting but simply to make it less shiny. The owner did not want to wait for natural weathering to do this as the building was located in Montana, and it would have taken considerable time. He was advised to use solutions of acetic acid or phosphoric acid, to rinse the panels very well, and to always try test panels first.

Building owners routinely call about the procedures for painting weathered, and sometimes rusted, galvanize. They are usually directed to a paint company websites where advice is offered on the best methods for doing this. In the coming year it is the intention of the GalvInfo Center to post a GalvInfoNote on painting of galvanize and repainting of weathered prepainted coated sheet.

Weldability

Questions are routinely received about how to weld coated steel sheet. There is much information published about how to weld these materials. Callers are usually referred to a welding handbook, such as that published by the American Welding Society[10]. As an example, a question was asked about arc welding procedures for 55% aluminum-zinc alloy-coated sheet for a roof and how they differ from those used for galvanize. One caller asked about how to solder phosphatized galvanize panels on a roof. Yet another asked how spot welding galvanized panels for a building wall would affect the corrosion protection. Answers exist to most coated sheet welding questions, so the GalvInfo Center will be writing another GalvInfo Note to cover this topic, with the aim of providing information to answer the most frequently asked questions.

Passivation

A message was received from an electronic equipment chassis manufacturer that European Union directives mandate elimination of hexavalent chromium coatings from material sold in the EU by 2006. The vast amount of passivated galvanize sold in North America today is passivated with chrome conversion coatings. These treatments cannot be guaranteed to be free of hexavalent chrome. This restriction affects North American manufacturers who sell their products in Europe. It is likely that similar rules will be adopted here. Alternate chrome-free treatments are available and it is probable that the demand for them will increase sharply in the not too distant future. The caller in this case was put in touch with a producer of chrome-free treatments to obtain more information about them.

Other Inquiries

A few calls have been received asking about the temperature resistance and even the fire rating of coated steel. In one case, an architect asked if the galvanized gang nails in uncharred wooden roof trusses that had been exposed to 250°C from a fire would have been damaged. As galvanize can be safely exposed to temperatures up to 300°C for extended periods without affecting the base steel or coating adherence, the caller was assured that the gang nails were unaffected. Another questioner asked if it was safe to use 55% aluminum-zinc alloy-coated sheet in cooking stoves. As this material can withstand temperatures of at least 370°C without harmful effects, it would be very useful in such applications.

Questions related to fire ratings are very difficult to answer, as any ratings for coated steel are dependent on the structure or building system they are part of. Callers are usually referred to websites of manufacturers who

have the fire ratings of their systems published. This is another area that AISI is working on in their goal to increase the use of coated sheet for lightweight steel framing.

Occasionally the Center is asked to clarify specifications for callers, usually to explain terminology they were not familiar with. Two questions pertained to formability problems on appliance parts, where the solution was related to the properties of the base steel rather than the coating.

SUMMARY

The frequency and varied nature of the questions received by the GalvInfo Center show that there is a need for the service. Aside from instances where the Center's input helped avoid an unnecessary rejection, it is evident that many users of coated sheet products do need help; not only in material selection but in the practices they use to store, join, fabricate and protect the material from corrosion. Many callers express their thanks for the service provided by the GalvInfo Center. The most frequent issue voiced in 2003 is with service life, mostly in the construction industry. The trends of all questions asked about construction and appliance applications show a need for further development in the following areas:

- Data base of actual corrosion rates and service life of LSF across North America
- Additional guides to coating weight selection for LSF as a function of service environments
- Guide to the use of galvanize in contact with or imbedded in concrete
- Rapid completion of studies to reduce the corrosiveness to zinc of the new wood preservatives
- Investigate if methods exist to easily remove white rust and restore some of the metallic sheen to the zinc
- Quickly finalize the investigation and disseminate the results of the zinc runoff study
- Determine if a significant market exists for a low gloss, matte grey finish for architectural panels, and if so, develop a low cost prepainted coating to meet it
- Develop and deploy chrome-free passivation treatments as soon as possible
- Obtain fire ratings for building systems made using LSF

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