VOLUME 2 HIGHWAY STRUCTURES: DESIGN (SUBSTRUCTURES AND SPECIAL STRUCTURES)

SECTION 3 MATERIALS AND COMPONENTS

PART 8

BD 7/01

WEATHERING STEEL FOR HIGHWAY STRUCTURES

SUMMARY

This Standard replaces BD 7/81. The requirements specified here cover design, construction and in-service maintenance aspects. It shall be used in conjunction with relevant parts of BS 5400 as implemented by overseeing organizations, except where otherwise indicated.

INSTRUCTIONS FOR USE

This revised Standard is to be incorporated in the Manual.

1. This document supersedes BD 7/81, which is now withdrawn.

2. Remove existing contents page for Volume 2 and insert new contents page dated for Volume 2 November 2001.

3. Remove BD 7/81, which is superseded by BD 7/01 and archive as appropriate.

4. Insert BD 7/01 in Volume 2, Section 3, Part 8.

5. Archive this sheet as appropriate.

Note: A quarterly index with a full set of Volume Contents Pages is available separately from The Stationery Office Ltd.

THE HIGHWAYS AGENCY

SCOTTISH EXECUTIVE DEVELOPMENT DEPARTMENT

THE NATIONAL ASSEMBLY FOR WALES
CYNULLIAD CENEDLAETHOL CYMRU

THE DEPARTMENT FOR REGIONAL DEVELOPMENT
NORTHERN IRELAND

Weathering Steel for Highway Structures

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REGISTRATION OF AMENDMENTS

Amend No	Page No	Signature & Date of incorporation of amendments	Amend No	Page No	Signature & Date of incorporation of amendments

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Contents

1. INTRODUCTION

Mandatory Sections

1.1 Sections of this document which form part of the standards of the Overseeing Organisations are highlighted by being contained in boxes. These are the sections with which the Design Organisations shall comply, or shall have agreed a suitable departure from standard with the relevant Overseeing Organisation. The remainder of the document contains advice and enlargement which is commended to Design Organisations for their consideration.

Major changes in this version of the Standard

1.2 The present version of the Standard incorporates the outcome of the research into the corrosivity of the environment under bridge decks and in-service performance of weathering steel used in bridges. Also information gathered from the use of weathering steels in highway construction in other countries. Major changes to BD 7/81 include:

(a) removal of the 7.5 metres headroom limitation for bridges over roads subjected to de-icing salt sprays. Such bridges are now allowed to be designed at standard headroom requirements

(b) introduction of a minimum headroom requirement of 2.5 metres for crossings over water

(c) reduction in thickness allowances

(d) options for appropriate welding consumables

(e) additional information on inspections, monitoring and maintenance

(f) updated references including International Standards (ISOs) for classification of environments.

1.3 This Standard replaces BD 7/81. It shall be used in conjunction with relevant Parts of BS 5400, as implemented by the Overseeing Organisations, except where otherwise indicated.

Implementation

1.4 This Standard shall be used forthwith on all schemes for the construction and improvement of trunk roads, including motorways currently being prepared, provided that, in the opinion of the Overseeing Organisation, this would not result in significant additional expense or delay. Design Organisations shall confirm its application to particular schemes with the Overseeing Organisation. In Northern Ireland this standard applies to all roads so designated by the Overseeing Organisation.

Definitions

1.5 Weathering steel (or weather resistant steel) shall be taken to mean structural steels with improved atmospheric corrosion resistance, supplied in accordance with BS EN 10155, and hot finished structural hollow sections in weather resistant steels, supplied in accordance with BS 7668.

Scope

1.6 This Standard specifies requirements for the use of weathering steel for the construction of highway structures. The requirements cover design, construction and in-service maintenance.

1.7 Weathering Steels are a class of low alloy steels containing about 2% of specific alloying elements such as copper, chromium, silicon and in some cases phosphorus.

1.8 Structural steels to BS EN 10155 are available in grades S235 and S355; grade S235 is unlikely to be used in bridgework. Structural steels to BS 7668 are available in grade S345.

1.9 Weathering steel to other specifications may be acceptable as a Departure from Standard, provided that they also comply with the requirements of BS EN 10155 and BS 7668.

Corrosion resistance

1.10 Under suitable exposure conditions, the atmospheric corrosion rate of weathering steels is lower than that for normal structural steels. In fact, the corrosion rate is low enough for weathering steels to be used unpainted and yet attain the 120 year design life, expected from a highway structure with normal maintenance. The enhanced corrosion resistance results from the formation of an adherent rust patina which acts as a barrier and inhibits further corrosion. The protective rust patina develops under conditions of alternate wetting and drying: it will not develop under conditions of prolonged dampness, where there is excessive exposure to chlorides or where general levels of atmospheric pollution are particularly high.

1.11 Although the corrosion rate of weathering steel is lower than that of normal structural steels, it is not negligible. The corrosion rate will have a range of values depending on the nature of the environment, in particular on the levels of pollutants and microclimate effects resulting from the design of the structure itself. The thickness of the rust patina should not be taken into account in structural assessments.

Appearance

1.12 When formed under suitable exposure conditions, the rust patina is generally considered to be more attractive than the rust formed on normal structural steel. The attractiveness depends on the combination of patina colour and texture. The patina colour can range from light brown to very dark brown depending on the age and exposure conditions, whilst texture ranges from very fine grained adherent to larger grained less adherent.

1.13 In general, the most attractive patinas develop on freely exposed surfaces which experience the most wet/dry cycles eg on south facing fascia of girders. Sheltered girders and north facing fascias tend to develop a larger grained patina.

1.14 Abrasive blast cleaning initially to remove mill scale is essential to the formation of a uniform rust patina.

Benefits of using weathering steel

1.15 The economic benefits of weathering steel depend on the balance between the additional costs of the material (both in cost per tonne and in extra material to cover the corrosion allowance) against the savings in eliminating initial and maintenance painting along with the costs associated with maintenance operations.

1.16 The economic advantage to be gained by the use of weathering steel as an alternative to ordinary steel is reduced or eliminated if painting is necessary for cosmetic reasons or for corrosion protection, for example to combat corrosion due to leaking deck joints, etc. However, local coating, as allowed in 2.3, in readily accessible areas may be possible at a relatively modest cost.

2. LIMITATIONS ON USE

2.1 Weathering steel may be used for highway structures without protective treatment except in the situations described under section 2.2.

2.2 Weathering steel shall not be used in the following situations:

(a) in a marine environment where the structure would be affected by chloride. Where it is unclear whether a location should be classed as marine, the level of chloride in the atmosphere may be assessed according to the international Standard ISO 9223: Corrosion of metals and alloys - Corrosivity of atmospheres - Classification. The test procedure is given in ISO 9225 - Corrosion of metals and alloys - Corrosivity of atmospheres - Measurement of pollution. Further details of the test procedure are given in Appendix A. A Salinity Classification of S3 shall rule out the use of weathering steel

(b) for structures or parts of structures where the use of de-icing salt is likely to lead to substantial deposits of chloride on steel. Surfaces, ie where salt laden water would flow directly over the steel

(c) where the steel would be continuously wet or damp (see 2.5 below)

(d) where the steel would be buried in soil

(e) in an atmosphere containing extremes of atmospheric pollution or concentrated corrosive industrial fumes. Where the classification is unclear the level of atmospheric pollution can be classified according to ISO 9223 using the measurement procedures given in ISO 9225. Further details are given in Appendix A

(f) for crossings over water where the headroom is less than 2.5 metres

(g) environments with pollution levels above P3 would rule out the use of weathering steel. Note, however, that this classification is based on levels of atmospheric sulphur compounds. If a source of other contamination is suspected, such as a specific industrial pollutant this will require special consideration.

2.3 Where the restrictions in 2.2 apply only to parts of a structure, Weathering steel may be used generally, provided that protective treatment is applied to those parts. For new works, the protective treatment system shall be in accordance with the requirements of the Manual of Contract Documents for Highway Works (MCHW) Volume 1, Series 1900. For existing structures, the protective treatment system shall be in accordance with the requirements of the MCHW Volume 5, Section 2. The colour of the final coat shall be chosen to harmonise with the anticipated final colour of the exposed weathering steel.

2.4 Regions that might benefit from local application of a protective treatment include the ends of girders where there is an expansion joint and the ends of integral bridges that might be in contact with soil.

2.5 In many bridges over rivers, weathering steels have performed satisfactorily. Steel members may remain continuously wet and damp when tree foliage or other obstructions prevent the natural drying process.

3. DESIGN - CORROSION ALLOWANCES

3.1 The corrosion allowances given in this section relate to the use of weathering steel without protective treatment. Where weathering steel is protected, for example where permitted by 2.3, it is considered to perform as ordinary structural steel and no allowance is necessary.

3.2 To cater for the loss of structurally effective material due to the developing rust patina during the life of the bridge, a corrosion allowance shall be made on each exposed surface, representing a loss of a thickness of material used for structural purposes.

3.3 The allowance shall be decided on the basis of a classification of the general bridge environment as either 'mild' or 'severe', for exterior surfaces, or 'interior' for the internally exposed surfaces in box girders. Bridges which cross a trafficked road subject to the use of de-icing salt will always be classed as a 'severe' environment.

3.4 In other cases, the environmental classification shall be based on a corrosivity assessment according to ISO 9223. Further details of this method are given in Appendix A.

3.5 For atmospheric conditions defined by ISO 9223 as class C1, C2 or C3 ('mild' environments for weathering steel) the corrosion allowance shall be 1 mm per surface.

3.6 For atmospheric conditions defined by ISO 9223 as class C4, C5 ('severe' environments for weathering steel) the corrosion allowance shall be 1.5 mm per surface.

3.7 For the 'interior' surfaces of box-sections the allowance shall be 0.5 mm. However no allowance is necessary if all external joints are continuously welded and access systems are detailed to avoid the ingress of water.

Welds

3.8 The allowances stated in clauses 3.6 and 3.7 above shall be applied to all fillet welds and partial penetration butt welds. Full penetration butt welds do not require any additional allowance, because an allowance will already have been made for the parent material.

4. DESIGN - GENERAL CONSIDERATIONS

Design Standards

4.1 Unless otherwise specified in this Standard, design and construction in weathering steel shall conform to the current requirements for design and construction in steel specified by the Overseeing Organisation.

Application of corrosion allowances

4.2 The sectional properties used in global analysis for load effects, in accordance with clause 7.2 of BS 5400: Part 3, may either be based on the nominal dimensions of the materials as supplied or on the nominal dimensions minus the thickness of corrosion allowance, as specified in section 3 of this standard.

4.3 The sectional properties for stress analysis, in accordance with BS 5400: Part 3, shall be based on the nominal dimensions of the materials as supplied minus the thickness of the corrosion allowance, as specified in section 3 of this standard.

4.4 The enhanced corrosion resistance of weathering steel depends on the steel undergoing wet/dry cycles so that a protective rust patina develops. It is therefore important that the design of the bridge is such that this condition is met. (See section on detailing below.)

4.5 Leaking expansion joints are a particular danger for weathering steel as they can allow water contaminated with de-icing salt to flow directly over the steel.

4.6 The use of integral construction, in accordance with BA 42 (which is mandatory in Scotland) is desirable. However, steel buried in the ground must be protected against corrosion with an appropriate coating. Steelwork encased in concrete requires no protective coating provided that there is sufficient depth of concrete cover for the required durability.

Detailing

4.7 Weathering steel bridges shall be designed to ensure that all parts of the structure can dry out. The design shall avoid features which allow water or debris to collect leading to prolonged wetness of the steel. Water and debris accumulate on horizontal surfaces, and in corners formed by horizontal and vertical plates. In “I” section girders, most susceptible locations are the bottom flanges.

4.8 Girders shall be detailed to encourage drainage. Vertical stiffeners or cleats welded to the bottom flange shall be designed with substantial drainage passages whilst stiffeners not welded to the bottom flange shall be cut off at least 30 mm above the flange.

4.9 Particular attention shall be given to the detailing of deck joints, the provision of adequate ventilation at and around abutment areas, and the avoidance of un-drained overlaps, pockets and crevices. Edges of concrete decks shall be provided with drips to prevent water running along the underside to girder.

4.10 The possibility of leakage at fixed and expansion joints shall be allowed for in the design by providing positive drainage systems. Expansion joints shall be located away from structural steelwork to ensure that water does not run on or down the steel.

4.11 The outlet pipes from the deck shall be of sufficient length to ensure that the discharged water does not spray onto the adjacent steelwork in any condition. The use of non-metallic drainage pipework is recommended.

4.12 The web plates of box girders should be extended about 20 mm beyond the bottom flange to ensure that water running down the web drips off and does not run along the underside of the flange.

4.13 A sealant should be provided along the edge of any interface between weathering steel and concrete. Such locations include the edges of the top flange and the profile of a beam that is cast into an end wall of an integral bridge.

4.14 Bi-metallic joints may promote corrosion in local areas when there are significant areas of dissimilar metals directly coupled to weathering steel structures. However, provided that small components are compatible or are of 'more noble' metal (such as stainless steel bolts in a weathering steel girder) this is not likely to be a problem.

4.15 Removal of graffiti from weathering steel is difficult, because the rust patina is somewhat absorbent. Blast cleaning provides a solution, but is costly. Any other method is unlikely to be visually satisfactory. Consequently, suitable provision should be made in the design to prevent or reduce such incidence as far as possible eg by the use of barriers to prevent access to the girders.

5. CONSTRUCTION

Welded Connections

5.1 The alloys in weathering steel increase its hardness and this has to be taken into account in selecting the welding procedure. As with any structural steel, weld procedures should be formulated either for the maximum carbon equivalent that could be encountered or with knowledge of the actual carbon equivalents of the materials that are to be used. Specification for welding consumables are defined in Manual of Contract Documents for Highway Works, Volume 1 (MCHW1) Specification for Highway Works - Series 1800 Clause 1803.

Bolted connections

5.2 There is a danger of moisture being drawn into crevices or between steel surfaces in joints of bolted connections. Any corrosion products which form will have a greater volume than the original steel and can lead to 'packout'. It is therefore important that joints are of adequate tightness and rigidity. This can be ensured by keeping within the recommended bolt spacing and edge distance requirements in 5.3 below.

5.3 It is recommended that inter-bolt spacings in lines adjacent to plate/section edges should not exceed 14 times the thickness of the thinnest component and in any event should not exceed 180 mm. The distance from the centre of any bolt to the nearest free edge of a plate should not exceed 8 times the thickness of the thinnest component and in any event should not exceed 130 mm.

5.4 In joints where bolt spacings are wider than recommended above, or where there are any features thought to be at risk from water intake, the joints should be protected by suitable sealants.

5.5 The chemical composition of bolts, nuts and washers including high strength friction grip bolts, for use with weathering steel structures shall comply with ASTM A325 Type 3 Grade A or equivalent.

5.6 Load indicating washers are not manufactured in weathering steel qualities and shall not be used. Alternative means of tightening, such as the half turn method, or bolts torqued to an appropriate design value shall be used.

Surface Treatment

5.7 Where steelwork is marked on its surface for identification, the marking material shall be such that it can be easily and completely removed after fabrication.

5.8 Surface contamination from concrete, mortar, asphalt, paint, oil and grease shall be prevented, as these have an adverse effect on the formation of a uniform rust patina.

5.9 After fabrication, all exposed surfaces shall be abrasive blast cleaned to a minimum standard of Sa 2 to ISO 8501-1 (BS 7079 Part A1) to achieve a uniform surface. After completion of erection any surfaces marked or contaminated during construction shall be cleaned to a similar standard.

5.10 Adequate protection shall be provided during construction against staining of the piers and abutments. This is particularly important in composite construction before and during the construction of the deck slab. During this stage protective sheeting or equivalent can be used to protect piers and abutments.

5.11 Wax or grease markers should not be used, because they are difficult to remove and can interfere with the weathering process.

5.12 Blast cleaning is often carried out at the fabrication works, but a final cleaning after site erection would assist the formation of a uniform rust patina.

6. INSPECTION AND MONITORING

Visual Inspection

6.1 Visual examination of the structure forms an important part of General Inspections.

6.2 For weathering steels, the type and appearance of the rust patina provides a useful indication of the corrosion performance of the weathering steel. Rust patinas can range from a fine adherent granular type to swelling laminations. In general, an adherent fine grained rust patina is a sign that corrosion is progressing satisfactorily whilst coarse laminated rust layers and flakes suggest an unacceptable performance.

6.3 When the appearance is unsatisfactory the visual inspection should be followed by an examination with a magnifying lens to check for flaking or swelling and taking steel thickness measurements with an ultrasonic instrument at positions identified at the construction stage. However, as currently available instruments read only to the nearest 100 µm meaningful results of thickness measurements will not be available until the structure is at least 6 years old.

6.4 General Inspections in accordance with BD 63 (DMRB 3.1.4) shall report the appearance of the rust patina in terms of adherence and type. Photographs of typical areas will assist in assessing any change in appearance with time.

6.5 The appearance of swelling of the rust patina indicates that there is a severe localised corrosion problem, and in such a case, immediate attention shall be given to identify the cause and take corrective action.

6.6 Inspections of the weathering steel in critical areas, particularly in the vicinity of ‘fixed’ and ‘expansion’ joints, bolted joints and sealants along concrete/weathering steel interfaces shall be carried out at each General Inspection or at intervals not exceeding 2 years.

6.7 Any indication of deck surface water leakage or wet patches on the weathering steel due to causes such as faulty drainage or leaking expansion joints shall be investigated and remedied.

6.8 The accumulation of dirt and debris will encourage corrosion and shall be removed by low pressure water washing where practical or other method approved by the Overseeing Organization.

Corrosion monitoring

6.9 The additional steel thickness specified to allow for corrosion during the life of the structure is only an estimate. It is important that the actual corrosion rate of the structure is monitored to verify that the corrosion allowance will remain adequate. The most appropriate method of doing this is to carry out measurements at Principal Inspections specified in BD 63 (DMRB 3.1.4) possibly at 6 year intervals. Such inspections shall measure residual steel thickness at previously identified points on the structure. From these measurements, an estimate of the corrosion rate of the steel in the structure can be made.

6.10 It should be appreciated that corrosion rates vary with time. During the initial period of exposure, the corrosion rate is governed by the availability of oxygen and water to the steel surface. As the protective patina develops and stabilises, the corrosion rate is reduced. The time for the rust patina to become effective in controlling corrosion depends upon the specific environmental conditions.

6.11 A satisfactory method of operating a corrosion monitoring programme requires the identification of exact locations for residual thickness measurements at specified locations critical for strength, or vulnerability to joint leakage or condensation.

6.12 Corrosion rates should also be determined after the weathering steel has fully developed its protective rust patina. The rates are expected to be less than 10 µm per year in a ‘mild’ exposed environment in the period following first few years of exposure.

6.13 Monitoring locations shall be established at suitable locations on the bridge steelwork and initial measurements of residual thickness of material shall be made at the end of the construction period. The initial measurements, at final completion of the structure, would indicate actual steel thicknesses, which should be within the rolling tolerances from the nominal thickness. These shall be recorded in the Maintenance Manual. Corrosion rates shall be calculated using subsequent measurements from the same locations. The position of the monitoring locations shall be recorded in the Maintenance Manual for the structure with sufficient accuracy so that subsequent measurements can be taken at the same locations.

6.14 The measurements shall be carried out using a modern digital ultrasonic thickness gauge. Suitable instruments for the purpose are described in Appendix B. At the Principal Inspection (DMRB 3.1.4 BD 63), measurements of the residual thicknesses at the monitoring locations shall be taken and recorded in the Maintenance Manual.

6.15 If projections from a series of measurements taken after the initial weathering period indicate that the likely total loss of thickness over the design life of the structure would be more than the allowances provided in the design, then consideration shall be given to providing a suitable protective system for the steel at an appropriate time.

7. MAINTENANCE

7.1 If in practice it is found that chlorides are adversely affecting the stability of the rust patina and causing corrosion of the substrate then this can be alleviated by annual cleaning with low-pressure water washing at the end of the de-icing period.

7.2 If a weathering steel structure is not performing satisfactorily, for whatever reason, which may be changes in the environment or poor design, provision of additional corrosion protection will need to be considered.

7.3 If painting is deemed necessary either for the whole structure or only in specific problem areas weathering steels can be protected with the same maintenance paint systems recommended in the MCHW Volume 5, Section 2.

7.4 The surface preparation necessary will depend on the protective system to be used and the lifetime required.

7.5 To ensure that the paint coating has a long life, it will be necessary to clean off all existing rust and contaminants.

7.6 Corrosion on weathering steel can lead to a pitted surface particularly in the presence of chlorides. To clean out such pits, wet abrasive blasting is recommended.

8. REFERENCES

8.1 British Standards Institution

BS EN 10155: 1993 - Structural steels with improved atmospheric corrosion resistance.

BS EN 10025: 1993 - Hot rolled products of non-alloy structural steels.

BS 7668 - Specification for weldable steels. Hot finished structural hollow sections in weather resistant steels.

BS 5400 - Steel, Concrete and Composite Bridges

BS 7079 Part A1 (ISO 8501-1) - Specification for rust grades and preparation grades of uncoated steel substrates and of steel after overall removal of previous coatings.

8.2 International Standards Organisation

ISO 9223: 1992 (E). Corrosion of metals and alloys - Corrosivity of atmospheres - Classification.

ISO 9224: 1992 (E). Corrosion of metals and alloys - Corrosivity of atmospheres - Guiding values for the corrosivity categories.

ISO 9225: 1992 (E). Corrosion of metals and alloys - Corrosivity of atmospheres - Measurement of pollution

ISO 9226: 1992 (E). Corrosion of metals and alloys - Corrosivity of atmospheres - Determination of corrosion rate of standard specimens for the evaluation of corrosivity.

8.3 Highways Agency Design Manual for Roads and Bridges (DMRB)

Volume 1 Section 3 General Design

Part 12 - BA 42 - The Design of Integral Bridges.

Volume 3 Section 1 Inspection

Part 4 - BD 63 - Inspection of Highway Structures.

8.4 Highways Agency Manual of Contract Documents for Highway Works (MCHW)

Volume 1: Specification for Highway Works (MCHW 1) 1900 Series.

Volume 5: Section 2: Maintenance Painting of Steel Highway Structures (MCHW 5).

8.5 Other Publications

Further information on the performance and use of weathering steel is given in the following documents:

Albrecht P, Coburn SK, Wattar FM, Tinklenberg GL and Gallagher WP (1989) ‘Guidelines for the use of weathering steel in bridges’ NCHRP Report No 314, Transportation Research Board, National Research Council, Washington DC, USA.

Albrecht P and Naeemi A H (1984) - Guidelines for the use of Weathering Steel in Bridges – NCRPR 314 US Transportation Research Board National Research Council, Washington DC, USA.

British Steel (1996) ‘Weather Resistant Steel: Use and applications’ British Steel, SP & CS, PO Box 30, Motherwell, Lanarkshire, ML1 1AA.

Brown C W (ISBN 92-9147-000-64) ‘The use of weathering steel in Bridges’ - Report No 81, European Convention for Constructional Steelwork.

Halden D (1991) ‘Design and performance of weathering steel bridges on Scottish trunk roads’ Paper 9689, Proceedings, Institution of Civil. Engineers, Part 1, 1991, 90 Apr., 447-462.

Mathay WL (1993) ‘Uncoated weathering steel bridges’ Highway structures Design Handbook, Vol. 1, Chapter 9, American Institute of Steel Construction, AISC Marketing, 650 Smithfield Street/Suite 750, Pittsburgh, PA 15222-3907, USA.

McKenzie M (1996) ‘The performance of in-situ weathering steel in bridges’ - Bridge Management Forum, Proceedings of the conference, University of Surrey, Guildford, Surrey, April 2000.

McKenzie M (1990) 'The corrosion of weathering steel under real and simulated bridge decks' TRRL Research Report 233, TRL, Crowthorne Berkshire.

McKenzie M (1978) 'The corrosion performance of weathering steel in Highway Bridges' TRRL Laboratory Report 857, TRRL Crowthorne Berkshire.

ASTM A325 High Strength bolts for Structural Steel Joints.

9. ENQUIRIES

All technical enquiries or comments on this Standard should be sent in writing as appropriate to:

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APPENDIX A - ENVIRONMENTAL CLASSIFICATION WITH RESPECT TO THE USE OF WEATHERING STEEL

The International Standards Organisation gives a method for classifying the atmospheric corrosivity with respect to the main metals used in construction (ISO 9223). This adopts two routes to classification - one based on environmental data and the second on corrosion tests using test coupons of specific metals.

Classification based on environmental measurements

The following environmental measurements are used:

Yearly time of Wetness (estimated from Time that RH > 80% AND temperature is > 0 ^{o}C) - categories T1 to T5

Pollution in terms of atmospheric sulphur dioxide levels - categories P0 to P3

The level of sulphur dioxide can be measured using either a deposition method or direct volumetric measurements of airborne concentration. In the deposition method, airborne sulphur dioxide reacts with an exposed surface of lead dioxide to form lead sulphate. The quantity is determined by chemical analysis. Specimens are usually exposed for a one month period, and the testing carried out for a year to give a representative average value.

Pollution in terms of airborne salinity - categories S0 to S3

This is determined by the deposition of airborne chlorides on a specific area of damp muslin exposed under a specific design of shelter. This device is known as a ‘wet candle.’ The quantity deposited in a given period, usually one month is determined by chemical analysis. Testing is carried out for a year to give a representative average value.

The combination of these wetness and pollution classifications is used to determine the overall corrosivity classification - C1 to C5 - for particular metals. The documents also give guiding values for the expected corrosion rates within each corrosivity category for carbon steel, weathering steel, zinc, copper and aluminium.

Classification based on corrosion rate measurements of standard specimens

This uses the results of the corrosion rates for standard metals exposed for a year in a specified manner to classify the corrosivity.

APPENDIX B - RESIDUAL STEEL THICKNESS MEASUREMENT USING ULTRASONIC GAUGES

Traditional ultrasonic thickness gauges measure the transit time of an ultrasonic signal originating at a probe head placed on one surface of the steel, then reflected from the steel air interface on the other side of the section back to the probe head. Surface coatings or layers of rust on the steel will increase the transit time and give an increased apparent steel thickness. As the signal speed through the coating or rust is not the same as through the steel, it is not straightforward to allow for this. To obtain the steel thickness alone, the surface coating or corrosion must be removed prior to measurement. The use of such gauges on weathering steel structures to monitor residual thickness has the following disadvantages:

(a) The rust layer must be removed without removing any of the underlying steel.

(b) The rust layer has now been removed at that point so will subsequently corrode in a different manner from the remainder of the steel. To estimate ongoing corrosion, further measurements need to be made at a different position.

(c) The procedure leads to unsightly blemishes on the steel surface.

These problems can be overcome by utilising a special type of thickness gauge which provides an accurate measurement of the residual steel thickness without the need to remove the rust coating. Instead of measuring the probe back to probe transit time, the instrument measures the time between echoes within the steel section. Typical instruments are small, light in weight, battery operated and have a digital display. A couplant material is needed to transmit the signal from the probe head through the rust into the steel. Water or a light easily removable material such as glycerol are effective in doing this.

Such instruments are accurate to +/- 0.1 mm. This is adequate for absolute residual steel thickness measurements for structural calculations. However this limited accuracy combined with the low corrosion rates of weathering steels - typically 5 to 15 μm per year - means that estimating corrosion rates from the difference in thickness readings at different times can only be done over long time periods.

Because the rust coating does not need to be removed, steel thickness can be measured at exactly the same position at different times.