

# Painting of Highway Steel

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Experiences of the author in 18 years of "trouble-shooting" premature paint failures on highway steel are presented. Causes of such failure, and recommendations for their prevention are fully discussed.

By far the greatest factors causing premature failure of highway painting jobs are substandard surface preparation and deficient paint thicknesses. In general, present specifications and materials are adequate, but inspection should be improved. Greater benefits will accrue from greater attention to inspection procedures than from current activities of paint testing.

Material testing and painting advisory services could be most economically and effectively performed by a central agency, supported by, and serving all states and authorities.

Zinc-fortified protective systems have advantage over currently used barrier paint systems. Traditional painting procedures should be discontinued, and painting conducted at centralized locations prior to erection.

•OF COURSE, everyone knows all about painting. Everyone: each paint salesman, any painting contractor, each specification writer, any engineer (and his wife) is a paint expert, and continue to be so until the first premature failure occurs, at which time all disappear, or disclaim any responsibility.

In presenting this paper, we must admit that we do not know painting of highway steel in its proper perspective. We, as painting consultants, are always called in when the experts have vanished, and are belatedly asked to determine who must be sued because of what negligence caused the now increasing failure, what should be done to repair it and who should pay for such repairs. Consequently we have never seen a good highway paint job, although I am assured that thousands exist. We have however acquired considerable expertise in what causes failures.

During these many years we have been compiling a dictionary of highway engineering phraseology:

When one says:

1. The fabricator must have applied the primer over dirt and soilage.
2. The field painting contractor did not properly assess the amount of spot repair of the shop prime, at the time of bidding and hence is coming in for an extra.
3. The painting was done according to these specifications.

We have learned that it means:

1. The specification did not call for, or inspector did not insist on mill scale removal.
2. The specification for shop priming did not call for enough thickness, and regardless, not enough was applied.
3. This is how it should have been done. We are not sure what was done.

Let us follow through the painting history of a typical new bridge as I, a painting-oriented sidewalk superintendent, have experienced them. A major bridge was selected for this example because such bridges represent the maximum in engineering attention and supervision.

Specifications for the painting are written, and they are good specifications—resulting from much study, borrowing from past specifications, and consultation with paint suppliers. Oh to be sure, any specification can be criticized for minor ambiguities and impracticalities, which usually only show up as the job progresses.

The specification is sent out for bids. The shop priming is usually bid as part of the fabrication contract. The contract for fabrication is awarded, and fabrication proceeds.

### SHOP PRIMING

The business of a fabricator is steel fabrication; this is his specialty, and he knows it well. Surface preparation and shop priming after fabrication are only a nuisance to him; slowing up the flow of work through his shop and yard. He cannot justify, or find time to keep pace with the advancing technology of paints and painting.

Surface preparation and shop priming operations are left to the judgment of the shop painters themselves. These are usually low-paid workmen; the bottom of the crafts. Their entire experience in painting is one of pressure: Get the steel painted and out of the shop! They have little opportunity, and no great interest in following the technology of painting. In some few instances, we have found them using wet thickness gages, but dry film gages and other control instrumentation are virtually unknown to them. They do not measure resulting dry thicknesses; the steel has been moved out into the yard by that time. They expect the inspector to tell them whether the thickness is up to specification; you can imagine what happens if there is no inspector!

If hand cleaning is called for, each will carry a wirebrush in his back pocket (where it usually stays), but can be seen diligently "removing" spots of oil drippage by smearing it around with a rag now well soaked with oil. If sand blasting is called for, they will scour off all loose dirt and scale in a big cloud of dust.

After such "surface preparation" the primer will be sprayed on until the steel shows the uniform color of the primer.

This is typical shop surface preparation and priming.

However, let us not be too critical of the fabricators and their personnel. The average shop painter never does see the specifications, and probably could not understand them if he did. Shop management recognizes and directs that either sand blasting or hand cleaning is called for, and the paint material to be used. Shop management does not have the background nor the time to learn the differentiation between "white," "near-white," and the various interpretations of "commercial" blast. He quite reasonably anticipates that the owner's engineer or inspector will instruct him and his painters in the requirements as the job progresses. He is quite prepared and willing to make such adjustments and changes. In the total cost of fabrication, the cost of the painting will neither make or break him. Just do not hold up the flow of work!

### SHOP INSPECTION

So that all-important man to priming quality appears: the owner's engineer or inspector. As the principal work conducted at this shop is fabrication of structural shapes, this man has been selected to be knowledgeable and observant of quality of weldments, positioning of gusset plates and other joint assemblies, accurate dimensioning of the shapes, and sufficient masking of faying surfaces to insure an adequate amount of rust on these surfaces for high-tensile bolting.

It is true that he has been given the extracurricular responsibility of inspecting the quality of shop priming; and in fact has come equipped with some type of dry thickness gage, with which he occasionally makes some desultory passes at painted steel which may be close by.

He has not been instructed in the interpretations and limitations of these instruments, however. He does not know that readings of spring-loaded gages will gradually tend to read higher than the true value due to vibration of the steel and spring elongation with

use, nor that magnetic flux gages will give inaccurate readings when measurements are taken too close to an abrupt change in direction of the steel. On balance, these gages in their usual improper use will give readings on the high side, and the inspector will, in confidence, pass work at typical subspecification prime thicknesses of  $\frac{3}{4}$  to 1 mil. After all, the inspector can be complacent about his lackadaisical attitude toward the painting. Doesn't the field painting specification call for repair of any deficiencies in the prime coat? No permanent harm will be done. Let the field inspectors, who should be more knowledgeable in paint technology take over!

As a result, the steel fabricator and his painters continue their traditional bad practices in honest and full confidence that they are fully meeting the specification. The primed steel moves out to the erection site.

### FIELD PAINTING

In the meantime, bids for field painting are taken—normally spot repair of prime plus three field coats. It must be appreciated that painting is normally awarded strictly on a competitive basis. The majority of painting contractors are responsible, knowledgeable firms, but there are always a certain number of "gypsies" on every bidding list.

These gypsies have learned from past experience the probabilities of any specification being actually enforced in the field and bid the job with the expectation of relaxing the requirements to the fullest; too often the requirement is only that the bridge be of specified color. If they are at times surprised by an insistent inspector, they have lined up a list of claims for "extras." If a few of these many claims are allowed, they usually can make out.

Reputable contractors can assume or know that they will be bidding against one or more of these gypsies. They can bid the job fairly and never get an award, or stay in business by skinning their bid to a no-profit, marginal quality level, and hope to make out by subsequent award of some high margin or "cost-plus" extras. Whichever way the award goes, marginal painting quality is the best that can be expected.

Bidding for field painting is made. Some bidders may have availed themselves of the opportunity of seeing some of the recently delivered shop primed steel, and estimated the amount of spot repairing of the prime which will be necessary. Other bidders will just assume a figure.

The field painting contract is awarded, and the painters start spot cleaning and spot priming any failure in the shop prime, barely having time to do this before the steel workers start the erection. A second field crew follows the erectors, applying the first field coat, for which the average thickness is found to be 1 mil, as will be all subsequent field coats. If this is a major bridge project, the inclement months of late fall, winter and early spring will interrupt all painting activities.

It is after this winter and early spring that the field painting contractor presents his claim for extras on the basis that he is now required to do more spot priming than he observed and bid upon the previous year (Fig. 1). His contention is, and the evidence is convincing to the owners, that the increasing prime failure is due to inadequate cleaning of the metal in the fabricator's shop, and that his extras should be back-charged to the fabricator. He is careful not to call attention to the fact that the prime thickness is thin, as this might call attention to the fact that his own field coats may also be thin.

The prime ranged between  $\frac{1}{2}$  to 1 mil. The first field coat, where applied, brought the thickness up to only  $1\frac{1}{2}$  to 2 mils. It has been proved by Pierce (1), and independently confirmed by others, that a minimum of 5 mils is required for protection in any but the mildest exposures (Fig. 2).

After fabrication, the steel was sent to the fabricator's yard, shipped, placed in the steel yard at the site, and subsequently erected before the first field coat was applied; a period varying between six to nine months of exposure to weather, which almost invariably includes a long wet winter and early spring.

The contractor is right in that the prime has progressively worsened during this exposure time, and most noticeably after the winter season. Failure was accelerated by

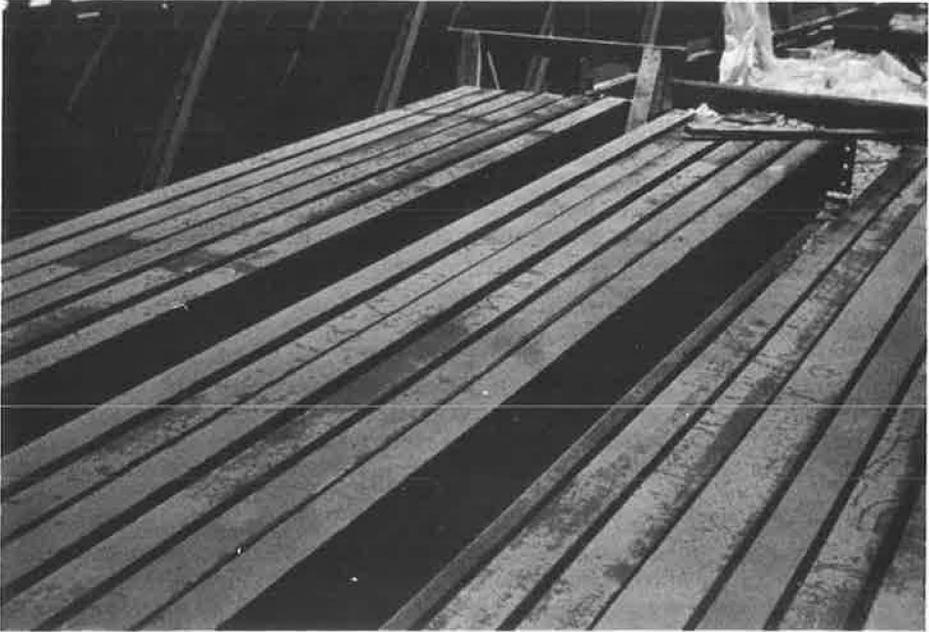


Figure 1. Failure of shop prime at erection site.

any deficiencies in surface preparation, by high prevailing humidity of water crossings, by adjacent industrial or chemical fume sources, and by underlying mill scale.

The extra is allowed and back-charged to the unhappy fabricator. The field painting contractor is now beginning to improve his original narrow or nonexistent margin. Even though he did estimate a nominal amount of spot repair of prime, he can now back-charge all spot repair to the fabricator on a profit-assuring cost-plus basis.

Thus, the field painting proceeds to completion, averaging 1 mil per coat, and a total finished thickness of  $3\frac{1}{2}$  to 4 mils; less if the contractor decides and finds opportunity to skip a coat. With luck this thickness will be sufficient to delay failure until the bridge is accepted by the state or authority, after which their maintenance departments had better be prepared to build up the deficient thicknesses.

#### PROBABILITY OF EARLY PAINT FAILURE

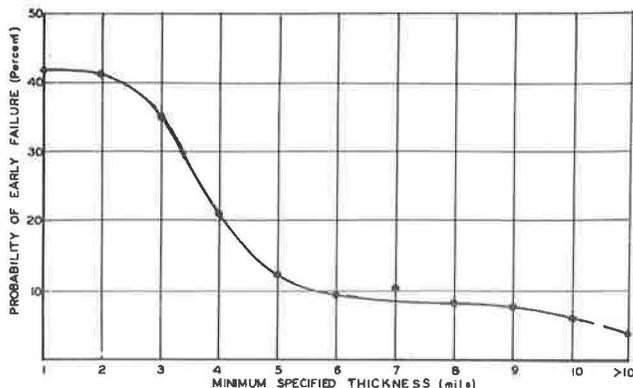


Figure 2. Five mils of paint is required for protection.

During this field painting period, the contractor will succeed in picking up enough high-margin extras for having to cope with real or alleged application deficiencies of the specified paint, damage by other crafts, and work unanticipated at the time of the bidding to keep him in his Cadillac and hunting lodge.

#### PAINT MATERIALS

In the preceding examples, no darts have been thrown at the paint material or its manufacturer, even though we may have been hard on the fabricator and painting contractor. Although there certainly have been instances of

poor paint selection, and paint materials inadequate in application characteristics and durability, these are relatively rare.

Certainly gypsies do exist in the paint manufacturing field. However, the nature of paint manufacturing is such that these are easily distinguished from the long-established reputable firms, if only by size and financial reports. On a major project few specifying engineers would care to take the responsibility of specifying materials from any but reputable manufacturers. True the specification may not specifically mention the manufacturer's name nor his product, but the specification writer is careful to see that the material description is such that only favored companies readily meet it.

Many highway engineers consider painting a necessary evil—an unavoidable repetitive cost of highway maintenance. They have found that in spite of exuberant claims of paint manufacturers there is very little difference in performance of one manufacturer's paint to another; each requires about the same cost for initial painting, and substantially the same frequency of repair and repainting. Thus to them paint is paint, to be selected primarily on the basis of cost or personal or political favoritism.

This is certainly true when the painting application is exposed for prolonged periods to wet, humid, or industrial exposures at protective thicknesses below 5 mils, or when painted over mill scale or soilage under or between coats. Under these conditions, the paint will perform little better than the worst.

Differences in paint quality only become apparent when applied over surfaces of adequate cleanliness, and when protective thicknesses equal or exceed 5 mils (3 to 4 mils in the case of zinc protection).

Paint materials may be broadly classified into two groups: barrier and galvanic protectives.

### Barrier Coatings

Barrier protectives are those with which everyone is familiar, those which everyone has been using in the past, and those which continue in general use today.

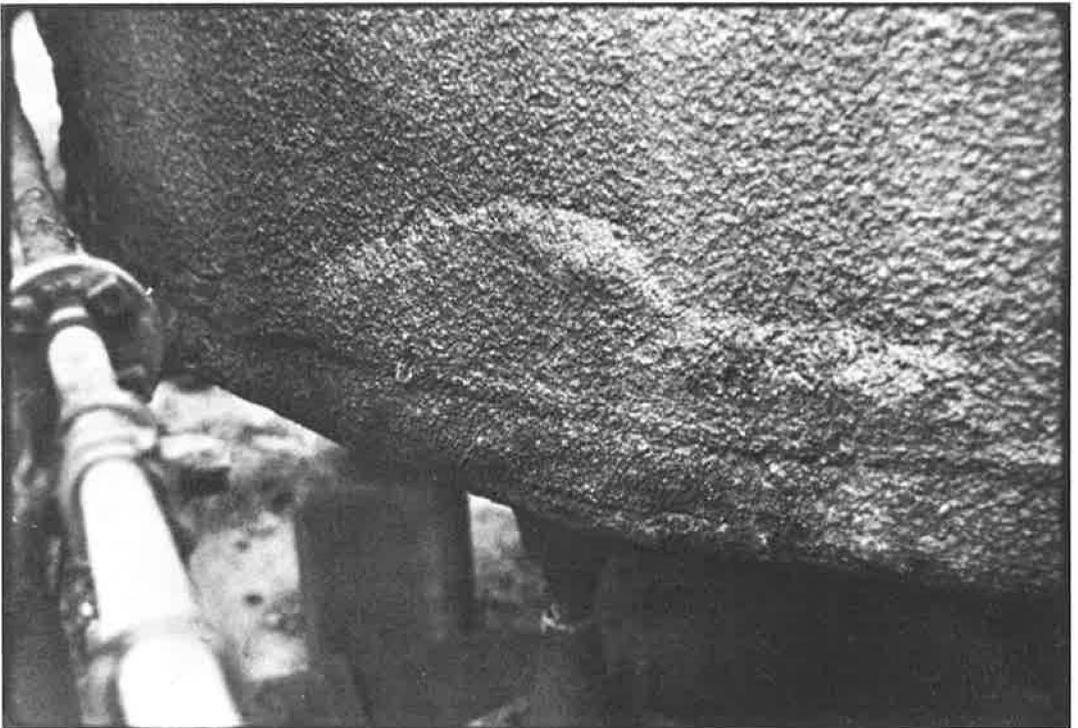


Figure 3. Failure will spread from breaks or holidays.

They protect by interposing a barrier film between the corrodible steel and the corrosive environment. As we have learned by such experiences as trying to sleep in a tent on a rainy night, a barrier is only effective as long as there are no pinholes, breaks, or weaknesses in it. At any such inadvertent discontinuities in the barrier, corrosion will start and if not discovered and sealed in by spot repair, will proceed by prying and undercutting to progressively destroy the entire paint protection (Fig. 3). Thus establishment and maintenance of an unbroken barrier film is essential to the success of these types of coatings. In order to maintain barrier continuity they must be applied in multiple coats, and to a minimum protective thickness of 5 mils.

Good exterior alkyds have proved their ability for nonmarine, nonindustrial exposures; phenolics and vinyls for marine, humid water crossings and occasional water immersion; phenolics, vinyls and epoxies for marine, and for industrial and chemical fume exposures, and for resistance to road salt. These are all barrier type of protectives and structures must be kept well painted in order to seal discontinuities caused by mechanical injury, abrasion, or imperfect application.

### Galvanic Coatings

Galvanic coatings, while not new, are only recently being given renewed attention for highway steel. In their oldest form these are hot-dip galvanize, and more recently zinc-rich coatings (Fig. 4).

Zinc-coated steel in the presence of an electrolyte (supplied by the weather) creates an electric battery, in which the zinc is the anode and corrodes, so generating an electric current, which protects the steel from corrosion. By this galvanic protection, so well proven by the protection of buried pipelines or elevated water tanks by cathodic protection rectifiers or anodes, small discontinuities or base steel exposures can be tolerated and protected. The establishment and maintenance of a continuous film, although desirable, is not required. However inasmuch as protection is electrical, it is essential that there be no insulating films between the zinc coating and the steel; thus the requirements for surface preparation are more rigorous than for barrier types of coatings.



Figure 4. Galvanized guardrails.

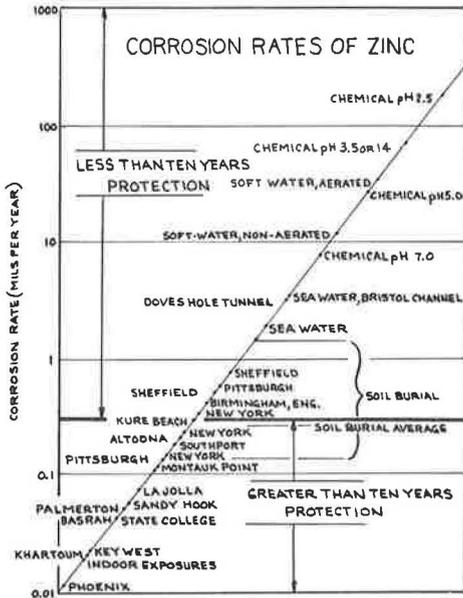


Figure 5. Zinc protection varies with the exposure.

Zinc in the form of galvanizing is an interesting alternative to painting. Galvanize has the advantage that application is by immersion and hence each structural piece is completely coated, with no holidays or pinholes. Even faying surfaces are coated, although it is my bet that research will show that zinc coating of these contact surfaces will be acceptable, and even desirable. Applications are made in the galvanizing plant under controlled conditions.

Galvanizing basically protects by galvanic action hence any base steel exposed by mechanical injury will be protected by electro-galvanic means until the zinc is depleted. In rural and neutral humid or wet exposures, the life of galvanize alone can be from 10 to 20 years, but will be uneconomically short in many industrial (particularly chemical) exposures, and will be shortened by road salts (Fig. 5). Wherever the latter exposures are anticipated, it is recommended that galvanize be overcoated with a barrier type of coating, being sure however to interpose a galvanize primer. The one disadvantage of galvanize is that galvanize protection cannot be economically renewed, it being practical only for fabricated pieces before erection.

Rather recently the solution to this disadvantage has become available: zinc-rich coatings. These are zinc in metallic powder form, with only sufficient binder or "glue" to hold the zinc particles in contact with each other and on the surface, and to render its application possible by conventional painting equipment (Fig. 6). Thus it is possible to apply or renew galvanic protection by painting. This method of zinc application does not have the limitations of size of galvanizing vats which restrict galvanizing of long pieces, and galvanic protection may be installed or renewed on any erected structure at any time. Like galvanize, it can serve as the sole one-coat protective in rural and neutral humid exposures, and like galvanize should be barrier coated in more aggressive exposures.

Thus by the use of zinc-rich coatings, one or two-coat applications are possible, in place of the four-coat systems specified today with barrier coatings. Such possibilities make these zinc fortified protectives competitive in application costs with conventional barrier systems, in spite of their higher material costs and more rigid surface preparation requirements (Table 1).

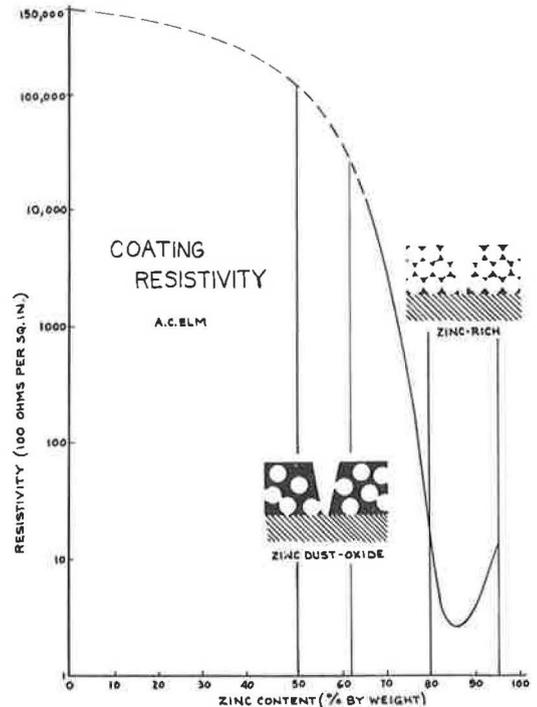


Figure 6. Zinc-rich is a coating of zinc—more than 80 percent zinc.

TABLE 1  
APPLIED COSTS\*

Item	One Coat Zinc-Rich	Two Coat Z-R Topcoated	Four Coat Conventional
Miscellaneous	5.5	5.5	5.5
Surface preparation	26.0	26.0	18.0
Application	3.1	6.2	10.0
Material	8.6	11.6	10.0
Total applied cost	43.2	49.3	43.5

\*Cents per square foot, based on average costs of field painting as determined by T6D-1 of National Association of Corrosion Engineers (2).

Figure 7 shows relative performances to first rust appearance of zinc coatings alone, conventional barrier paint systems, and a barrier topcoated zinc in high humidity-salt exposures, common to river crossings in the northern climates. There is synergistic increase in maintenance-free life of zinc which has been topcoated with a barrier coat (comb); resulting in annual maintenance costs only 20 percent of that required for currently used barrier systems.

While these advantages are impressive enough, there is more—the initial paint application is a zinc-rich coat in place of the present shop prime. This single coat is more resistant to damage by handling and erection than conventional shop primes, and possesses the ability to protect over the inclement winter months (in fact several winters); its performance will in fact be improved by such weathering. Thus, reduction in the cost of field spot repairing will be an added savings.

In the use of zinc coatings, it is imperative that surface preparation be of good quality, and that coating applications be up to a 3-mil minimum. It should also be cautioned that there is no such thing as a "zinc-rich paint." Unlike hot-dip galvanize, many variations of zinc-rich coatings are available, each useful for certain applications and exposures. Be sure to select that formulation best suited for your use.

### INSPECTION

I hope that it is now clear that without doubt the greatest cause of premature paint failure on highway steel is caused by inadequate surface preparation and deficient paint thicknesses. These deficiencies are usual, in spite of the fact that the painting specifications called for and defined qualities which would insure durable protection. What happened?

Would you hire a blind man as a paint inspector? Sure you would! There is no point in ducking the responsibility!

In many cases the fabricators or contractors do not realize that they are doing a defective job. They are doing your job just as well as you have allowed them to do it in the past. It is the owner who has created abuses, by traditional lack of insistence in the field on quality application—not the fabricator nor the painting contractor. It can only be corrected by universal insistence on adherence to specifications.

Interestingly enough, no reputable painting contractors will resent fair,

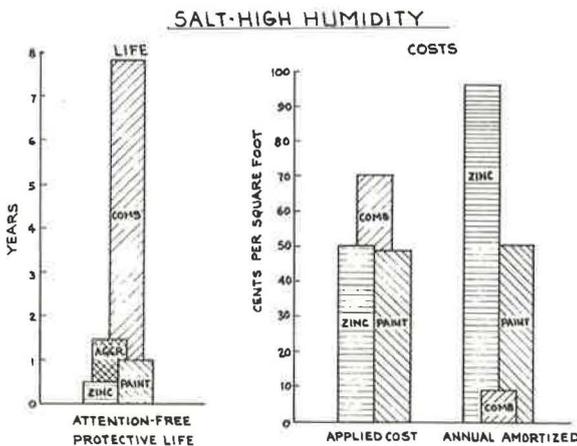


Figure 7. In severe exposures, paint the zinc coating.



knowledgeable and rigid inspection. In fact they welcome it, as it will drive the gypsies out of competition, and permit them to do a paint job that they can be proud of at a fair rate of compensation. We can say this with authority, for we have listened to painting contractors plead in public meetings for more rigid inspection for this purpose. Never have we had a responsible contractor resent the presence of our inspectors on any job, but quite frequently there has been resentment from lesser contractors.

Oh, I know you have inspectors on the job! But do you have, in fact? How knowledgeable are they in the requirements for durable painting? How well equipped are they in instrumentation for their job? An inspector's kit should include an accurate magnetic thickness gage, together with standards and means for verifying and adjusting its accuracy; an optical thickness gage for use as a referee gage and to assess the quality of prior coating applications (Fig. 8); a hygrometer and surface thermometer for determining climatic suitability for painting (Fig. 9); surface preparation standards (Fig. 10); and may include a wet thickness gage, and instrumentation for judging blast profile depth. If your inspectors have such instruments, do they know their limitations?

A recent survey made by the Steel Structures Painting Council in its study on highway painting has indicated that 65 percent of the states are working on improvements of painting specifications, 50 percent are testing paints, but only 25 percent are "improving inspection or procedures." It is apparent from these figures that less than 25 percent of the states are concerned with improving their inspection. Improvement of specifications, already reasonably good, is futile if no provision is made to see that these specifications are lived up to.

State highway departments today are, and traditionally have been, spending much time and effort in testing paints. Variations in paint types and formulations do influence durability, but none will give durable performance if improperly applied. Within any protective type of paint the increase in durability between the best and an average formulation will seldom exceed 20 percent, whereas with any paint system the improvement in performance of a properly applied system over one casually applied will be of the order of several hundred percent. Aren't we penny-wise and pound-foolish to devote so much attention to paint testing, and so little to improving our inspection system?

Keeping abreast of new paint material development and assessing the suitability of each material for highway use is useful. But need it be uneconomically duplicated by



Figure 10. Surface preparation standards.

each state or authority? Such testing could be cooperatively centralized, for the benefit of, and supported by all states. Such centralized test coordination must, by cooperative testing, take into account regional climatic differences and other special conditions which may be unique to any locality.

Inspection however cannot be delegated to others; it must be done on the site. If each state or authority devotes the time now spent for paint testing to improvement and development of an adequate and qualified corps of painting inspectors, benefits will be manifold from current efforts in material testing.

### Inspectors

It might be argued that it would be economically impossible to maintain a corps of paint inspectors sufficient to follow each highway paint job. However, only the major installations would require a full-time inspector. For the multitude of lesser jobs, a roving district inspector checking the work at frequent unexpected intervals should suffice, particularly with the availability of the optical paint inspection gage (4) which permits assessing of coat thicknesses and quality of applications made during periods of his absence (Fig. 11). The days are gone when the painter can cover up deficiencies with another coat of paint.

Furthermore, the paint inspector can have other assignments. But let's not make them too foreign to that of his paint technology; it has been demonstrated that a structural engineer has little knowledge or interest in painting. The paint inspector can also be responsible for the quality of caulking, plastic membraning and constructions, and specification and application of galvanized metal and other corrosion-resistant alloys—all in the related field of corrosion prevention.

It might also be said that it is physically impossible to provide an inspector at each source of highway painting: each fabrication plant and the plant of each equipment supplier. There is a solution to this, where all painting will be conducted at one place under the supervision of a single inspector.

The paint inspector need not be a paint expert. It is necessary that he be an honest, conscientious, observant man with strong legs and arms and good eyesight—coupled with the ability to be able to read and understand specifications. His job is only to recognize and report sub-specification work; more knowledgeable superiors will decide the action to be taken. It is our experience however that the mere observance of substandard work by the inspector will usually cause that work to be corrected by the contractor without the need for referral to higher authorities.

Often the responsibility for inspection by a representative of the paint manufacturer is made a stipulation of the paint procurement. Certainly these manufacturers' representatives know proper application procedures, and will do everything within their available time and obligations to see that their paint is applied properly. However in the use of such "inspectors" it must be ap-

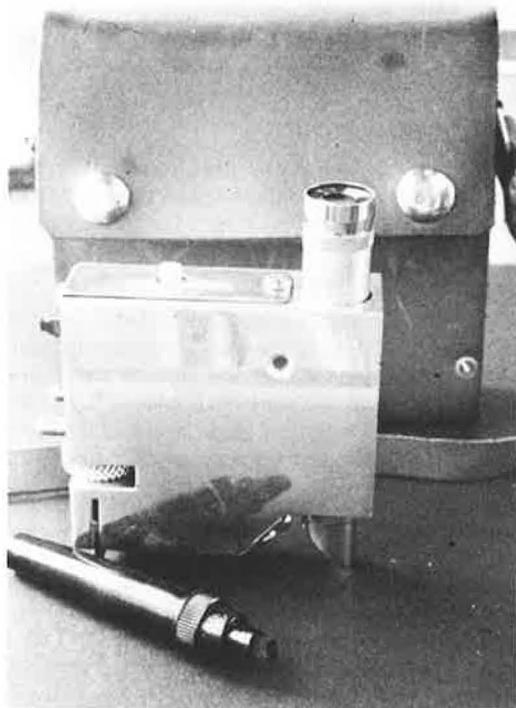


Figure 11. Tooke optical inspection gage.

preciated that such men have dual allegiance. The contractor is his customer! Painting specifications are usually written to give the painting contractor some choice in whose paint he might use, and a contractor is always a big paint purchaser. If a representative of the favored paint supplier should bear down too hard on him, the contractor might choose to discontinue the use of that paint and buy from another approved manufacturer. Thus a paint manufacturer's representative is over the barrel when he serves as a painting inspector.

For the moment let us concentrate on upgrading the quality of our surface preparation and paint application. Sure, there are other factors conducive to paint durability, but let's get these more rewarding problems licked first. It might be said that most of the highway and bridge specifications which we have read are adequate in respect to these. Even on jobs showing premature failure the fault seldom was in the specification, but in disregard of it.

### SURFACE PREPARATION

Would you lay paving on top of a sandy beach? Or on the surface of a wet swamp? Would you set your bridge piers on sandstone? Sure. Many of you would! Many of you have your eyes closed when paint is applied over loose rust, dust and other soilage on your steel, and when paint is applied over oily or damp spots on the surface. Most of you believe that "mill scale is a good paint base."

Surface preparation, or the cleaning of surfaces preparatory to painting, has been sometimes called, with partial justification, the greatest single determinant of durability of the paint job.

To many people surface preparation is synonymous with blasting, and the terminology is replete with such words, as impressive as they are meaningless in actual use, as profile depth, anchor pattern, and blast profiles. Surface preparation is not these!

Surface preparation is very simply and concisely the removal from the surface of all nonadherent residues, and materials which will be incompatible with the paint to be applied. Thus effective surface preparation may be, under some conditions, washing down with a garden hose; under other conditions, the rigorous operation of sand blasting. It is also leaving on old paint which is sound and adherent and compatible with the paint about to be applied.

#### Nonadherent Residues

Loose residues are self-evident: nonadherent and peeling old paint, surface dust and soilage, and nonadherent rust. Mill scale and certain types of rust may be initially adherent, but may be counted on to loosen up in service.

#### Incompatible Residues

Incompatible surface materials are readily recognized when they are in the form of moisture, oil or grease. Previously applied paint films may or may not be incompatible. We all know that we cannot paint over an old tar-based paint, but there are others not so obvious. Paint compatibilities should be known, or spot tests made. Water soluble salt residues from road salts or from industrial contaminants are incompatible. They will set up an osmotic pressure cell in or under the paint film causing blistering and peeling.

#### Rust

Rust can exist in many forms. The only stable form of rust is the orange-brown variety: the highest oxidation product of iron. We have all seen dark brown varieties of rust, and even black rust scale. The latter is also commonly experienced as mill scale, a special creation of rust. Any of these darker forms of rust is iron oxide in an unstable state of incomplete oxidation. By slow combination with oxygen or water (which will slowly diffuse through any paint film) these will gradually increase in volume, lose adhesion to the steel, and finally attain the stable orange-brown form. Thus,

even though they are initially adherent, these darker forms of rust and mill scale should be considered potentially loose residues and removed.

"But can we paint over rust? The man says we shouldn't." Sure you can, as you know from many successful experiences in painting in rural areas. But be sure you know your rust! Be sure that the rust is of the stable orange-brown type, loose rust has been wiped off, and no water soluble contaminants are in the rust. Rural areas favor this acceptable condition, and the uncontaminated rainfall will soon wash deicing salts from the rust.

### Mill Scale

"But mill scale is a good paint base." Sure it is, as sand is a good material on which to build a house. Performances will be satisfactory for a time, but the final result will be catastrophic. Most of the highway engineers of my acquaintance tell me that they have no mill scale failure, but do point to local areas of paint failure, "started from mechanical injuries and abrasions," even though these may be twenty feet or higher from any traffic deck. Pigeons with sharp beaks maybe?

No matter what we do, oxygen will inevitably get through to the mill scale converting this scale to a more voluminous nonadherent base under our coating; sand on which we build our house. As permeation is inversely proportional to coating thickness, the day of eventual failure can be postponed by applying more paint, but mill scale failure is inevitable.

More enlightened states are discovering that it is more economical in the long run to completely remove the mill scale by blasting or pickling before shop priming. Even the less enlightened states have a good thing going for them. Many fabricating shops specializing in bridge construction find that they can get better welds if mill scale and other surface soilage is removed prior to welding. Consequently these have installed rotary blast equipment through which most all bridge steel is cleaned of mill scale prior to welding and shop priming.

### PAINT THICKNESSES

Would you try to hold water in a sieve? Use a toy balloon as an automobile tire? Sure you would! All of you would!

It is our experience that no matter what the provisions of the specification, shop prime thicknesses will vary between  $\frac{1}{2}$  and  $1\frac{1}{2}$  mils, and each field coat will average 1 mil, making a total protective barrier of  $3\frac{1}{2}$  to  $4\frac{1}{2}$  mils for a specification which usually calls for a minimum of 6 mils. It is well recognized that durable barrier protection cannot be obtained with thickness less than 5 mils (1).

You are expecting a shop primer of thicknesses ranging between  $\frac{1}{2}$  to  $1\frac{1}{2}$  mils to protect steel for periods of three to twelve months during wet winter periods and in areas of industrial or chemical fumes. Ask your best painter to paint one coat of shop prime on a piece of glass; let it dry. Now hold it up to the light and see what sort of protection you are depending upon!

It behooves you to get your full protective thickness on as soon as possible, and especially before exposure to inclement weather and to marine or industrial environments. To best accomplish this, call for a critical review of past painting practices and improvements in these.

### PAINT ON THE GROUND

The average bridge specification calls for a shop prime and three field coats. Why couldn't two of these field coats be applied on the ground before the steel is erected?

It is self-evident that a painter can do better quality work, at a higher production rate and at lower cost, standing comfortably on the ground with the steel within ready reach, than he can swinging on a staging or bosun's chair. Of course there will be sling and erection damage, but it will be much more economical to spot repair this damage and only apply the last field finish coat after erection than to apply three full field finish coats up in the air.

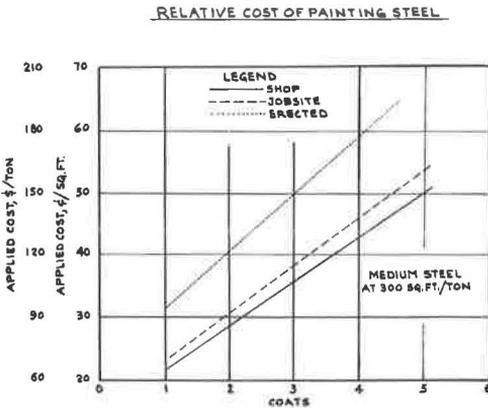


Figure 12. Paint on the ground and at one location.

For this purpose the field painting contractor will get the whole job, and will set up on-site an efficient blasting and painting area, protected from inclement weather. The work will be moved through the painting area, to and from the steel yard by mobile cranes.

#### SUMMARY

We appreciate the opportunity given us by the Highway Research Board to present our view of current highway painting practices. We know that we have stepped on some toes. We are sure that the great majority of these toes belong to men who will mull over what we have said, and where correction is needed, in their judgment, will find solutions much more effective and far-reaching than any that we have suggested. We feel:

1. By far the greatest factors causing premature failure on highway painting jobs are substandard surface preparation and deficient paint thicknesses.
2. In general, present specifications and materials are adequate, but inspection should be improved.
3. Greater benefits will accrue from greater attention to inspection procedures than from current activities of paint testing.
4. Material testing and painting advisory services could be more economically and effectively performed by a central agency, supported by, and serving all states and authorities.
5. Zinc-fortified protective systems have advantage over currently used barrier paint systems.
6. Traditional painting procedures should be discontinued, and painting conducted at centralized locations prior to erection.

#### REFERENCES

1. Pierce, R. R., Key to Savings in Painting Costs. *Chemical Engineering*, p. 149. May 1952.
2. Committee Publication 61-14. Economics of Chemical Plant Maintenance Painting. *Corrosion*, p. 599t, Dec. 1961.
3. Martinson, C. R., Maintenance Painting Costs Can Be Reduced. *Corrosion Control Reporter*, Vol. 15, No. 4. Relationship of Environment and Design Characteristics to Coating Performance and Maintenance, Building Research Institute, Spring Conference, 1963.
4. Tooke Paint Inspection Gage. Kenneth Tator Associates, Coraopolis, Pa.

Monsanto Company (2), adopting this procedure for new plant construction, has realized 24 percent savings in painting costs. In addition, the quality of the job and hence its maintenance-free life is markedly improved. With all painting being conducted at a central location, an inspector can inspect all work more completely and efficiently than scrambling over large expanses of high steel.

While on the subject of conducting painting operations at the field site, why not go "whole hog"? As one of the uncertainties of painting is the quality of surface preparation and priming done by the fabricator, why not ask the fabricator to deliver the steel to the site without shop priming? In this way all segments of paint protection will be conducted at one place by one contractor. Quality of application can be controlled most efficiently with a minimum of inspection staff.