11.1 Introduction

Maintenance of protective systems on structures is an essential part of the overall strategy of protection. Maintenance costs enormous sums of money throughout the world, yet in many cases scant attention is paid to the overall problems of repainting. Maintenance painting represents by far the largest part of structural steel painted, yet the understanding of the basic processes and the technology available are far less advanced than for painting new steel. Often an almost fatalistic attitude is adopted, yet, with the correct approach, considerable economies are possible. There are examples of structures where 30 coats of paint have been applied over the years; this can be checked by microscopic examination of detached paint flakes (see Figure 11.1). Such areas generally have not corroded but, on
the same structure, other parts have rusted quite badly because virtually no paint is present on the steel. It is possible that at the next repainting, a thirty-first or thirty-second coat will be applied to the sound areas and they will continue to protect the steel, while the corroded parts will, after wire-brushing and application of a three-coat system, be rusting again within a year or so.

The situation may be slightly more serious because the amount of corrosion may have reached a stage where the structural stability has been affected and welding of additional steel may be required. Although thick coatings generally will protect the steel, internal tension arising from the number of coats applied over the years may lead to cracking and flaking; there is, therefore, a limit to the number of coats that can be applied and, eventually, the whole coating may have to be removed.

The above scenario does occur but it would be unfair to maintenance engineers to suggest that it is typical of all structures and plants. Nevertheless, unless certain clearly defined steps are taken, it is often difficult to avoid this situation, particularly when the repaint is being carried out largely for cosmetic reasons and the overall appearance is considered to be more important than the protection of the steel from corrosion.

There are two main reasons for carrying out maintenance repainting:

(i) Preservation of the structure’s integrity so that it can perform its function satisfactorily over its design life without the need for structural repairs.

(ii) To preserve its appearance: this may be a legal requirement in certain situations but generally it is more concerned with maintenance of a satisfactory overall environment and is, of course, taken to be a measure of efficiency and good housekeeping.

Clearly (i) is the more important but (ii) cannot be discounted, particularly where buildings and structures are visible to the public and shoddy appearance has a serious effect on the environment.

It might be assumed that in the process of maintaining the appearance the structural integrity would automatically be covered. However, this is not necessarily so, because appearance is a matter of visual approval often at some distance from the structure and important structural elements may not be apparent to the viewer. Therefore, even where constructions are regularly painted for aesthetic reasons, it is still necessary to take account of ‘hidden’ steelwork. Some paint types, for example bitumen, often have sufficient elasticity to accommodate the expansion of corrosion products on the steel surface without obvious disruption of the paint film.

Conversely, the structural preservation may be achieved without necessarily providing an overall attractive appearance to the structure itself. A considerable amount of corrosion can occur on some parts of
steelwork without affecting the integrity, whereas on other parts attack by corrosion may be critical. It follows, therefore, that a proper plan must be formulated based on the requirements. If appearance is unimportant and the critical areas are properly protected from corrosion, then very limited repainting may be required, particularly on structures with a short life expectation. However, this approach must arise from a decision made on the requirements, not as a result of indecision regarding the overall attitude to maintenance. Furthermore, an element of monitoring should be incorporated to ensure that corrosion is maintained within acceptable limits.

In some situations, painting can be avoided altogether by adding suitable corrosion allowances. In fact, this may be essential if the design involves spaces where access for repainting is impossible.

Having decided the reasons for regular repainting and the requirements involved, there should be a clearly formulated plan of action to ensure satisfactory and economic maintenance procedures. Undoubtedly this is best carried out at the initial design stage but revision of the plan may be necessary during the lifetime of the structure because of changes in the use and purpose of the structure, alterations in the environment and developments of new materials and techniques for coating steelwork.

11.2 The general approach to maintenance painting

It must be said at the outset that the efficiency of maintenance treatments will be directly related to and affected by the initial protective system and the standard of maintenance treatments over a period of years. It is much easier to plan maintenance on a new structure that has been adequately protected to meet the service conditions. On older structures, the level and cost of maintenance will be determined by the history of painting over its lifetime. If there has been a long record of neglect or if the original protective systems and surface preparation of the steelwork were inadequate for the service conditions, no amount of touching up will solve the technical and economic problems posed.

In such situations, only the complete cleaning of all corroded steelwork and the virtual repainting of the structure will provide a long-term economic solution. Unfortunately, in many situations it will not be possible to blast-clean the steelwork so other less effective cleaning methods will have to be used. This will result in shorter periods between repainting and an increase in the overall costs of maintaining the structure. This is particularly disadvantageous for structures with long design lives. Typically, highway bridges may be designed to last for over 100 years and a proper approach to maintenance is essential if costs are to be controlled. On other structures designed for, say 25 years, the problem is less acute and while
the appearance may be poor, the structural integrity may be unaffected. It is, therefore, important at the outset to determine the reasons for repainting and to formulate a clear strategy for the maintenance of structures. The *ad hoc* approach often adopted is unsatisfactory, both from the technical and economic standpoints.

It is worth making a point regarding maintenance budgets because in times of financial stringency they are the ones most likely to be cut and are always subject to reductions to an unrealistic level for the work required. To some extent, attitudes are changing because the importance of asset preservation is better appreciated nowadays. In situations where immediate savings are required, it may be quite reasonable to reduce maintenance budgets, including those for repainting. However, the remaining part of the budget should be spent on the critical parts of the structure to ensure maximum benefit from the expenditure and this is not usually done. In fact, it can only be done if maintenance is properly planned so that individual areas can be assessed.

### 11.3 Planning maintenance

Planning is always necessary, particularly in difficult situations such as on offshore structures where repainting must be carried out over a limited period. However, planning is being considered here in the sense of a long-term commitment to maintenance. This will involve decisions regarding the acceptable criteria of breakdown of paint coatings before repainting is carried out.

It is not unusual for Codes of Practice, etc., to specify that the ideal time for maintenance painting is when the painted steelwork shows a percentage, say 5%, visible rusting. This is a legacy from the old days when the surface preparation of the steelwork was weathering and wirebrushing. In those cases 5% visible rusting was probably just the tip of the iceberg and there would be significant rusting under the remaining paintwork that appeared to be sound.

The objective of modern-day maintenance painting should be to repaint when only the minimum (and easily carried out) surface preparation is necessary. Dry blast-cleaning, wet abrasive blast-cleaning and even UHP water jetting will generally be more difficult, even impossible, to carry out in the maintenance situation.

The condition of painted surfaces can be divided into the following categories:

- **Surface condition 1.** The top coats with loss of decorative appearance by fading, chalking (see Chapter 13), possibly slight cracking or checking of the top coat only, no visible rusting or deterioration of the substrate.
This is the ideal surface for maintenance, requiring only that any surfaces still glossy should be abraded and any loose, powdery deposits be removed by brushing or low-pressure water jetting.

Surface condition 2. The major part of the paintwork similar to condition 1, but visible rusting occurring in vulnerable areas, for example, where there is water entrapment.

Too often when the visible rust areas represent a small percentage of the total, the standard of surface preparation is governed by the larger area of reasonably sound paint. The result is normally that the rusted areas are inadequately treated, fail again prematurely and consequently set the pattern for the maintenance painting cycle and possibly even threaten the integrity of the whole structure. Any significant rusting of the steel, however small in area, requires some form of blast-cleaning or UHP water jetting, if it is not going to become the weak link in the system. In these cases it is necessary to ensure that the existing paint is sound enough to withstand the ‘feathering’ needed to adhere the new paint to the old.

Surface condition 3. This is where there is pinpoint rusting as opposed to rust blistering. This is caused by inadequate thickness of paint, almost certainly below that originally specified or recommended by the paint supplier. Generally, this does not indicate that the paint coating is undermined by corrosion and washing/brushing, plus abrasion, may be sufficient surface preparation.

Surface condition 4. This is where there is apparently random corrosion blistering, cracking or flaking down to the steel. This generally means that the entire surface has to be cleaned down to bare metal, preferably by UHP water jetting or wet abrasive blasting.

Although improved hand-cleaning methods, including use of special discs, are available as alternatives to blast-cleaning, they are comparatively expensive in the time required for use and are unlikely to provide cleaning to the same standard. The above discussion has been concerned with conventional paint coating systems of up to about 200µm total thickness. Thicker coatings, possibly over 1 mm in thickness, do not generally fail in the same way. Often the adhesion between the coating and steel weakens, leading to flaking over comparatively large areas rather than the local spread of rust. The criterion for maintenance with such coatings may be different and will be determined by factors other than the amount of rust formed on the steel surface.

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Irrespective of the particular criterion chosen, it is clearly necessary to inspect structures so that maintenance can be properly planned and this will be considered below.

11.4 Inspections and surveys for maintenance

Some form of inspection is carried out on all structures but from the standpoint of corrosion and coatings it is often of a somewhat cursory nature, frequently being carried out from a point some distance from the steelwork to be examined. In some cases, this is the only practicable way of inspecting a structure because of problems of access. In these situations, the use of binoculars and viewing from different positions may provide useful information. However, wherever possible, close contact inspection is necessary to determine the extent and requirements for maintenance. Undoubtedly, proper surveys are the most satisfactory way of assessing the situation. Obviously, there is a cost factor involved in carrying out such surveys, particularly for access to allow close examination of the coating. Consequently, this level of examination may be limited to certain parts of the structure, to reduce costs to a reasonable level. The experience and competence of the surveyor will clearly be important in providing an overall view of the maintenance requirements on parts that have not been physically examined. The purpose of a survey can be summarised as follows:

(i) To assess the extent of coating breakdown and rusting over the structure as a whole.
(ii) Based on assessment (i), to determine the critical areas for maintenance and the overall methods to be used for the surface preparations and re-coating.
(iii) To provide a basis for the preparation of a sound specification for the re-coating work.
(iv) In conjunction with (iii), to obtain tender prices for the maintenance work.

The survey should cover both the deterioration of coatings and actual corrosion of the steel. In some situations, corrosion can be measured by simple direct methods, using calipers and gauges. Sometimes other methods, such as ultrasonics, may be required. It is, of course, usually necessary to remove rust before making such measurements, although ultrasonic probes are available with which such removal is not necessary.

Often the amount of corrosion cannot be determined because the original thickness of the members is not known. In such cases it is still possible to measure the thickness of steel remaining, which is the essential
requirement for determining whether it is structurally stable. The survey also provides opportunities to determine whether specific features of the design are promoting corrosion of the steel or breakdown of the coatings, e.g. water traps or crevices; recommendations for remedial action can be made to alleviate such problems.

11.4.1 Survey procedures

The procedures will be determined to some extent by the nature and siting of the structure. Where access is comparatively easy, a full survey can be carried out without too much difficulty. However, where the structure is in continuous use, e.g. a highway bridge, then both the costs and difficulties of a full survey may be such that only a limited survey can be carried out. Its effectiveness will depend very much on the expertise of the surveyor. Such surveys require careful planning to ensure that a reasonable overall assessment is made, because the most inaccessible parts may be those that will require most attention during maintenance.

The engineer responsible for the structure should discuss the work with the surveyor to ensure that a cost-effective plan is produced. The main options open to the engineer are:

(i) A full survey of the whole structure. This will not always be practicable and will be the most time-consuming and expensive option. Where the deterioration of the protective coating is not uniform, it may be the required option, if long-term protection is to be achieved. The type of structure will be a determining factor, as will the overall history of coating maintenance. Only close examination will determine the exact nature of a surface defect. Often what appears to be a sound coating when viewed from a distance proves to be in the early stages of failure, e.g. there may be a lack of local adhesion that can spread to large areas over a period of time.

(ii) A limited survey is more common, particularly where access is difficult. Such surveys should be carefully planned to ensure that representative areas are examined to provide a reasonable assessment of the whole. Certain areas are always more prone to coating breakdown and corrosion than others and where practicable these should be included.

11.4.1.1 Planning the survey

The engineer must decide the extent of the survey and the requirements for inspection. The survey should be carried out as near to the time of maintenance painting as is practicable. It should not be carried out more than a year beforehand since additional breakdown may have occurred in that time so the survey may then not provide an accurate assessment of
the requirements. In the case of limited surveys, the actual areas to be examined must be defined and the requirements specified. The type of access for each area must be decided, with agreement on the testing to be carried out \textit{in situ} and the recording required. Additionally, any laboratory testing should be specified.

The areas must be designated in some suitable way with numbered location and with sketches where required. Although each structure requires separate treatment, the overall approach is well illustrated by considering a bridge.

\textit{Planning a bridge survey}. The UK Highways Agency has its own specifications and standards for highway bridges and these include survey requirements which must be followed. However, in the case of other bridges and similar structures, which do not necessarily follow the Department’s procedures, variations may occur.

The engineer should supply drawings of the structure so that the areas to be surveyed can be suitably marked. Alternatively, the surveyor may prepare simple sketches for this purpose.

Bridges can be divided into well-defined areas:

(i) Main span(s).
(ii) Span supports, e.g. piers and abutments.
(iii) Superstructures, e.g. parapets, towers (on suspension bridges), cables, etc.
(iv) Special areas, e.g. bearings and joints.

\textbf{Sample Areas}

\textit{Main span}. On main spans, for a limited survey, sample areas of reasonable size should be selected at right angles to the main beams so that all beams are included. The widths of band may vary but should not be less than 0.5 m. For each beam this would provide a number of different areas for examination. Other transverse elements such as stiffeners would also be included. For a box girder, there would be only one sample area on each side and on the soffit, making a total of three. The insides of box girders should be treated in the same way and should include elements such as stiffeners and diaphragms. Welded and bolted areas should be included in sample areas.

The number of sample areas will be determined by the size and nature of the bridge.

\textit{Span supports}. Sample areas can be chosen at intervals at right angles to the main direction of the support as horizontal bands round the support.

\textit{Superstructure}. Parapets can be sampled in a manner similar to that for the main span. Other features such as cables require individual decisions for adequate sampling.
Special areas. The selection of special areas will depend on the bridge design but would include bearings, expansion joints and special features that had not been included in the other sample areas.

11.4.1.2 Inspection and testing

The type of inspection and requirement for testing should be agreed for each sample area. The types of observation and tests are considered below.

(i) Observations

(a) Type and amount of coating breakdown by visual assessment. This must be carried out to provide the maximum amount of information both for the maintenance requirements and as an indication of the performance of the coating. There are a number of published methods that can be used but the essential requirement is for all those concerned with the maintenance procedures to be clear what the observations mean. Vague comments such as ‘some blistering and slight rust’ can be ambiguous. The recording methods may be based on ISO 4628. Paints and Varnishes. Evaluation of Degradation of Paint Coatings Designation of Intensity, Quantity and Size of Common Types of Defects.

Part 2: Blistering
Part 3: Visible Corrosion
Part 4: Cracking
Part 5: Flaking
Part 6: Chalking

These standards contain diagrams with numbered ratings which can be used to provide a fairly rapid and accurate assessment of a painted surface. However, useful though these methods are, it is often advantageous to include a description and photograph, particularly where the appearance does not closely relate to the standard photograph. If deep pitting is evident the depth should be estimated and included in the observations. A more accurate indication is provided if a pit gauge is used.

(b) An indication of obvious surface contamination should be provided.

(c) Areas showing abnormal or severe breakdown should be reported as these may require special attention during maintenance.

(d) Where breakdown is associated with specific design features or occurrences such as dripping of water onto an area, this should be reported.

(e) Where appropriate, the surveyor should use a suitable magnifier, preferably illuminated (×10 to ×20 magnification), to obtain further information, e.g. on checking and surface contamination.
(ii) **Non-destructive testing.** The thickness of the coating can be measured with suitable dry film thickness gauges. These are described in Chapter 9, with an indication of methods of calibrating and usage.

(iii) **Destructive tests.** Adhesion can only be tested by destructive methods. Various test methods are available. The method in which a ‘dolly’ is stuck onto the painted surface and then pulled off using a calibrated pull-off adhesion tester provides a quantitative reading. There are a number of proprietary makes of adhesion testing instruments that can be used under site conditions. They use various methods to exert the pull-off force. The limitations for their use for surveys are: the difficulty of scoring around the ‘dolly’ under site conditions, the need to wait for the adhesive to cure and the number of tests carried out in one batch is determined by the number of ‘dollies’ available. The X-cut or ‘St Andrew’s Cross’ test (see Figure 11.2) can be carried out very quickly over a large area and, although not quantitative, in expert hands can give a very good indication of the adhesion and brittleness of the coating.

BS 3900 Part E6, the cross-cut test, is a straightforward test for panels in the laboratory but is difficult to carry out correctly on site (see Figure 11.3).

ASTM D3359-83 Method A is simple and capable of providing the required information. It is carried out using a sharp blade, e.g. a ‘Stanley’ knife and cutting through the coating to the metallic substrate, preferably
with one stroke. The cut, approximately 50 mm long, is then repeated across the original cut at an angle of approximately 30° to form a St Andrew’s Cross. Adhesive tape is then applied over the centre of the cross and pulled sharply from the surface. The maximum area of detachment of paint from the position of the crossed cuts is reported. The greater the length, the poorer the adhesion.

Abrasion of the coating down to the steel exposes all paint layers (see Figure 11.4).

Further tests using the end of the knife to detach more of the coating will, in experienced hands, reveal additional information that will indicate whether the paint can be mechanically cleaned or locally blast-cleaned or must be removed over a large area. The surveyor should report the results of these tests and where appropriate indicate the state of the surface from which the paint has been detached, e.g. whether clean, rusted steel or primed steel.

(iv) Paint flakes. Paint flakes, when examined microscopically, can provide useful information such as thickness of individual coats in a system. Special thickness measurement instruments that use an inclined or V-cut can be used but it is not always easy to determine individual coatings.

Paint flakes should be stored in individual bags with proper identification.

(v) Site analytical tests. Tests for surface contamination are detailed in Section 9.5.1.3.
(vi) **Solvent swab test.** The surface of the paint is rubbed with a cotton wool swab wetted with xylene. If the top surface dissolves readily it indicates that the paint is of the non-convertible type, such as chlorinated or acrylated rubber. This information will influence the choice of coating for repainting.

(vii) **Laboratory tests.** Certain tests may require to be carried out in well-equipped analytical laboratories. The test samples will be collected by the surveyor, identified, and then sent to a suitable laboratory for analysis. Other tests are more straightforward and may be carried out by the surveyor with comparatively simple equipment. An experienced surveyor should be able to examine detached paint flakes provided he has access to a binocular microscope with a magnification of \( \times30 \) to \( \times45 \).

High magnifications do not have sufficient depth of focus for the roughness of a paint flake to be examined. Paint flakes are generally not mounted and polished like metallurgical specimens because the polishing process tends to destroy the surface of the paint. Examination of cross-sections of paint flakes gives useful information on individual coating thicknesses and adhesion between coats. Also, the underside of the flakes can be examined for contamination.

Ideally, the microscope should have a camera attachment so that monocular photographs can be taken. Since the enlargement of the magnification of the final prints will be different from the microscope enlarge-
ment this should be determined so that direct measurements can be made from the photographic prints.

The presence or absence of lead pigments may govern the choice of surface preparation method. Other environmental factors, e.g. vicinity to a river or public place, may also require the analysis for other toxic substances such as cadmium and chromium.

In the laboratory, a range of techniques can be used for the comprehensive analysis of paint (see Section 16.6).

The routine determination of water swab samples will include chlorides, sulphates, pH and total dissolved solids. The engineer should specify whether analysis is required for other suspected contaminants.

11.4.1.3 Access for surveys

Arrangements for access must be made in advance of the survey. Failure to do this may lead to expensive delays. Scaffolding is rarely justified except possibly at some areas of special interest. Ladders are the cheapest form of access and may be suitable for the examination of limited areas. However, they are not really suitable for the type of examination required in surveys and moving them can also be time consuming, particularly where they have to be lashed to members for safety reasons. Access should be by mobile lifting platforms or hydraulic hoists for most parts of a structure but other methods may be required for areas that present difficulties of access. The surveyor has to carry out a number of tests, so satisfactory access is important.

11.4.1.4 Recording of survey

It is convenient to record on printed sheets which cover the main items to be included in the report. These would include:

- Identity of sample area
- Film thickness measurements
- Breakdown of coating (type and quantity)
- Swab tests
- Adhesion
- Paint flakes and other samples taken
- Photograph identification (when taken)
- Comments on contamination of surface, exposed substrates and any areas requiring special attention (see Figure 11.5)
- Weather and date of survey.

If sketches assist, then they should be included. Photographs will often be of assistance to engineers, particularly where
11.4.1.5 Recommendations

On the basis of the survey, recommendations can be made on surface preparation and repainting of the structure. On a large structure the recommendations will vary depending on the state of the coating at different parts. Additionally, any other recommendations that will be of value to the engineer should be included, e.g. design features that have promoted corrosion.

11.4.1.6 Comments on surveys

Surveys can be quite expensive and are carried out primarily to determine coating maintenance procedures. However, if carried out regularly, surveys provide a ‘log book’ of coating performance. This will be useful for determining suitable coatings for other structures and will indicate likely problem areas so that subsequent surveys may be more limited in

Figure 11.5 Corroded special areas.
scope with an overall saving in cost. On parts of the structure where the breakdown is such that complete removal of the coating is to be recommended, only limited detail of the paint breakdown is required. The general methods of a survey should be used even if the overall examination is carried out on a limited scale.

11.4.2 Feasibility trials

The Highways Agency (UK) advises a feasibility trial after its bridges have been surveyed, before a specification for maintenance painting is prepared. This is a sound approach because it is often difficult to determine both the extent of the surface preparation requirements and the difficulties in achieving them. Furthermore, this type of trial provides an opportunity to check compatibility of coating systems. It also ensures that contractors who tender for the work will be aware of any difficulties involved in the maintenance painting and will, therefore, be able to provide tenders that meet the requirements of the client with a minimum of disagreement. Although such trials add to the overall cost, they may prove to be economic on surveys of structures other than bridges.

11.5 Maintenance procedures

The two main aspects to be dealt with are (i) surface preparation and (ii) repainting. The survey prior to maintenance should provide sufficient information to determine the type and level of surface preparation and painting required. Even the most limited survey is advisable to ensure that a reasonable specification can be produced. Without this, maintenance repainting may prove to be a difficult, and often unsuccessful, operation.

11.5.1 Surface preparation prior to repainting

As already noted, maintenance of paint coatings is most economically achieved by repainting before there is any serious deterioration of the coating or rusting of the steel substrate. In such a situation, the procedures are fairly straightforward on conventional coatings used for land-based structures. On more specialised structures, e.g. offshore structures and dock gates, special procedures may be required and these will often be specific to the particular situation, although the same approach will usually be adopted.

(i) Where coatings are firmly adherent with no signs of incipient breakdown such as blistering, they should not be removed as they will provide a sound basis for the maintenance coats. Generally, further coats can be applied without difficulty after the surface has been thoroughly washed to remove contaminants. However, some coatings, e.g. two-pack epoxies,
harden to an extent where some abrasion of the coating is required before repainting to ensure good adhesion. Even oleo-resinous paints may require some abrading to remove gloss. On small areas, power-operated discs may be satisfactory to provide the abraded surface, but on larger areas light blast-cleaning will usually be more economic.

(ii) Where there is some minor deterioration of the paint coating but no rusting of the steel substrate, then all loose paint should be removed by the methods noted above, i.e. by power-operated tools, UHP water jetting or blast-cleaning. The choice will be determined by environmental and economic factors. The surface must be washed before further coatings are applied.

(iii) If the deterioration has reached a stage where the coating is failing and the steel is rusting, the procedures will be determined by the extent of the breakdown. The only really effective way of cleaning steelwork where there is a considerable area of rusting is by blast-cleaning, but this is not always practicable. It may not be possible, for environmental reasons, to use open blast-cleaning, and vacuum methods, i.e. with recovery of the abrasive, may be uneconomic, particularly from the point of view of time required for cleaning. In such situations, power tools may be the only acceptable method.

It follows that if there is a considerable area of rusting to be dealt with and blast-cleaning or UHP water jetting is not practicable, then the maintenance coatings applied to such surfaces will tend to provide comparatively short lives.

The coating breakdown may well be quite severe at welds and a decision must be made regarding the cause of this breakdown. It may be necessary to grind weld areas to avoid a repetition of such failures after repainting.

The requirements for surface preparation prior to repainting can be summarised as follows. Suitable action must be taken to provide a firm base for future coats of paint. The effectiveness of this operation will to a large extent determine the life of the coatings applied during maintenance. If rust and poorly adherent paint are the surfaces to which new paint is applied, then poor performance will be inevitable. Further requirements concerning paint compatibility are discussed below.

(iv) The above comments have been concerned with paint films but metal coatings also eventually require maintenance and this is usually achieved with paint coatings. Hot-dip galvanised coatings may be used bare, i.e. not painted, and over a period of time the zinc will corrode away, usually not evenly over the whole surface, leaving a mixture of zinc, alloy layer and rust. Undoubtedly it is preferable to paint galvanised surfaces before any significant rusting of the steel substrate occurs. At this stage it is comparatively easy to remove loose zinc corrosion products by manual cleaning methods and then to apply a paint system.

If the galvanised steel has been painted and no rusting is occurring, the
treatment will be similar to that for paint coatings applied directly to steel. There is usually no requirement to remove areas of sound galvanised surface even if the paint has flaked or weathered away. All loose paint should, of course, be removed. In situations where a great deal of rusting of the steel has occurred, blast-cleaning is probably the only satisfactory way of treating the surface prior to repainting. Sherardised coatings should be treated in a similar way to those that have been hot-dip galvanised. For small areas of breakdown, power-operated abrasive wheels can be used, but this is uneconomic for large areas. Sprayed metal coatings present a more difficult problem, particularly if they have been painted, a procedure rarely adopted nowadays for zinc.

Some authorities consider that once the underlying sprayed zinc coating has corroded under the paint film, then the only course of action is to blast-clean the surface with sharp abrasives to remove the whole of the coating system, i.e. paint and zinc. Others consider the light blast-cleaning to remove the paint and surface zinc corrosion products is a satisfactory procedure, provided dry-blast methods are used. Wet-blasting of zinc sprayed coatings is not recommended except where they are to be completely removed. This is because of the difficulties of ensuring that the remaining zinc coating is completely dry before repainting. Again, where previously non-painted zinc sprayed coatings are to be painted, it is preferable to remove zinc corrosion products by dry brushing methods. Although painting of zinc sprayed coating is not considered good practice by many authorities, it may be necessary to apply paint over badly corroded zinc coatings if the removal of the remaining zinc coating by blasting is impractical. In such situations, power-operated tools can be used to remove zinc and corrosion products, but a layer of the sprayed coating will remain on the steel surface provided rusting has not occurred.

Sprayed aluminium coatings are generally less of a problem than those of sprayed zinc, but in situations where they have virtually corroded away they require to be removed by blast-cleaning. Other methods such as the use of power tools are unlikely to be effective in removing the whole coating, although they can be used for removing surface corrosion products.

11.5.2 Painting

The effectiveness of maintenance painting will be determined by the substrate to which the paint is applied, the compatibility of the material used in relation to the coating on the structure and the overall thickness of the final coating. The importance of preparing the surface properly, both the steel and retained coatings, has been discussed above. Although the necessity to provide a sound base for maintenance coatings is obvious, it is
sometimes difficult to achieve under practical conditions, and in such situations it is unlikely that the coatings will provide long-term protection. If they are applied to steel that is rusty, or if chloride and sulphate salts remain after blast-cleaning, then further corrosion under the paint film is probable, with blistering, cracking and eventual flaking. Again, if the retained paint coating has poor adhesion to the steel, then it may well flake off carrying the maintenance coating applied to it.

Compatibility between the coatings on the structure and those applied during maintenance is essential. For example, although solvent-evaporating types of paint can be applied to epoxies, the reverse situation may lead to problems, because the strong solvent in the epoxy will soften the chlorinated-rubber binder. As noted earlier, where paints have hardened during service it may be necessary to abrade them to provide a key for the maintenance coatings.

The choice of coatings will depend upon a number of factors. Traditionally, oil-based coatings with mild, slow evaporating solvents have been used for maintenance, because of their tolerance of minor weaknesses in the existing film and to small levels of contamination. The requirement for faster drying, higher film build, plus environmental legislation requiring reductions in the levels of volatile solvents has encouraged paint manufacturers to produce high solids, low solvent formulations. These can be applied to the older type of weathered coatings without any sign of immediate incompatibility. Paint manufacturers claim such will up-grade the coating system from single-pack to two-pack. However, even those two-pack materials described as ‘surface tolerant’ can produce weaknesses in existing coating systems that were not previously evident. Even coatings claimed to be able to be applied over damp surfaces do not perform well when there is excessive moisture, condensation or when the existing coating is cohesively weak and retains moisture after the surface-tolerant material has cured. On general land-based structures it is usually advantageous to apply the same types of paint, provided they have given sound protection. However, there is often a requirement to up-grade the overall protective system using more durable coatings. In such cases, checks for compatibility are essential and this should preferably be carried out on the structure. Generally, a number of different types of area have to be dealt with as follows:

(i) Intact paint coating of acceptable thickness: usually, apart from washing down with clean water, no further action is required.
(ii) Reasonably intact coating but with slight blistering or flaking: after removal of all the loose paint coating, the surface is washed to remove contamination and undercoat(s) and finishing coats are applied to provide the required thickness.
(iii) Areas where there has been rusting of the steel or where the coating
has been removed prior to repainting: a full protective system including, where appropriate, an inhibitive primer, should be applied to the appropriate thickness.

Careful application to ensure a smooth final coating is necessary and the finishing coating is generally applied over the whole structure, after the various areas have been patch painted. Metal coatings are treated in the same general way, but it is a more difficult operation, particularly where there is a variation in the state of the metal coating on different parts of the structure, and it may be useful to obtain specialist advice.

11.6 Environmental conditions during repainting

Unlike the initial protection of steelwork, which can be carried out in a shop with reasonably controlled conditions, the only environmental control usually possible when carrying out maintenance painting is the choice of an appropriate time of the year for the work. Sometimes for operational reasons, maintenance painting has to be carried out under less than ideal weather conditions. The effect of rainfall and condensation on surface preparation and paint application are obvious, but cold temperatures, extreme humidities (high and low) and air movement also affect different coatings in different ways.

Coatings that dry by solvent evaporation, such as vinyls, acrylics, bitumens, etc. are affected by the cold because all solvents have a lower vapour pressure as temperatures are reduced, thereby slowing the evaporation from the film. Solvent entrapment in primers and undercoats can cause subsequent blistering or loss of adhesion in the top coats. With waterborne coatings, the more humid (moisture-laden) the air is, the less able it is to hold water evaporating from the film, the cure is slowed down and the longer the coating stays vulnerable to rainfall, etc. High humidity can also affect coatings that cure by oxidation, for example alkyds. Different formulations are affected to different extents and the paint manufacturer should be consulted about the maximum humidity recommended for their material.

Low temperatures can also inhibit the cure of oxidation curing coatings, but particularly two-pack materials that cure by chemical reaction, such as unmodified epoxies. Normally these will not cure at all below 5°C and should preferably only be applied above 10°C. Some modified epoxy coatings used for maintenance coating are claimed to cure down to 0°C, albeit slowly. The use of isocyanate curing agents can lower this threshold. Care is also necessary when applying paint at normal ambient temperatures, but where the paint is itself excessively cold due to poor storage conditions or a heavy steel structure is excessively cold due to the heat-sink effect. High winds can also lower temperatures below the ambient due to the wind chill
effect and they can also cause dry spray (see Chapter 13) and increase the risk of overspray.

It is also important to realise overspray can travel surprisingly great distances, hence containment must be effective to ensure claims are not made by third parties, because of contamination of their property by this airborne overspray. To provide a controlled environment for work and reduce dust contamination, containment of the painting area is now common (see Figure 11.6).

Ventilation is an important factor inside containments to protect the health of the operators, remove solvent vapours, provide adequate visibility for performing the work and reducing contamination of freshly blasted or painted surfaces by abrasive particles. A general guideline is to provide one complete change of air every three minutes during the blasting operation. For ventilation during the painting period, both the explosive limits (LEL) of the solvent vapour and the threshold limit value (TLV) of the airborne toxic material must be considered. Using containment under adverse weather conditions may well need a combination of heating, ventilation and dehumidification. Details are beyond the scope of this book and, if required, experts should be consulted.³

![Figure 11.6](image)

*Figure 11.6* Containment of blasting and painting operations in a sensitive area.
11.7 Health and safety matters

Health and safety requirements for maintenance painting are the same as those described in Chapters 3, 4, 5 and 9. In addition, it is particularly important that any contractors, inspectors, surveyors, etc. are made immediately aware of the safety requirements for a specific site. Also, since surveyors often work on their own, there should always be an additional person in sight of – and in contact with – the surveyor, to assist if an accident or dangerous situation occurs. This applies in all situations on site, but particularly those where the surveyor is working in any area which may be regarded as an enclosed space.

References