



TRUNK ROAD MAINTENANCE MANUAL : VOLUME 2

*Routine and Winter
Maintenance Code*

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Volume 2 Introduction

Introduction

(i) General

The Trunk Road Maintenance Manual contains three volumes:

- Volume 1 : Highways Maintenance Code
- Volume 2 : Routine and Winter Maintenance Code
- Volume 3 : Management of Health and Safety

This Volume deals with the routine maintenance of highways, the operational winter maintenance of the trunk road network, and the routine maintenance of highway structures. Volume 2 shall be read in conjunction with Volume 1 for bidding, allocation and outturn of funds for routine and winter maintenance and reimbursement of MA's costs.

In addition, Volume 2 should be read in conjunction with the appropriate Volume of the Highways Agency's Design Manual for Roads and Bridges (DMRB).

Volume 2 supersedes:-

- (a) TRMM 4/85 Code of Practice for Routine Maintenance of Motorways and All-Purpose Trunk Roads.
- (b) The Code of Practice for Routine Maintenance (Blue A4 file) published in 1985.
- (c) The Statement of Service and Code of Practice for Winter Maintenance (Orange A4 booklet) published in 1987.
- (d) TRMM 4/88 Winter Maintenance: Ice Detection Systems, Thermal Mapping and Road Weather Forecasting.

Version 1 of Volume 2 was originally issued in November 1992. Following a complete review of its contents, this revised version No. 2, dated February 1996, supersedes the earlier version in its entirety.

As it is a new version, the amendments summary sheet will start from scratch again at Amendment 0, Issue date Feb '96 and Part nos 1 to 3.

(ii) Parts

Volume 2 is split into 3 parts:

Part 1 : Routine Maintenance of Highways.

Part 2 : Routine Maintenance of Structures.

Part 3 : Winter Maintenance.

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(iii) List of Principal Abbreviations used

AA	Agent Authority (County, Metropolitan County, Metropolitan Borough or London Borough Council)
AADT	Annual Average Daily Traffic
APTR	All-Purpose Trunk Road
BE	Bridges Engineering Division - The Highways Agency
CSS	County Surveyors Society
CHART	Computerised Highway Assessment of Ratings and Treatments
cv/d	Commercial Vehicles per Day
DA	Design Agent (either Agent Authority or Consulting Engineer)
DLO	Direct Labour Organisation
DMRB	Design Manual for Roads and Bridges
EC	European Community
ECP	Emergency Crossing Point
FO	Forecasting Organisation
HA	Highways Agency (on behalf of the Secretary of State)
HGV	Heavy Goods Vehicle
IHMS1	Integrated Highway Maintenance System - Module 1
LGV	Large Goods Vehicle
MA	Maintenance Agent (either Agent Authority or Consulting Engineer)
NATS	National Structures Database
NIS	Network Information System - The Highways Agency's Trunk Road Management Information System
OSD	Operations Support Division - The Highways Agency
PI	Principal Inspection of Highway Structures
PSTN	Public Switched Telephone Network
RMMS	Routine Maintenance Management System
RO	Regional Office - The Highways Agency
TRMM	Trunk Road Management and Maintenance Notice
WMAM	Winter Maintenance Area Manager
WMRM	Winter Maintenance Regional Manager

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(iv) Enquiries

Enquiries about the content of this Code should be made to:-

Highways Agency
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Room 5/64
St Christopher House
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(v) Amendments Summary

Amendment set	Issue Date	Part No	Chapter No.	Section No.	Initials	Date
0	February 1996	1 to 3	All	All		
1	April 1998	1	1.15	1.15.1		
			1.19	1.19.1		
		2	2.1	Various		
2	August 1999	1	1.10	All		
			1.11	All		
			1.12	1.12.1		
			1.19	1.19.1		

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1.1 Routine Maintenance Management

1.1.1 Introduction

This Part is intended to ensure consistency of standards and value for money in routine maintenance practice on the trunk road network. It sets out the procedure for and frequency of inspections to determine what routine maintenance tasks are to be carried out and, in some cases, the manner in which they are to be performed on motorways and all-purpose trunk roads (APTRs) for which the Highways Agency is responsible as the Highway Authority.

Throughout this Part, reference to trunk roads shall be taken as meaning both motorways and APTRs.

This Part covers areas of activity in which work is generally short term or cyclic and necessary to keep the highway in good working order. It does not deal with the replacement or renewal of those parts of the highway which, over a longer term, become unserviceable because of general wear and tear which would properly be dealt with by planned programmes of structural maintenance work. The inspection procedures may, however, assist in identifying the need for replacement or renewal under such programmes.

The following activities are covered:

Emergency Procedures;	Hedges and Trees;
Minor Carriageway Repairs;	Sweeping and Cleaning;
Footways and Cycle tracks;	Safety Fences and Barriers;
Covers, Gratings, Frames and Boxes;	Fences, Walls, Screens and Barriers;
Kerbs, Edgings and Pre-formed Channels;	Road Studs;
Highway Drainage;	Road Markings;
Motorway Communications;	Road Traffic Signs;
Embankments and Cuttings;	Road Traffic Signals;
Grassed Areas;	Road Lighting.

The general requirements will not be appropriate to all circumstances and there will be instances where they will have to be varied to take account of local conditions. Such **local variations** shall be subject to the **approval** of the **Highways Agency's Regional Office (RO)**. Approval will only be given where the need for such a variation is **clearly** justified.

For the purposes of this Part, urban trunk roads are those APTRs with a mandatory speed limit of 40 mph or less. Exceptionally there may be lengths of APTR with a higher speed limit and lengths of motorway which, for most routine maintenance purposes, have urban characteristics. Urban maintenance requirements may then be appropriate to these lengths of road and this should be considered as a local variation subject to the agreement of the Highways Agency.

1.1.2 Routine Maintenance Management System

Management procedures for the routine maintenance of highways are implemented by the **Routine Maintenance Management System (RMMS)**. RMMS enables all inspection and other reports, complaints and third party claims to be assessed in conjunction with the inventory, previous maintenance actions and other relevant data.

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As well as being in the interests of good management and safety, the RMMS is necessary in order to deal with claims which may arise as a result of an alleged defect on the highway, sometimes after remedial action has been taken and there is no longer site evidence of the defect. In this context, a **nil record** is as important as a positive record; experience has shown that oral statements are of little use on their own.

While it is generally accepted by the Courts that a public highway can never be in perfect condition at all times, the Highways Agency must be able to show that it is meeting its responsibilities in a reasonable manner. An adequate inspection system is an essential part of that requirement.

Computer systems have been developed to cover the two main aspects of the RMMS, namely;

- (a) data collection
- (b) data storage, maintenance and use.

The Highways Agency has contributed towards the cost of installation of a computerised database system in all MA's offices. This allows the interrogation and cross referencing of information collected and stored. Electronic Data Capture Devices (DCDs) shall be used for site collection of data.

The computerised RMMS has five main components:

- (a) Network
- (b) Inventory
- (c) Inspections
- (d) Cyclic Maintenance
- (e) Works Order Interface

The **network** to be managed is defined to enable unique identification of any location. The RMMS uses the CHART referencing system which defines any position on the network by Link, Section number, Chainage and Cross-sectional position.

An item **inventory** of the highway infrastructure and furniture is an **essential** part of the RMMS. The inventory items and details to be collected and stored are detailed in the Highways Agency's RMMS Manual. Data Capture Devices (DCD) shall be used for collection of inventory data and down-loaded into the database system.

Inspection and reporting procedures, actions to be taken and, where appropriate, standards to be met are set out in this Part. The RMMS implements these requirements using standardised records of **inspections** which also register subsequent decisions and actions. The same record is used for reports and complaints from outside sources such as the general public, the police, and motoring organisations. DCDs with standard data capture programs enable consistent recording of inspections using check lists (derived from the Highways Agency's RMMS Manual) which set out the items to be inspected and defects to be reported.

In addition to recording defects identified by inspections, the RMMS records **cyclic maintenance** works undertaken in accordance with this Part and prompts subsequent cyclic maintenance as it becomes due.

The **works order interface** provides the facility to review recorded defects periodically, to group them together according to appropriate programmes of work and to interact with works ordering systems in instructing rectification of the defects.

Features designed into the database also allow assessment of performance by means of audit reports.

Summary RMMS inventory data shall be provided to the Highways Agency annually as detailed in **Annex 1.1.1**.

1.1.3 Inspection Types

The motorway and APTR network shall be inspected for the purposes of identifying the need for routine maintenance tasks to be carried out. The requirements shall apply equally to rural and urban trunk roads. Where a particular interval is specified between inspections, this shall be adhered to as closely as possible.

All personnel shall be sufficiently responsible and competent for the task and receive suitable training to be fully conversant with the inspection procedures and safety requirements of the Highways Agency.

In the 17 areas of maintenance activity identified in this Part, 2 types of inspection are required - **Safety** and **Detailed**.

Safety Inspections - are designed to identify those defects which are likely to create a danger to the public and therefore require **immediate** or **urgent attention**. They shall normally be mobile inspections carried out from slow moving vehicles, with the occasional need to proceed on foot, at frequencies which reflect the importance of a particular road. Additional Safety Inspections may be required in response to reports or complaints from the police, other organisations, and the public; as a result of major incidents; or as a result of extreme weather conditions.

Detailed Inspections - are carried out at less frequent intervals than Safety Inspections and are designed primarily to establish programmes of routine maintenance tasks not requiring urgent execution. Requirements for Detailed Inspections are set out under the appropriate activity headings.

In addition to these two types of inspection, **Safety Patrols** are required to supplement Safety Inspections on some roads.

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1.1.4 Maintenance Requirements

Defects which are identified as a result of Safety or Detailed Inspections, Safety Patrols, or following other reports and complaints, will fall into two categories:

Category 1 - those which require prompt attention because they represent an **immediate** or **imminent hazard** or because there is a risk of short term structural deterioration;

Category 2 - all other defects.

Category 1 defects shall be corrected or made safe at the time of inspection, if reasonably practicable. In this context, making safe may constitute displaying warning notices, coning off or fencing off to protect the public from the defect. If it is not possible to correct or make safe the defect at the time of inspection, repairs of a temporary or permanent nature shall be carried out as soon as possible and in any case within a period of **24 hours**. Temporary repairs shall be inspected regularly as part of a Safety Inspection and a permanent repair carried out within **28 days**.

Category 2 defects shall be repaired within planned programmes of work. The computerised RMMS includes a facility to assign 3 levels of priority to Category 2 defects. These priorities shall be considered, together with access requirements, other works upon the road network, traffic levels and the need to minimise traffic management, in compiling the programmes of work.

Further Maintenance Requirements applying to specific activities are detailed in the relevant chapters. For several activities these also include requirements for cyclic maintenance.

All action taken, including temporary protective measures and repairs, shall be promptly recorded and details retained for a minimum of 6 years.

1.1.5 Safety Inspection Requirements

Safety Inspections are designed to identify defects which constitute an imminent or immediate hazard to the public i.e. **Category 1 defects**. Whenever such defects are encountered, they shall, if reasonably practicable, be corrected, made safe or otherwise protected by the inspection personnel before being reported to the base office at the earliest opportunity with a request for immediate action.

Safety Inspections shall normally be carried out by trained personnel operating as a two person team from a slow moving vehicle. Occasionally, where circumstances require, (e.g. in the case of town centres, principal shopping areas, subways and footbridges and at complex road junctions), inspection personnel shall proceed on foot either to confirm suspected faults or to complete the Safety Inspection. It may be appropriate to undertake Safety Inspections during off-peak periods or at night in order to minimise traffic disruption and maximise safety of both the inspectors and the public.

Safety Inspection data shall be recorded on DCDs and down loaded onto the RMMS database upon return to the base office. It is essential that all inspections, including those showing a nil return, are entered onto the database promptly. Records shall be retained for a minimum of 6 years.

Reports and complaints received from other sources shall be similarly recorded on the database and retained together with details of specific inspections and actions taken.

The Safety Inspection record shall include details of the weather conditions, road surface condition and any unusual features of the method of inspection.

Table 1.1.1 assigns inspection priorities (Inspection Categories A, B, and C) to trunk roads.

The frequency of Safety Inspections is determined by the Inspection Category of the road;

Inspection Categories A and B - shall receive a **Safety Inspection** at intervals of 7 days.

Inspection Category C - shall receive a **Safety Inspection** at intervals of 28 days.

Slip roads and link roads within interchanges shall receive Safety Inspections at the same frequency as the main carriageway of the trunk road.

Certain very vulnerable sites, (e.g. the Severn Bridge and M25 tunnels), may be subject to continuous surveillance. Any such surveillance which is largely dependent on video monitoring, and is primarily designed to allow prompt reaction to traffic incidents, should not be considered as an alternative to Safety Inspections.

1.1.6 Safety Patrol Requirements

The function of **Safety Patrols** is to supplement Safety Inspections by providing a structured, more frequent surveillance of the road network to identify obvious hazards (Category 1 defects).

A Safety Patrol shall normally be carried out by a single inspector in a vehicle travelling as slowly as prevailing traffic speeds allow without disruption of traffic flow. Occasionally it may be appropriate for Safety Patrols to be undertaken on foot.

Any hazards which are observed shall if reasonably practical be corrected, made safe or otherwise protected and reported to the base office for action, in the same manner as defects discovered by a Safety Inspection. They shall be recorded on the RMMS database as Category 1 defects.

A record shall be made of all Safety Patrols undertaken, including the date, the inspector, the method, and the time that each section of the road was patrolled. These records shall be retained in an appropriate format for a minimum of 6 years; there is no provision for their entry onto the RMMS database (except in the reporting of Category 1 defects).

Safety Patrols shall be undertaken on Inspection Category A roads daily (including weekends and bank holidays) between the weekly Safety Inspections.

Safety Patrols are not normally required on roads in Inspection Category B and C but there may be circumstances in which occasional Safety Patrols are appropriate on one of these roads; a local variation should be agreed with the RO.

At standard junctions it will generally be unnecessary to patrol both the main carriageway and all the slip roads, but at more complex interchanges it may be necessary to traverse some of the link roads. A schedule of any link roads and slip roads to receive safety patrols shall be agreed with the RO.

Inspection Category	Motorways	All-Purpose Trunk Roads
A	All, except Inspection Categories B and C	A1 (Birtley to Seaton Burn) A1 (Doncaster By-pass to Scotch Corner) A1 (Beds to Doncaster By-pass) A2 (M25 to M2) A5 (M54 to A49) A14 (M11 to A1) A19 (A174 to A689) A38 (M6 to M1) A40 (M50 to Welsh border) A42 (M1 to M42) A46 (M6 to M40) A102 (London in between A102M) A102M A282 A5103 (M56 to M63)
B	A1M (Scotch Corner to Birtley) M6 (Cumbria) M41 M45 M58 M65 A3M A40M A66M A194M	A1 (A406 to M25) A2 (M25 to A102M) A2 (M2 to Dover) A3 (A31, Guildford to A219, London) A4 (M4, Junction 5 to A406) A10 (M25 to North of Ware Bypass) A11 (M11 to A45) A11 (A12 to A106) A12 (A11, London to A45, Ipswich) A13 (M25 to A1206) A14 (M1 to A1) A14 (Felixtowe to M11) A19 (A689 to Seaton Burn) A20 (M25 to B263) A23 (M23 to Brighton) A27 (Hants, M27 to eastern end of Chichester By-Pass) A27 (Lewes to River Adur) A30 (A312 to A4) A31 (Cadnam to A347/A348 Junction) A34 (M3, Junction 9 to M40, Junction 9) A38 (M5, to Saltash Tunnel) A40 (A40M to M25) A40 (M40 to north of Oxford) A41 (A406 to M25) A56 (M65 to M66) A63 (M62 to Hull) A74 (M6 to Scotland) A127 (A12 to M25) A106 (A11 to A102M) A168/A19 (A1 to A174) A180 A312 (A30 to M4) A316 (M25 to A312) A404 (M40 to M3) A405 (M1 to A414) A406 A414 (A405 to A1M) A419 (M4 to north of Swindon)
C		All except as above

Table 1.1.1 Inspection Priority for Trunk Roads

1.1.7 Detailed Inspection Requirements

Detailed Inspections are designed to identify routine maintenance work required on the trunk road network and to enable efficient programming of that work.

Specific requirements for Detailed Inspection of each activity are set out in Chapters 1.3 to 1.19 and the Departmental Standards referred to therein. Table 1.1.2 summarises the required frequencies of Detailed Inspections for each activity.

Arrangements for Detailed Inspection shall seek to minimise disruption to traffic whilst ensuring adequate access for proper inspection and maintaining a safe working environment for the inspection personnel.

Wherever possible, inspections that require lane closures shall be carried out when closures are in operation for other maintenance work. Where separate lane closures are necessary, inspections should be undertaken in off-peak periods, and consideration given to night-time working or mobile lane closures to keep traffic delays to a minimum.

Detailed Inspections for defects to items in and along the edges of D3M and D3APTR or wider should be carried out from the hardshoulder or grass verge/nearside lane respectively. The condition of the carriageway surface, roadstuds and road markings in all lanes should also be observed from these locations at frequencies laid down for these areas of activity. Additionally, gullies, kerbing and edgings adjacent to the nearside verge and central reservations should be inspected from these locations at the appropriate frequencies.

At intervals of 2 years (or less if lane closures for other purposes allow or previous expertise has demonstrated it to be necessary) a Detailed Inspection shall be carried out from the central reserve with the offside lane coned off. This inspection shall cover all items within and adjacent to the central reserve and those items scheduled for inspection at 2 yearly intervals or less. Additionally the centre and offside lanes of the carriageway, as well as the roadmarkings and roadstuds between, shall be inspected.

For D2M and D2APTR inspections from the hardshoulder and grass verge/nearside lane respectively should be adequate for recording defects across the full carriageway width. Offside lane restrictions for these roads should only be instituted at intervals of **2 years** or greater to protect personnel inspecting items within the central reservation.

Detailed Inspection data shall be collected on DCDs, using standard data capture programs which include check lists setting out the various defects to be noted. The report shall be down loaded onto the RMMS database and retained for a minimum of 6 years.

The Detailed Inspection record shall include details of the manner of inspection (e.g. off-side lane closure or hard shoulder), the weather conditions and any other unusual features of the inspection. Nil returns shall also be recorded onto the database.

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Activity	Detailed Inspection Frequency (Years)													
	0	1	2	3	4	5	6	7	8	9	10			
Minor Carriageway Repairs - urban APTR	X	X	X	X	X	X	X	X	X	X	X	X	X	X
- m/way, rural APTR	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Footways and Cycle Tracks - urban	X	X	X	X	X	X	X	X	X	X	X	X	X	X
- rural	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Covers, Gratings, Frames and Boxes	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Kerbs etc - urban APTR	X	X	X	X	X	X	X	X	X	X	X	X	X	X
- rural footways (only)	X	X	X	X	X	X	X	X	X	X	X	X	X	X
- other	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Highway Drainage:														
Piped Drainage Systems	X													X
Gullies, Catchpits and Interceptors	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Piped Grips > 5m in length	X													X
Ditches	X								X					X
Filter Drains	X								X					X
Culverts	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Balancing Ponds - no outflow controls	X								X					X
- with outflow controls	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Ancillary Drainage Items - headwalls, aprons	X	X	X	X	X	X	X	X	X	X	X	X	X	X
- sluices, tidal flaps	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Motorway Communication Installations :														
Telephones (1)	X			X				X				X		X
Matrix Signals (2)	X			X				X				X		X
Cabinets (2)	X			X				X				X		X
Transmission Stations (2)	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Cable Markers	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Other Equipment (2)	X			X				X				X		X
Electrical Supplies	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Embankments and Cuttings	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Hedges and Trees	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Safety Fences and Barriers	X			X				X				X		X
Fences, Walls and Barriers - integrity	X	X	X	X	X	X	X	X	X	X	X	X	X	X
- structural condition	X			X				X				X		X
Roadstuds	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Road Markings (3)	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Road Signs - faces, supports, fittings, electrics (4)	X			X				X				X		X
- moving parts, obscuration by foliage	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Road Traffic Signals (5)	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Road Lighting (6)	X	X	X	X	X	X	X	X	X	X	X	X	X	X

- Notes:**
- (1) Additional inspections also required every 28 days.
 - (2) Additional inspections also required every 3 months.
 - (3) Frequency reduced to 2 years for thermoplastic markings.
 - (4) Additional inspections for lamp failures required every 28 days.
 - (5) Inspection interval for structural condition indicated. Additional inspections for operational failures also required.
 - (6) Inspection interval for structural condition indicated. Additional inspections for lamp failures and obscuration by foliage required every 14 days (APTRs) or 28 days (motorways).
 - (7) Detailed Inspections of grassed areas and for sweeping and cleaning are not required.

Table 1.1.2 Frequency of Detailed Inspections for each Activity

Annex 1.1.1

Provision of Integrated Highways Maintenance System Module 2/3 Data

Prior to the commencement of the bid cycle within IHMS2/3, summary RMMS Inventory data must be provided to the Highways Agency through the IHMS data transfer option within the RMMS system. Data must be provided to the Highways Agency by the end of January for inclusion in the bidding process.

The resultant data files should be renamed in the following format:

AAAARMNN.DAT

where AAAA represents the Maintenance Agent code
RM represents RMMS Inventory data
NN represents forthcoming financial year

Hence 0100RM95.DAT would represent RMMS Inventory data submitted from Avon County Council for forthcoming financial year 1995/96.

The renamed data files should be copied to a 3½" High Density floppy diskette (or equivalent) and should be clearly labelled:

IHMS Transfer Data - RMMS
Maintenance Agent Name, eg. Avon County Council
Contact name and telephone number
Data transfer disk created
Number of disks expected and sequence, eg. Disk 1 of 2

The completed disk(s) should be forwarded to:

Highways Computing Help Desk
Room G04
Jefferson House
27 Park Place
Leeds
LS1 2SZ

who will acknowledge receipt by return of post. The data received will be loaded by HC onto IHMS2/3 and made available for use within 20 working days of its receipt. HC will contact the data supplier whenever this timescale cannot be achieved.

1.2 Emergency Procedures

1.2.1 General

In the event of an emergency occurring on the highway it is essential for maintenance personnel to respond as quickly as possible in order to minimise any danger, disruption or delay to the public. This section states the response times to be achieved by MAs in attending emergencies on the trunk road network.

Information about accidents is frequently required by the Highways Agency to determine liabilities, to review design standards or to consider maintenance techniques. This section sets out new procedures for **Accident Pathology** - a system of recording details of major incidents promptly, of appropriate detail and subject matter, to enable analysis for the Highways Agency's particular purposes.

In achieving these response times and levels of service, reliable and efficient communications has a very important role to play. The majority of MAs already operate adequate communication systems. However, some systems may require improvement and/or be augmented with mobile telephones and radio pagers. It will be for the MA to provide any additional equipment required to enable the requirements of this chapter to be met.

Similarly, the MA shall provide suitable plant and equipment, from whatever source, to enable him to respond to the emergency. No specialised or dedicated plant will be provided by the Highways Agency.

1.2.2 Response Times

The **Response Time** for attendance at an emergency is defined as the time taken from receipt of notification of the emergency to commencement of appropriate action at the site of the incident.

Response times should always be as short as practicable but in any event shall not exceed the maximum times given in Table 1.2.1. These maximum allowable response times take into account the type of road (Inspection Category as defined in Table 1.1.1) and the time of day.

INSPECTION CATEGORY (Table 1.1.1)	MAXIMUM RESPONSE TIME	
	0700 hrs - 1900 hrs	1900 hrs - 0700 hrs
A and B	1 hour	1½ hours
C	1½ hours	2 hours

Table 1.2.1 - Maximum Emergency Response Times

The maximum response times may be varied by the Highways Agency in the following circumstances:

- (a) On roads carrying over 115,000 vehicles AADT where a rapid build up of traffic can occur, the Highways Agency may agree a shorter response time with MAs in order to keep delays to a minimum;
- (b) On roads carrying less than 6,000 vehicles AADT the Highways Agency may agree a longer response time with MAs.

1.2.3 Emergency Facilities

Facilities shall be provided by the MA to clear the highway following an accident/spillage, or any other incident, which requires attendance under emergency conditions.

The MA shall ensure the availability of suitable plant, equipment and personnel to enable him to respond effectively to the emergency, in accordance with the maximum response times stated in 1.2.2.

The MA shall arrange for a suitably qualified member of staff to be on standby 24 hours a day, 7 days a week. Standby is defined as committed to be available to attend on site without delay, when an emergency arises or when called upon by the Highways Agency.

The MA shall provide the Regional Office with a Method Statement covering all aspects of the procedures for emergencies and in particular how an emergency response can be initiated.

1.2.4 Breakdown of Communication Installations

The Highways Agency places high priority on the rectification of faults in the motorway communication system and associated electrical equipment. Maintenance of these communication installations is the responsibility of the specialist contractors appointed directly by the Highways Agency but the MA is responsible for assisting the specialist contractor in works associated with the repairs.

Breakdown or damage which renders the communications installations inoperable shall be considered an emergency and the MA shall ensure the availability of resources to give all necessary assistance to the specialist contractor within the maximum response times stated in Table 1.2.1.

1.2.5 Accident Pathology

New requirements for **Accident Pathology** are currently being developed in conjunction with Police Authorities. **The MA shall not commence implementation of the following procedures until instructed to do so by the Regional Office.**

Accident Pathology procedures shall be instigated for all accidents involving fatalities on the trunk road network.

A primary aim of Accident Pathology is to collect, at the time of the accident, information which is unlikely to be available later. Police Authorities will therefore be requested to ensure that MAs are advised immediately of fatal accidents on their network. The MA shall ensure that lines of communication for this notification are clearly defined by nominating a single point of contact and agreeing this with the Police.

It is essential that the MA's representative responds to the incident promptly and neither disrupts the work of the emergency services at the scene nor delays the re-opening of the carriageway. The MA's representative shall therefore **attend as soon as possible and in any event within 1 hour** of notification of the accident; at all times following instructions and directions given by the Police, including arrangements for reaching the site. He shall report immediately to the senior Police officer at the scene, obtain Police agreement before proceeding with any investigation and comply with any instructions given by the Police. The work of the emergency services and the re-opening of the carriageway shall always take precedence over the MA's investigation.

The level of investigation of an accident shall be determined by a threshold based on the number of fatalities and/or serious injuries:

$$\text{Threshold} = \text{No. of Fatalities} + \frac{\text{No. of Serious Injuries}}{5}$$

- (a) A **full** investigation shall be undertaken when an accident meets a threshold of 3 or more.
- (b) A **preliminary** investigation shall be undertaken for all other fatal accidents.

Annex 1.2.1 gives guidance and requirements for a **full investigation**. This includes information to be collected at the time of the accident and information to gather in subsequent investigation. The completed report shall be forwarded to the RO and to the "officer in the case" at the Police Authority within 2 months of the accident. An interim report shall also be produced and forwarded to the same nominees within 14 days of the accident.

A **preliminary investigation** shall consist of a photographic record at the time of the accident and a brief description of the incident, with particular emphasis on any unusual features. The MA must also ensure that any damaged or failed components of the highway infrastructure are retained. The MA shall retain the preliminary investigation information pending any requests for further investigation.

Annex 1.2.1

Accident Pathology

Full Investigation Report

1. Investigation at the Incident

Information to collect at the time of the accident shall include:

- (a) a photographic record of the site (but not of victims).
- (b) detail photographs (failed components, any unusual features, items with maintenance or design implications).
- (c) traffic details, traffic management, details of the approach to the site (including photographs and preferably a video record).
- (d) weather conditions (at the time of and prior to the accident).
- (e) details of unusual aspects of the incident.
- (f) malfunctioning highway equipment (e.g. lighting, signs).
- (g) winter maintenance operations in progress, if appropriate.
- (h) retention of damaged/failed components (by Police or MA).

2. Further Investigation

Information to gather after the incident shall include:

- (a) details of the road layout and alignment design.
- (b) conditions of the highway (including skid resistance tests etc. if appropriate).
- (c) testing of any components involved if appropriate (e.g. safety fence).
- (d) copies of press reports
- (e) police records

3. Police Records

The collection of Police records for the Police report will be co-ordinated by the "officer in the case". MA's should identify this officer at the time of the accident and liaise with him after the event in compiling their investigation report.

4. Report

The MA's report shall comprise a factual account of the accident, including all relevant information compiled as discussed above. The report shall also discuss the circumstances of the incident with particular reference to any implications for highway design or maintenance and consideration of any aspects for which the Highways Agency might be held liable. The report shall be completed within 2 months of the accident and forwarded to the RO and to the "officer in the case" at the Police Authority. An interim report shall also be produced and forwarded to the same nominees within 14 days of the accident.

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1.3 Minor Carriageway Repairs

1.3.1 General

The requirements of this chapter relate to minor repairs to the carriageway. The requirements do not relate to larger scale work needed to strengthen the carriageway or to work which would be classed as, or linked to, structural maintenance schemes.

The need to differentiate between routine and structural maintenance activities for work that is similar in nature is self-evident. It is usual, before carrying out surface dressing or resurfacing, to ensure that the underlying road structure is sound. This often requires repairs to potholes, rutting, open joints, etc., that would otherwise be carried out as routine maintenance operations, if there was no major structural work following.

The repair of defects reported from inspections may be absorbed into structural repairs already due to be carried out, within the Highways Agency's required timescale. However, structural repairs will usually be contained within a long term national programme, determined on the basis of national priorities and the availability of structural maintenance funds. These schemes sometimes have to be deferred and this may then make it necessary to carry out the originally identified routine maintenance repairs separately and at relatively short notice.

Some minor carriageway repairs may be due to the activities of the utilities or licence holders who are governed by the New Roads and Street Works Act 1991. From the 1st January 1993 if the excavation is still within its guarantee period and fails to meet the performance criteria, as defined in Paragraph S1.2 and Chapter S2 of the Specification for the Reinstatement of Openings in Highways⁽¹⁾, the undertaker should be informed of the defect, using the procedure contained in Chapter 4 of the Code of Practice for Inspections⁽²⁾ and the defect inspection procedure invoked. If a dangerous reinstatement is discovered the reinstatement should be protected by signing, lighting and guarding and the undertaker's attendance requested. In exceptional circumstances the reinstatement may be made safe by the MA. Any costs incurred in making safe a reinstatement must be recovered from the undertaker and not charged to the Highways Agency. During the guarantee period of an undertaker's reinstatement, both interim and permanent, the undertaker remains responsible for its maintenance and performance and the Highways Agency's requirements will not apply. However, defects at this stage may well be picked up as a result of one of the inspection procedures (see 1.1.3).

1.3.2 Inspection Requirements

Detailed Inspections shall be carried out at intervals of **6 months** on urban APTRs and at intervals of **1 year** on motorways and rural APTRs. They shall be coordinated as fully as possible with the detailed inspection of other items in the highway as a whole.

The Highways Agency's RMMS Manual gives guidance on the items to be inspected and defects to be noted. Check lists are also programmed onto the DCDs used to record the inspections, enabling quick reference on site.

Detailed Inspections are designed to note only those types of defects likely to require routine maintenance rather than to establish general structural condition. They may point to the need to bring forward a CHART or Deflectograph survey.

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1.3.3 Maintenance Requirements

Maintenance Requirements are as stated in 1.1.4.

- (1) Specification for the Reinstatement of Openings in Highways - A Code of Practice approved by the Secretaries of State for Transport, Wales and Scotland under sections 71 and 130 of the New Roads and Street Works Act 1991. HMSO - ISBN 0-11-551143-1.
- (2) Code of Practice for Inspections - A Code of Practice issued by the Secretaries of State for Transport, Wales and Scotland on behalf of the Highway Authorities and Utilities Committee. HMSO - ISBN 0-11-551148-2.

1.4 Footways and Cycle Tracks

1.4.1 General

The requirements of this chapter relate to minor repairs to footways and cycle tracks. The requirements do not relate to larger scale work which would normally be classed as, or linked to, structural maintenance jobs.

A footway is a paved facility for pedestrians, usually within the highway boundary. Footways include the walking surfaces of subways, underbridges, overbridges and pedestrian rights of way which are the responsibility of the Highways Agency and which may occasionally fall outside the highway boundary.

A cycle track is a paved facility available for persons with pedal cycles, with or without a right of way on foot, usually within the highway boundary.

Reference to footways and cycle tracks is made in the Inspection Requirements for CHART surveys. It should be noted however that these may not be intended to cover all footways, particularly where these are remote from the carriageway.

Many footways and cycle tracks adjacent to trunk roads, even in urban areas, have fallen into complete or relative disuse, possibly because of unnecessary provision in the first place or changed circumstances with the passage of time. Disused facilities should only be inspected to meet the requirements for Safety Inspections, and maintenance action taken if defects are found that constitute an immediate hazard to highway users. A little used facility in an urban area may be considered for re-classification as "rural" for maintenance purposes. Where a disused facility represents a significant maintenance liability, consideration should be given to removing it.

Damage to the footways may be caused by vehicle over-riding, particularly in urban areas and at road junctions where the footway may be immediately adjacent to the carriageway edge. Consideration should then be given to the provision of high strength in-situ concrete margins up to 1 m wide behind the kerb or locally at road junction radii. Alternatively, consideration should be given to carrying out an improvement scheme to alleviate the problem in which case a report and proposal for action should be made to the Highways Agency.

Pre-cast concrete footway slabs which have superficial cracks only should not be replaced as a routine maintenance operation unless there is a need to reset the slab because of some other defect.

1.4.2 Inspection Requirements

Detailed Inspections shall be carried out on footways and cycle tracks associated with urban APTRs at intervals of **6 months**. Those associated with rural APTR shall be carried out at intervals of **3 years**. They shall be coordinated as fully as possible with the Detailed Inspection of other items in the highway as a whole.

The Highways Agency's RMMS Manual gives guidance on the items to be inspected and defects to be noted. Check lists are also programmed onto the DCDs used to record the inspections, enabling quick reference on site.

Detailed Inspections are designed to note only those types of defect likely to require routine maintenance rather than to establish general structural condition. They may point to the need to bring forward a CHART survey.

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1.4.3 Maintenance Requirements

Maintenance Requirements are as stated in 1.1.4.

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1.5 Covers, Gratings, Frames and Boxes

1.5.1 General

The requirements of this chapter relate to repairs to, and the occasional replacement of, all types of gratings, covers, frames and boxes that are the direct responsibility of the Highways Agency. Although the requirements do not relate to repairs to items that are the responsibility of other parties, it may be necessary on occasions, if there is a hazard to road users, to make such defects safe and to recover the costs incurred from the other parties.

The majority of covers are situated in carriageways and footways but those in verges, particularly those verges that are likely to be traversed by pedestrians, should not be ignored.

It may often be difficult to decide whether a cracked or broken item is in real danger of collapse. If in doubt, it should be replaced, irrespective of its position.

Defects in covers and gratings may pose particular danger to pedal and motor cycle users. It should be remembered that their occupancy on a carriageway will not always be limited to the nearside lane. Rocking gratings or covers with only small movement under load may nevertheless be a nuisance in urban areas because of the intrusive noise they make. If complaints are received, they should be corrected.

Many covers in carriageways, footways and cycle tracks are the responsibility of the utilities and possibly other parties. Section 81 of the New Roads and Street Works Act 1991 requires an undertaker to maintain his apparatus in the street to the reasonable satisfaction of the highway authority. If an inspection indicates a hazardous defect, it should be made safe and at the same time the owner should be given notice to carry out permanent repairs within a specified period depending on both the severity of the defect and the effectiveness of action undertaken to make the defect safe. The cost of making safe must be recovered from the undertaker and not charged to the Highways Agency.

1.5.2 Inspection Requirements

Detailed Inspections shall be carried out at intervals of **1 year**. They shall be coordinated as fully as possible with the Detailed Inspection of other items in the highway as a whole, or alternatively, with the cleaning out of highway gullies, catchpits and interceptors.

The Highways Agency's RMMS Manual gives guidance on the items to be inspected and defects to be noted. Check lists are also programmed onto the DCDs used to record the inspections, enabling quick reference on site.

When inspecting the gratings of gullies and other similar surface water catchment items, the opportunity should be taken to check that the item appears to be functioning satisfactorily and is not, for example, partially or wholly blocked.

1.5.3 Maintenance Requirements

Maintenance Requirements are as stated in 1.1.4.

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1.6 Kerbs, Edgings and Pre-formed Channels

1.6.1 General

The requirements of this chapter relate to minor repairs to kerbs, edgings and pre-formed channels of all types. The requirements do not relate to larger scale works that would be classed as or linked to structural maintenance jobs.

Although these items tend to be stable by their nature and construction specification, hazardous conditions can develop quickly when either individual kerbs, or short lengths, are damaged or put out of alignment by heavy vehicles, or when local subsidence occurs. Frequent damage by heavy vehicles may suggest the need for local re-alignment or a more robust specification. Short, sometimes isolated, lengths of kerb serving gullies or grips should not be overlooked.

1.6.2 Inspection Requirements

Detailed Inspections shall be carried out at the same frequency as that laid down for the abutting carriageway, footway or cycle track. Where a carriageway kerb also abuts a footway or cycle track, the higher frequency of inspection shall apply.

The Highways Agency's RMMS Manual gives guidance on the items to be inspected and defects to be noted. Check lists are also programmed onto the DCDs used to record the inspections, enabling quick reference on site.

Detailed Inspections are designed to note only those types of defects likely to require routine maintenance rather than to establish general structural condition. They may point to the need to bring forward a CHART survey.

1.6.3 Maintenance Requirements

Maintenance Requirements are as stated in 1.1.4.

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1.7 Highway Drainage

1.7.1 General

In determining the Highways Agency's requirements two basic principles have been taken into account:

- (a) water reduces safety if allowed to accumulate on the trafficked surfaces of the highway;
- (b) the road pavement structure must be adequately drained in order to reduce maintenance liabilities and realise the design life of the road.

Whilst the effects of (a) are readily observable, those of (b) are not. The inspection procedures and frequencies laid down in 1.7.2 to 1.7.11 have been designed to allow, as far as possible, a correct assessment of the action that is necessary to keep the highway in a safe condition, and to avoid structural deterioration of the road pavement.

MAs have a duty to prevent nuisance to adjoining landowners by flooding.

MAs also have a responsibility to ensure that polluted effluent from clearing of highway drainage is not directed indiscriminately into watercourses.

Any Maintenance Requirements noted in the following paragraphs are in addition to those stated in 1.1.4.

1.7.2 Piped Drainage Systems

(a) General

The requirements of this section relate to minor repairs and treatment of defects within all types of piped drainage systems, including slot drains. Culverts, as defined in 1.7.8, are excluded.

A **record** of piped drainage systems excluding gully connections, slot drains and piped grip connections **shall be maintained** by the MA. The record, preferably in the form of layout plans, will supplement information held on the RMMS inventory by providing details of pipe runs. Ownership of the drainage systems should be established and indicated on the record.

If properly designed and constructed, piped drainage systems should be self-cleansing and maintenance should only become necessary when a blockage or other fault occurs. Those parts of a system that habitually give trouble should be known to the MA and will need to be inspected more frequently than normal.

Symptoms of blockage or faults that should normally prompt further investigation include: backing up and flooding at the entry points to the piped drainage system; dry outfalls; wet areas on verges; and the presence of lush vegetation.

(b) Inspection Requirements

Detailed Inspections of piped drainage systems shall normally be carried out **once every 10 years** unless the need for a greater frequency has been agreed with the Highways Agency as a local variation, or there is evidence of blockage or some other fault noted on safety inspections, or reports and complaints received from other sources.

Inspections shall be carried out using techniques appropriate to the nature of the drainage system. Methods of inspection which may be suitable include:

- (i) Pulling a mandrel through the pipe line: This may indicate if a pipe is broken, distorted, silted up or contains roots, but it will not distinguish between these defects;
- (ii) Flushing: Flushing pipelines is less informative than using a mandrel but will provide the best method of inspection in areas of subsidence and where the use of a mandrel is not appropriate;
- (iii) Inspection at catchpits and interceptors during or immediately following a period of prolonged rainfall: Measurement of the depth of water within the entries of pipes, in successive catchpits or interceptors along a drain-run will give an indication of whether there is any blockage or fault;
- (iv) Video inspection: This technique may be appropriate, although its use should generally be restricted to parts of the network having particular drainage problems.

Maximum use shall also be made of gully, catchpit and interceptor emptying and cleansing operations, and of their inspection procedures, to check that piped drainage systems are operating satisfactorily.

1.7.3 Gullies, Catchpits and Interceptors

(a) General

The requirements of this section relate to the removal of silt and other detritus from the traps of all types of highway gullies, catchpits and interceptors and, so far as possible, to an inspection of the condition of the items and their operation. They do not relate specifically to the inspection of frames and gratings (chapter 1.5) or to the cleansing of gratings (chapter 1.12), although these operations shall be carried out whenever emptying takes place.

A record of all gullies, catchpits and interceptors should be held on the RMMS database, together with required emptying frequencies.

(b) Inspection Requirements

Detailed Inspections of gullies, catchpits and interceptors shall be carried out at intervals of **1 year**. They shall be coordinated as far as possible with emptying and cleansing operations and, where applicable, with the detailed inspection of other items in the highway.

(c) Maintenance Requirements

Gullies, catchpits and interceptors shall be emptied **once per year**, although a need for a greater (or lesser) frequency may be established and agreed as a local variation. The frequency of cleansing of oil interceptors will depend upon their design and location, and should be given particular consideration.

Once the frequency of emptying has been decided, the exact timing of the emptying programme is a matter for determination by the MA, so that local factors can be taken into account as far as possible.

Silt and other solids arising from emptying and cleansing operations pose a potential threat of pollution and shall be disposed of in an appropriate manner, preferably to licensed tips.

1.7.4 Piped Grips

(a) General

The requirements of this section relate to repairs to piped grips (weirs or offsets), defined as short lengths of pipe, usually in rural areas, carrying water from a channel across the verge direct to a ditch, filter drain or soakaway, without a gully-pot, but sometimes with a grating. Where pipe lengths exceed 5 m the requirements in 1.7.2 shall also apply. Gratings, where fitted, shall be dealt with as set out in 1.7.3 and chapters 1.5 and 1.12.

The importance of piped grips should not be under-estimated. They have often been placed in position some time after road construction or re-alignment, at known sensitive drainage points and therefore deserve regular attention. The connecting pipe is usually laid close to the surface and is therefore prone to damage, which may in turn result in blockage. A waterlogged verge is often an indication of ineffective operation.

(b) Inspection Requirements

No specific **Detailed Inspection** regime is required for piped grips unless pipe lengths exceed 5 m, when the requirements for piped drainage shall apply. An extraordinary inspection may be required in response to Safety Inspections or other reports of blockage or faults.

(c) Maintenance Requirements

During the execution of cyclic maintenance of gullies, catchpits and interceptors, the opportunity shall be taken to check that piped grips are operating satisfactorily, and, where necessary, to carry out maintenance work. This check should include proving, by flushing or jetting with water, that the connecting pipe has sufficient fall and is not blocked.

1.7.5 Grips

(a) General

The requirements of this section relate to repairs to grips, defined as open channels cut across rural verges and leading to ditches or filter drains, ending at an appropriate distance from the carriageway or hard shoulder. The principles set out in 1.7.4 apply equally to grips.

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(b) Inspection Requirements

No specific **Detailed Inspection** regime is required for grips. An extraordinary inspection may be required in response to Safety Inspections or other reports of blockage or faults.

(c) Maintenance Requirements

Grips shall be re-cut cyclically not more frequently than **once per year**, except where it is agreed with the Highways Agency that a greater frequency is necessary as a local variation. This work should, as far as possible, be coordinated with other cyclic operations such as siding and gully emptying.

1.7.6 Ditches

(a) General

The requirements of this section relate only to clearing and minor repairs to ditches.

Within the boundaries of motorways, the maintenance of ditches is generally the responsibility of the Highways Agency, but this may not apply to connecting ditches outside the motorway. In the case of APTRs, ditches along older sections are more likely to be the responsibility of adjacent landowners or occupiers, while those on more recently constructed lengths (where land has been specifically purchased for the road), are likely to be the Highways Agency's.

Ditches can become overgrown with vegetation; silted up; blocked with debris, rubbish or bank erosion, to the extent that the flow is impeded. Water in a ditch is not itself harmful unless stagnation occurs (resulting in a health hazard), flooding is caused, or a resulting higher water table adversely affects the road or other structural foundations. There can also be the problem of nuisance to adjacent land users.

A record of all ditches is held on the RMMS database, together with required clearing frequencies.

(b) Inspection Requirements

Detailed Inspections of ditches shall be carried out at intervals of **5 years** unless a need for a greater frequency has been agreed with the Highways Agency as a local variation, or there is evidence arising from Safety Inspections of a fault in the intervening period, or reports and complaints are received outside the normal inspection procedures. They shall be co-ordinated as far as possible with clearing operations.

(c) Maintenance Requirements

Ditches, wherever practicable, shall be cleaned out by machine not more frequently than **once every 5 years**. Clearance at more frequent intervals shall be subject to the agreement of the RO as a local variation.

1.7.7 Filter Drains

(a) General

The requirements of this section relate to minor repairs to filter drains which may, or may not, incorporate a properly formed invert or collection pipe. If pipes are incorporated the requirements in 1.7.2 shall also apply.

Filter drains act as a drain for surface water run-off from carriageways, hardshoulders, verges, cutting and embankment slopes, and adjacent land. Separately, or in combination, they also control the ground water level below the road and other structures, adjacent verges and land outside the highway.

The efficiency of filter drains can be seriously impaired by the formation of a silt crust, with attendant vegetation growth, at the top of the filter material, or by the accumulation of trapped silt in the lower layers. Each defect can occur with or without the other.

The surface defect can be detected easily by inspection at ground level, but the deeper accumulations can only be confirmed by excavation, usually by means of trial pits. Where the drain performs the dual role of surface and sub-surface water collection, ponding at the surface will occur if defects are present. If there is no obvious surface defect, ponding will almost certainly indicate silt in the lower layer.

It is probable that, unless there is an obvious cause for a localised defect, a length of filter drain will show a consistent defect. The replacement of the filter media, by either new or cleaned existing material, will be a large enough job to warrant a special scheme, which should be part of the normal planned programme of works.

(b) Inspection Requirements

Detailed Inspections of filter drains shall not normally be carried out at the surface more frequently than **once every 5 years**, unless the need for a greater frequency has been agreed with the Highways Agency as a local variation, or there is evidence arising from Safety Inspections of existing or potential blockage or some other fault, or reports and complaints are received outside the normal inspection procedures. Detailed inspections of filter drains may involve excavation of trial holes if there is surface evidence of existing or potential blockage or some other fault.

Maximum use shall be made of gully, catchpit and interceptor emptying and cleansing operations, and inspection procedures, to check that filter drains are operating satisfactorily.

1.7.8 Culverts

(a) General

The requirements of this section relate only to examination for scour and the maintenance of free flow of water through culverts. Routine maintenance is therefore largely a matter of inspection and clearance when the need arises.

Larger culverts, as defined in Part 2, shall be inspected and maintained as highway structures, and are outside the scope of this Part.

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It should be noted that many culverts can tolerate some silting and vegetation growth before efficiency is impaired to the point where the culvert should be cleared. Grilles fitted across the ends of some culverts are however particularly prone to blockage, restricting free flow of water through the culvert.

(b) Inspection Requirements

Detailed Inspections of culverts shall be carried out at intervals of **1 year**, normally after winter.

1.7.9 Balancing Ponds

(a) General

The requirements of this section relate to repairs to balancing ponds. They do not relate to any associated feeder pipes or ditches, which are covered in 1.7.2 and 1.7.6 respectively.

Balancing ponds and associated feeder pipes, or ditches, are sometimes provided for flood control purposes where the storm run-off from highway surfaces is too rapid to be safely dealt with by the receiving water courses. This important provision and the need for maintenance can easily be overlooked, since the ponds are sometimes some distance from the highway. Flooding and/or damage to installations downstream of the pond can be a serious matter and maintenance should not be neglected.

The effectiveness of balancing ponds can be easily and seriously impaired, so particular attention should be paid to the following possible faults:

- (i) blockage of the feeder pipe or ditch;
- (ii) silting in the pond causing a loss of storage capacity;
- (iii) damage or erosion to the pond banks, walls or bunds;
- (iv) damage or obstruction to the pond outlet, which will affect the controlled rate of discharge.

A record of all balancing ponds is held on the RMMS database. Specific details of each pond, including capacity and means of access should be added to this record.

Balancing ponds may often become important sites for nature conservation. Prior to commencing any maintenance of a balancing pond, MAs should consult the RO, to ascertain whether inspection by an ecologist is required.

(b) Inspection Requirements

Detailed Inspections of balancing ponds with an outflow regulating device shall be carried out at **6 month** intervals, once in the spring and once in the autumn, unless it is agreed with the Highways Agency that a greater frequency is necessary as a local variation.

Detailed Inspections of balancing ponds with no outflow regulatory device shall be carried out at intervals of **2 years**, unless it is agreed with the Highways Agency that a greater frequency is necessary as a local variation.

1.7.10 Ancillary Items

(a) General

The requirements of this section relate to maintenance and repairs to ancillary drainage items including headwalls, aprons, sluices, tidal flaps, penstocks, valves and pumps.

A **schedule** of the more important ancillary items for highways drainage, including all sluices, tidal flaps and pumps, **shall be prepared and maintained** by the MA.

A complete drainage system may include many ancillary items and these should be inspected for erosion damage and operational efficiency. It is particularly important that sluices, tidal flaps and pumps operate as intended because a fault can result in extensive damage and flooding.

(b) Inspection Requirements

Detailed Inspection of headwalls, aprons and the like where associated with culverts, shall be carried out at the same time and at the same frequency as for culverts i.e. at intervals of **1 year**.

Those associated with piped drainage systems shall be carried out at the same time as piped drainage systems (see 1.7.2).

Detailed Inspection of sluices, tidal flaps and the like shall be carried out at intervals of **6 months**, once in the spring and once in the autumn.

Detailed Inspection of pumps and other specialised equipment shall be carried out in accordance with the manufacturers' recommendations.

(c) Maintenance Requirements

Maintenance of pumps and other specialised equipment shall be carried out in accordance with the manufacturers' recommendations.

1.7.11 Flooding

(a) General

The requirements of this section relate to flooding of the highway caused by the inadequate provision or operation of highway drainage facilities, by abnormally high river and tidal water or by inadequacies in the non-highway drainage system.

The advantages of an accurate, location referenced inventory system for gullies and other drainage items is further highlighted by the problems which are often experienced when dealing with flooding. Such drainage items are often submerged and may be the cause of flooding. Their easy location will help to speed relief and reduce the extent of the hazard and any related interference with traffic flow, claims and complaints.

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(b) Inspection Requirements

Additional **Safety Patrols** (see 1.1.6) shall be undertaken during or immediately after periods of very heavy/prolonged precipitation to identify areas which may be prone to flooding.

(c) Maintenance Requirements

Where flooding occurs, causing hazardous conditions, the appropriate warning signs shall be placed in position as quickly as possible.

The cause of the flooding shall be ascertained and given prompt attention, in order to restore the highway to a reasonable condition. Where it is determined that the flooding is attributable to inadequate infrastructure, given the nature of the weather conditions under which it occurred, the necessary action to permanently relieve the problem shall be the subject of a prompt report, and proposal for action, to the Highways Agency. If the cause is attributable to the actions of a third party, the matter should be taken up with them at the earliest opportunity.

1.8 Motorway Communication Installations

1.8.1 General

The motorway communications system is a national network providing emergency telephones and signals on all motorways in England.

The requirements of this chapter relate to the general maintenance of non-specialised electrical plant, its housings and surroundings, which form part of the system. Maintenance of the specialised electrical/electronic plant is undertaken by a specialist contractor under separate contracts let directly by the Highways Agency and falls outside the scope of this Part, although the duties of the MA includes undertaking the civil engineering works (e.g. cable-laying, traffic management) required to support the specialist contractor. The borders of responsibility of the MA and the Highways Agency's specialist contractor at each communications installation site shall be clearly defined and agreed with the RO.

The motorway is a single system in the context of the Electricity At Work Regulations. Before undertaking electrical inspections and tests it will be necessary to determine whether the motorway communications supply forms the primary supply or that of a subsystem. The boundaries must be clearly identifiable to all parties before work is undertaken and those responsible for the primary supply and subsystems must coordinate their activities to ensure that testing is undertaken without risk to personnel or unplanned disruptions of systems and services.

In the context of motorway communications it must be borne in mind that the systems have a high safety profile and provide emergency communications and signalling. The systems are self monitoring and the specialist maintenance contractors will be called out automatically to attend faults if power is interrupted. Arrangements must be made to coordinate activities and ensure that disruption is kept to a minimum. This will require coordination with the police and the specialist maintenance contractors. If necessary the RO should be consulted.

A record of all above ground communication installations is held on the RMMS database. In addition the MA shall **maintain record drawings** showing the location of communication cable runs and associated power cables. The MA shall also maintain record drawings giving details of the electrical supply and distribution to the communications installations. These record drawings shall be **reviewed and updated annually** and shall be **amended** whenever the cables are affected by any works.

Accurate records of communications installations are essential to ensure compliance with the Electricity at Work Regulations 1989, particularly in respect of ensuring safe digging practices are followed.

Detailed Inspection requirements for motorway communication installations have to be sufficiently rigorous to ensure that this emergency service is kept as fully operational at all times as is possible. The frequency of inspection, and response times, are therefore more onerous than for the majority of other items within this Part.

Although this chapter applies to motorways, increasingly communication installations are being extended to some parts of the APTR network. The frequencies of the inspection regimes for motorways shall be applied equally to APTRs, where these are the responsibility of the MA. The MA shall agree a schedule of communications installations on APTRs with the RO.

Any difficulties experienced in dealing with defects in communication installations shall be referred to the RO electrical engineer for advice.

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1.8.2 Inspection Requirements

The Highways Agency's RMMS Manual gives guidance on the items to be inspected and defects to be noted. Check lists are also programmed onto the DCDs used to record the inspections, enabling quick reference on site.

(a) Telephones

Detailed Inspection of all emergency telephone installations shall be carried out at intervals of **28 days** to ensure that they are accessible, that the telephone housing is correctly aligned and that the telephone identification number is visible.

The poles and housing shall receive a **Detailed Inspection** at intervals of **2 years** in respect of structural condition and surface protective finish.

(b) Matrix Signals

Detailed Inspections of signal lanterns and matrix signals shall be carried out for visibility including the legibility of the signal identification number at intervals of **3 months**.

All matrix signals mountings and posts shall receive a **Detailed Inspection** at intervals of **2 years** in respect of structural condition and surface protective finish.

(c) Motorway Communication Equipment Cabinets

Detailed Inspections of cabinet sites shall be carried out at intervals of **3 months** to check that drainage is adequate and installations appear weatherproof, to ensure that paths, steps and handrails provide safe, unobstructed access and to confirm external identification numbers are present. The cabinet doors should not be opened during this inspection.

The cabinets shall receive a **Detailed Inspection** at intervals of **2 years** in respect of structural condition and surface protective finish. Normally the cabinet doors should not be opened.

(d) Transmission Station Buildings and Sites

Detailed Inspections of the sites of transmission stations shall be undertaken at intervals of **3 months** to check for safe access.

Detailed Inspections of all transmission stations shall be carried out externally at intervals of **1 year** to check structural condition. In particular, attention should be paid to leaking roofs and badly fitting doors, to the operation of gutters and downpipes, and to accessibility and security (including fences and gates).

(e) Communications Cabling

No regular Detailed Inspections of communication cable runs are required.

Detailed Inspections to check the visibility of cable duct markers and cable joint markers shall be undertaken at intervals of **1 year**.

(f) Other Equipment (Variable Message Signs, Fog Detection, Ice Detection, Cameras etc.)

Detailed Inspection of the sites of other equipment shall be undertaken at intervals of **3 months** to check for safe access.

Detailed Inspections of associated poles and cabinets shall be carried out at intervals of **2 years** in respect of structural condition and surface protective treatment.

(g) Electrical Supplies

Detailed Inspections of all electrical supplies to communications installations shall be carried out at intervals of **1 year** by a competent person in accordance with the requirements of the Institution of Electrical Engineers Wiring Regulations and to the approval of the RO.

The MA shall maintain records of all such electrical inspections.

1.8.3 Maintenance Requirements

The following Maintenance Requirements are in addition to those stated in 1.1.4.

Defects to electrical installations which represent an immediate hazard (Category 1 defects) shall be protected or, whenever possible, made safe at the time of inspection. The defects shall be reported at the earliest opportunity, with a request for immediate action. Such action shall be arranged within the shortest possible time of the notification to the base office and in any case within a period of 24 hours.

Rectification of faults in the communications system due to breakdown or damage is the responsibility of the Highways Agency's specialist contractor but MAs should note the requirements of **1.2.4** in respect of emergency assistance to be given.

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1.9 Embankments and Cuttings

1.9.1 General

The requirements of this chapter only relate to inspection regimes and repair timescales for the routine maintenance of earthworks on trunk roads.

Guidance on failure modes and their identification and procedures for repairs are set out in the Highways Agency's Design Manual for Roads and Bridges, Volume 4, Section 1, HA 48/93, Maintenance of Highway Earthworks and Drainage (HA 48 (DMRB 4.1)).

A record of all embankments and cuttings, including height details, is held on the RMMS database.

Slopes at an early stage of instability can often be recognised by bulging of the slope profile (at the bottom of the potential slip), by development of tension cracks (at the top of the potential slip) or by evidence of water seepage from incipient slip planes. The presence of lush, greener or marsh type vegetation will often serve to identify seepage areas where water is not visible on the surface.

1.9.2 Inspection Requirements

Detailed Inspections of all embankments and cuttings shall be carried out at intervals of **1 year**, to check for any indication of slippages or rock slides. If evidence is found that the embankment, or the cutting, may be unstable in any way, a further inspection by a geotechnical specialist shall be requested to confirm the initial findings.

A **Detailed Inspection** of all embankments and cuttings shall be made by a competent person at intervals of **5 years** to check slope stability, in accordance with the guidance given in HA 48 (DMRB 4.1). These inspections shall be programmed, wherever possible, to follow periods of heavy rain, severe frost, or prolonged dry weather.

1.9.3 Maintenance Requirements

The following Maintenance Requirements are in addition to those stated in 1.1.4.

It is recognised that in cases where geotechnical investigations have to be undertaken and remedial works designed, it may not be possible to carry out effective permanent repairs within 28 days (see 1.1.4). Details of any design and analysis carried out in accordance with HA 48 (DMRB 4.1) will need to be retained for a specified period agreed with the Highways Agency.

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1.10 Landscape Maintenance (Grassed areas and scrub)

1.10.1 General

The requirements of this and the following chapter relate to the maintenance of all landscape and ecological elements within the Highways Agency's responsibility, to trees within falling distance of the highway and to hard surfaced areas that are to be maintained free from vegetation. DMRB Vol 10 provides advice on landscape and nature conservation issues. The Landscape Management Advice Note (DMRB vol. 10A) will give further advice on landscape maintenance when published.

Safety of the highway user is of prime concern but amenity, nature conservation and nuisance to others must also be considered. The design intention of landscape schemes, ie the landscape and ecological functions (formerly landscape objectives), must be taken into account and commitments made in Environmental Statements, at public consultation and at Public Inquiry must be honoured.

Expert advice from landscape managers should be sought to achieve the correct balance between safety, amenity, nature conservation and value for money. They will confirm when additional specialist advice is required. Where landscape management plans exist, they should be used to inform maintenance requirements as part of route management strategies. Where environmental databases exist they should be consulted before any work is carried out.

Named species and habitats are protected under UK and EC legislation and **all** highway works must comply. Where designated sites lie within or adjacent to the highway boundary, the soft estate should be maintained on the advice of English Nature or local wildlife trusts.

The Highways Agency is developing a Biodiversity Action Plan for the network to protect and enhance species and habitats. This will help to inform maintenance programmes in addition to delivering actions set out in the Government's species and habitat action plans and in local biodiversity action plans where they include highway verges.

Legislation requires that English Nature are informed where important habitats and species may be affected, such as removal of trees used as bat roosts. This should be done well in advance of the work to allow for seasonal factors.

Grassed areas and scrub

Vegetation must not restrict visibility at junctions, access points and bends. Sight lines and minimum stopping distances must be kept clear and signs, lights and marker posts must not be obstructed. **Visibility cuts** may be required in accordance with the appropriate Technical Directives.

Overhanging vegetation must not obstruct users of the highway or highway personnel carrying out inspections or surveys. One or two cuts a year in the form of a **swathe cut** may be sufficient to maintain verges for safety but amenity and nature conservation requirements must also be considered. Edging (siding) may be required on a cyclical basis.

Standards of maintenance should reflect the surrounding landscape. A higher standard of maintenance for amenity may be appropriate in built-up areas where housing and businesses front the highway and on important "port of entry" routes into England. The cost of removing cuttings may be prohibitive when balanced against traffic management but more frequent cutting can reduce costs where this is appropriate.

Highway verges that have developed botanical interest or nature conservation value, whether by design or through the development of the existing verge over time, should be managed to conserve and enhance the nature conservation value.

Weeds can cause problems if they spread prolifically and control methods may include the use of herbicides. The Control of Pesticides Regulations 1986 govern the use of pesticides and require that persons specifying and applying pesticides hold the appropriate certification.

The Highways Agency is committed to taking a proactive approach to controlling the **injurious weeds** which are covered by the Weeds Act 1959 and the Wildlife and Countryside Act 1981. Where injurious weeds on highway land are a nuisance to adjacent landowners, it is advisable to work with the adjacent landowner to ensure that weed control measures are undertaken simultaneously to avoid recontamination across the highway boundary.

Scrub species such as gorse and bramble can become a fire hazard as they mature and their removal may be necessary on safety grounds. Alternatively, where there is a nature conservation or amenity value, the plants may be cut back on a cyclical basis to maintain juvenile growth.

1.10.2 Inspection Requirements

Detailed Inspections

Grassed Areas – biannual inspections as a minimum

1.10.3 Maintenance Requirements

Visibility cuts – one or two cuts per year

Swathe cuts – one or two cuts per year

Grassed areas (including weed control) – to be advised by landscape manager

Injurious weeds – one treatment per year, or as advised by landscape manager

1.11 Landscape Maintenance (Hedges, trees and planted areas, wetlands and special ecological measures)

1.11.1 General

This chapter includes boundary hedges which remain the responsibility of the Highways Agency, individual street trees and planted areas. It also relates to the maintenance of wetlands for nature conservation and to special ecological measures.

Hedges, trees and planted areas

Where **hedges** were planted alongside a motorway fence, it was intended that they should be laid and maintained to produce a stockproof barrier, to replace the fence. This has seldom been carried out and the options include gaining access from adjacent land to repair the fence or laying and maintaining the hedge.

The Highways Agency is currently exempt from, but acts in the spirit of, the Hedgerow Regulations 1997, and where hedgerows are affected by our work, they should be protected. Where a hedgerow or part of a hedgerow has to be removed, it should be replaced and those which would qualify as "important" under the Hedgerow Regulations should be replaced as essential mitigation.

Trees are important for amenity and nature conservation reasons and should be preserved but they can be a serious hazard to highway users and adjoining land users if they are allowed to become unstable. The HA is also responsible for ensuring that trees outside the highway boundary but within falling distance are safe; all trees within falling distance are collectively termed "highway trees". Section 154 of the Highways Act 1980 empowers the HA to deal with hedges, trees and shrubs growing on adjacent land and which overhang the highway.

Inspections by highway maintenance personnel during the normal course of inspections can reveal evidence of damage to trees or signs of ill health and expert arboricultural advice should then be sought. All highway trees require an arboricultural inspection every five years but this period may be reduced on the advice of an arboriculturist.

It is important that arboricultural advice is obtained to advise on the appropriate frequency of inspections and works required for each individual street or mature tree. Trees which have to be removed should be replaced as close as possible to the original location. Whilst the HA is currently exempt from tree preservation orders (TPOs), some highway trees may be protected by a TPO and it is advisable to inform the local authority tree officer of intended works.

Planted areas may comprise native trees and shrub species on the inter-urban network, or non-native species in urban areas. Appropriate management techniques including thinning, coppicing and pruning will be required to achieve the design intention.

For older plots of trees where the original design intention is unknown, expert advice will be required to determine the most appropriate management techniques for the age and species mix of the plot, taking measures to minimise any adverse impacts on adjoining landowners and occupiers. In particular, thinning must be carried out with care where plots perform a screening function or have nature conservation value.

Legislation requires that English Nature are informed where important habitats and species may be affected, such as the removal of trees used as bat roosts. This should be done well in advance of the work to allow for seasonal factors. It is also advisable to inform the local authority or local residents in advance of works to remove trees. In some cases there may be other authorities which require notification before any work takes place.

Pest control

New planting schemes may be vulnerable to animal damage and will require protection. It is important that protection measures are maintained for as long as they are required. Rabbits are of particular concern to farmers on adjacent land. The Highways Agency is not covered by legislation, notably the Pests Act 1954, but the HA should take a proactive approach and work with adjacent landowners to carry out control methods simultaneously. The Highways Agency is not obliged to provide fencing to prevent rabbits moving onto adjacent land or to prevent recontamination across the highway boundary and the correct solution will be determined by site-specific requirements and value for money.

Plant diseases can cause extensive damage and expert advice will be required to determine the appropriate methods of control. Diseased plant material must be disposed of in accordance with horticultural best practice and, where a disease is notifiable, in accordance with MAFF's recommendations.

Wetlands

Drainage ditches and balancing ponds are increasingly being developed for their nature conservation value and maintenance must be carried out using techniques timed to be the least damaging to the flora and fauna. Expert advice from an ecologist should be sought to determine the correct methods and timing of maintenance works. Even where nature conservation was not a design objective, water bodies may develop nature conservation value. In cases where there has been no ecological survey since the last maintenance operation was carried out, or there has been no regular ecological inspection, the advice of an ecologist should be sought.

Special ecological measures

The HA has installed fencing to prevent deer and other animals crossing the highway, it has also provided measures such as badger tunnels and bat boxes, often as essential mitigation. These measures must be maintained so that they continue to be effective and meet the HA's commitments. Expert advice from an ecologist should be sought to determine the correct techniques and the timing of maintenance works. Where the HA is committed to monitoring special ecological measures, monitoring must be carried out by ecologists with the correct specialist knowledge.

Hard surfaced areas

Vegetation should be removed from areas of the highway such as hard central reserves by methods which are appropriate for the location, in accordance with the Control of Pesticide Regulations 1986. In areas where mechanical methods cannot be used for reasons of safety, herbicide applications may be the most cost effective method of control.

1.11.2 Inspection Requirements

Hedges, trees and planted areas – twice a year as a minimum; inspections of highway trees should be annual with arboricultural inspections at least every five years.

Wetlands – twice a year, or as advised by ecologist

Special ecological measures – twice a year, or as advised by ecologist

1.11.3 Maintenance Requirements

Pest control - as advised by landscape manager

Hedges and trees and planted areas – as advised by landscape manager; highway tree works to be advised by arboriculturist

Wetlands – as advised by ecologist

Special ecological measures – as advised by ecologist

1.12 Sweeping and Cleaning

1.12.1 General

Under the provisions of the Environmental Protection Act 1990: Code of Practice on Litter and Refuse, responsibility for the cleaning and sweeping of APTRs is transferred from MAs to district and borough councils. Sweeping and cleaning of motorways, and the APTRs listed in Table 1.12.1, will remain the responsibility of the Highways Agency and will continue to be dealt with by MAs.

Road No.	Description
A2	From its junction with the M2 Motorway (Junction 1) to its junction with the M25 Motorway (Junction 2).
A282	From its junction with the M25 Motorway (Junction 30) to its junction with the M25 Motorway (Junction 2).
A27	From the southern end of the A3(M) to its junction with the M27 Motorway (Junction 13).
A40(M)	From its junction with the A40 trunk road (Westway) to its junction with the A5 Edgware Road.
A56	From its junction with the M66 Motorway to its junction with the M65 Motorway (Junction 8).
A5103	From its junction with the M56 Motorway (Junction 3) to its junction with the M63 Motorway (Junction 9).

Table 1.12.1 All-Purpose Trunk Roads with Retained Litter Clearing Duties

Sweeping and cleaning of APTRs listed in Table 1.12.2 has been transferred back to the Secretary of State under Section 86(11) of the Act. Highways Agency has contracted out the sweeping and cleaning of these roads to Design Build Finance and Operate (DBFO) concessionaires.

The requirements of this chapter relate to the Highways Agency's responsibility under the Environmental Protection Act for the sweeping and cleaning of all channels and hardshoulders, clearing and removal of debris from traffic lanes, hardshoulders, verges and central reservations, removal of litter, and footway and cycle track sweeping.

It should be noted that there is nothing in the Environmental Protection Act that removes the responsibility of the Highways Agency to keep trunk roads safe for the travelling public. There will, therefore, be a continuing need for sweeping to be carried out by the Highways Agency's MAs (eg. dealing with shed loads, spillages and accident debris).

Road No.	Description
A1	From a point 350 metres south of its junction with the Great North Road at Alconbury to a point 280 metres north of the Fletton Parkway Interchange.
A1	From a point 520 metres south of the Old Great North Road at Micklefield to a point 1 kilometre north of the A64(T) Leeds Road.
A14	From a point 420 metres south east of its junction with Rusts Lane to its junction with the A1 trunk road.
A19	From its junction with the A168 road at Thirsk to the roundabout at the junction with the A185 county road immediately south of the southern entrance to the Tyne Tunnel.
A30	From its junction with the M5 Motorway (Junction 29) to its junction with the A35 trunk road at Honiton.
A35	From its junction with the A30 trunk road at Honiton to the western leg of the roundabout at the junction of A35 and A31 trunk roads north east of Bere Regis.
A50	From the boundary between the City of Stoke on Trent and the Borough of Stafford at the junction with the A521 county road to the junction with the A516 trunk road.
A66	From its junction with the A19 trunk road to a point 265 metres east of the overbridge to Teeside Retail Park in Stockton on Tees Borough Council.
A69	From its junction with the M6 Motorway (Junction 43) to its junction with the A1 trunk road (West Road Interchange).
A168	From a point 350 metres east of the county road overbridge located 650 metres east of the A1(M) bridge over the eastbound carriageway of the A168 trunk road at Dishforth to its junction with A19 trunk road at Thirsk.
A174	From its junction with the A19 trunk road at Parkway Interchange to the junction with the A1053 trunk road.
A417	From its junction with the A419 trunk road to the grade separated junction at Ordnance Survey Grid Reference 388500E, 217600N near M5 (Junction 11a).
A419	From its junction with the M4 Motorway (Junction 15) to its junction with the A417 trunk road.
A1053	From its junction with the A174 trunk road to its junction with the A1085 county road at Grangetown.

Table 1.12.2 All-Purpose Trunk Roads with Litter Clearing Duties contracted to DBFO concessionaires

1.12.2 Inspection Requirements

No Detailed Inspections shall be carried out and reliance shall be placed on the regular Safety Inspections and Safety Patrols (see Chapter 1.1) to decide when any special action needs to be taken.

1.12.3 Maintenance Requirements

The following Maintenance Requirements are in addition to those stated in 1.1.4.

Hardshoulders, verges, channels, central reservations and slopes shall be swept and scavenged as the need arises in order to achieve the standards of cleanliness set out in the Environmental Protection Act 1990: Code of Practice on Litter and Refuse. To achieve these standards the Highways Agency should respond to the accumulation of litter in a pro-active rather than a re-active way. This can be achieved best by a combination of programmed scavenges, as need dictates, to establish the overall cleanliness standard, and "black spot" scavenges in locations where the highway has become heavily littered as a result of other factors such as debris from vehicles or wind blown litter. If a particular source of wind blown litter can be identified then the owners should be requested to control their site more effectively.

Dealing with weed and vegetation growth in channels, which is likely to obstruct the flow of water or cause structural deterioration, does not fall within the scope of the Environmental Protection Act. Such growth should be treated in accordance with section 1.10.1(e).

Footways and cycle tracks associated with those APTR's listed in **Table 1.12.1** shall be swept as the need arises but not more frequently than **once per year** unless it is agreed with the RO that a greater frequency is necessary as a local variation.

Litter bins should be provided only at designated picnic sites and those lay-bys with toilets and/or picnic tables. Such sites that are the responsibility of the Highways Agency shall be scavenged as necessary.

Debris encountered by inspectors and other maintenance personnel in traffic lanes and on hardshoulders, and which constitutes an immediate hazard, shall be removed immediately, if reasonably practical. Otherwise road users shall be protected as far as possible. As a minimum, the aim should be to display notices warning of the hazardous conditions, before reporting at the earliest opportunity with a request for immediate action. Such action shall be completed within the shortest possible time, and in all cases within 24 hours.

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1.13 Safety Fences and Barriers

1.13.1 General

The requirements of this chapter relate to repairs to all types of vehicle safety fences and barriers and to pedestrian guard rails. They do not relate to parapets and guard rails on bridges and other structures, which are outside the scope of this Part.

Maintenance of safety fences and barriers is generally confined to the repair of damaged sections and ensuring correct assembly and operation. The repair of damaged sections will usually be instigated by Safety Inspections or reports from other sources and will require prompt attention in view of the likelihood of danger to road users. Maintenance Requirements are therefore more onerous than for the majority of other items within this Part.

1.13.2 Inspection Requirements

Detailed Inspections of all steel and wire rope **safety fences** shall be carried out at intervals of **2 years** in respect of mounting height, surface protective treatment and structural condition.

Detailed Inspections of **pedestrian guard rail** shall be carried out at intervals of **2 years** in respect of surface protective treatment and structural condition.

Detailed Inspections of **concrete barriers** shall be carried out at intervals of **2 years** in respect of height and structural condition.

1.13.3 Maintenance Requirements

The following Maintenance Requirements are in addition to those stated in 1.1.4.

Tensioning bolts of steel tensioned safety fences shall be checked and reset to the correct torque every **2 years**, preferably in conjunction with the Detailed Inspection.

Damaged sections of safety fences and barriers shall be treated as **Category 1** defects unless damage is clearly superficial with no loss of integrity of the safety fence/barrier. Permanent repairs shall be carried out as soon as possible and in any case within **7 days**.

Sections of safety fence that are found to be mounted at heights outside the limits specified in **Annex 1.13.1** or for which the structural integrity is in doubt, should be treated as **Category 2** defects.

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Annex 1.13.1

Mounting Heights for Safety Fence

The specified limits of the mounting heights for the various forms of safety fence, outside which a defect shall be recorded, are as follows:

(Note that these limits are not necessarily identical to the tolerances for new construction).

- (a) Tensioned Corrugated Beam, Open Box Beam and Rectangular Hollow Section Safety Fences;
535 mm to 685 mm to the centre of the beam
- (b) Untensioned Corrugated Beam Safety Fence;
 - (i) 500 mm to 560 mm to the centre of the beam (when the safety fence was erected to a nominal height of 530 mm to centre of the beam).
 - (ii) 535 mm to 685 mm to the centre of the beam (when the safety fence was erected to a nominal height of 610 mm to the centre of the beam)
- (c) Inclined Tensioned Corrugated Beam with Off-Set Brackets;
655 mm to 715 mm to the top edge of the beam.

(Note that this design of safety fence is no longer included in the Highways Agency's standard types of safety fence).

- (d) Wire Rope Safety Fence;
575 mm to 595 mm to the centre of the upper pair.

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1.14 Fences, Walls, Screens and Environmental Barriers

1.14.1 General

The requirements of this chapter relate to repairs to all types of fences (excluding safety fences), walls, anti-glare screen fences and environmental barriers which are the responsibility of the Highways Agency. They do not relate to vehicle parapets and pedestrian parapets on bridges and other structures, including the structural elements of environmental barriers, which are outside the scope of this Part. They do not relate to retaining walls of retained height greater than 1.5 m, which are covered in Part 2.

A record of all fences, walls, screens and barriers is held on the RMMS database.

The replacement of steel, concrete, and timber elements made necessary as a result of long term deterioration is not covered by this Part, but the requirements for Detailed Inspections are included to provide a means of identifying the need for a replacement scheme.

In general the decision to fence land rests with the owner and occupier of the land fronting onto the highway, although in most locations he will be liable in negligence if damage is caused by his animals straying onto the highway.

The Highways Agency on the other hand has no general obligation to fence off its highways, although there is a power to fence highways in Section 80, as modified, of the Highways Act 1980. Any fencing along the boundaries of APTR is therefore generally the responsibility of the adjoining landowner/user, following any agreed maintenance period after installation on new schemes. In some circumstances however fencing for the protection of wildlife may remain the property of the Highways Agency.

Motorways, because of their special status and high-speed characteristics, require a different approach to avoid the hazard to traffic presented by trespassers and wandering animals. It is the Highways Agency's practice to accept responsibility for the construction or erection and maintenance of the fencing along its motorway boundaries. This does not necessarily absolve the adjoining landowner/user from his statutory obligations under the Animals Act 1971.

Although it is the Highways Agency's practice to provide and maintain adequate fencing, it does not accept responsibility for alterations to the fence necessitated by adjoining landowners/users changing their requirements after installation. In those circumstances it is for the landowners/users to provide and maintain any additional rails/netting/wire needed to prevent the egress of animals onto the highway.

However, in the interests of safety, MAs are expected to use discretion about carrying out minor/temporary repairs on any part of the fence added by the landowner/user, where such parts are found to be defective as a result of inspection, or reports from the police or public. Serious defects should normally be reported to the landowner/user with a request for them to be rectified. If, in the interest of safety, repairs need to be carried out immediately, the MA should carry out the necessary work and make a request to the landowner/user for reimbursement of any substantial expenditure incurred.

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In areas where hunts occur the Highways Agency normally permits the person responsible for the hunt to attach wire mesh additions to the usual type of post and rail fence to help keep foxes and hounds off the motorway. Maintenance of such additions is entirely a matter for those persons. Any serious breaks or defects in such additions, encountered in the course of inspections, should be brought to the attention of persons responsible for the hunt.

Fences designed for other special purposes, such as security of goods or the protection of traffic from sporting activities, and installed by the owners on land adjoining the motorway boundary, remain their responsibility, but any serious defects should be drawn to the attention of the owner.

1.14.2 Inspection Requirements

Detailed Inspections shall be carried out in respect of integrity, and where appropriate stockproof qualities, at intervals of **6 months**, as far as possible during the course of inspection of other highway items. A higher frequency may be necessary in some locations; (eg. in built-up areas where vandalism is known to be likely). Such higher inspection frequencies shall be subject to the agreement of the RO as a local variation.

Detailed Inspections shall be carried out at intervals of **2 years** in respect of structural condition.

1.14.3 Maintenance Requirements

Maintenance Requirements are as stated in 1.1.4.

1.15 Road Studs

1.15.1 General

The requirements of this chapter relate to reflective and non-reflective road studs of all types and colours, including stainless steel studs originally installed as CHART node markers before the cored thermoplastic type (see Volume 1).

To be effective, all types of road studs must be firmly fixed and remain at the correct level. Reflecting types must retain their reflectivity. All studs depend on a degree of trafficking to keep lenses clean but the the lenses can become dirty, or obscured by deposits of detritus, and can become less effective by becoming more deeply embedded in the road surface. A depressible stud has an insert which wipes the lens as it is depressed while a non-depressible stud relies purely on the tyre rolling over it.

Road studs which become loose or displaced are further defects which need maintenance attention. Road studs can lose adhesion and break up under severe stress from vehicle wheels and as a result of snow clearance activities. In the case of depressible road studs, lenses can become detached from the depressible insert, the insert can be detached from the housing or the housing can become loose in its seating and subsequently removed by the action of vehicle wheels. Although this removal is rare in relation to the numbers of this type of road stud fixed in carriageways, its occurrence can have serious consequences. However, evidence suggests that the Highways Agency's current specification for the installation of depressible road studs, which is based on the specification of the appropriate manufacturer, is adequate, and displacement has generally occurred where installation has not been as specified, or the base had been installed to a previous specification.

Inspection of all road studs for looseness is virtually impossible in terms of both scale and practicability, particularly in those traffic conditions where displacement is more likely to occur. The Highways Agency's requirements are that Detailed Inspections for this purpose should, wherever possible, be carried out when lane closures for other activities are in operation. Where displacement is beginning to occur in significant groupings, indicative of a general fault condition, specific closures for road stud inspection should be arranged.

1.15.2 Inspection Requirements

Detailed Inspections for reflective conspicuity shall be carried out at intervals of **1 year** during the hours of darkness and where possible at the same time as other similar inspections for road and sign lighting, and reflective road markings and signs. Inspections shall be programmed to enable maintenance works to be completed before the onset of winter (see 1.15.3).

Detailed Inspections for defective or missing road studs shall be carried out at intervals of **1 year** in conjunction with the inspection of other carriageway items.

Defects relating to the general condition of road studs are likely to be detected in the first instance by Safety Inspections.

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1.15.3 Maintenance Requirements

The following Maintenance Requirements are in addition to those stated in 1.1.4.

Displaced road studs lying on the carriageway, hardshoulders or lay-bys and loose road studs, if judged to be a hazard, shall be removed immediately if reasonably practicable. Otherwise road users shall be protected as far as is possible. As a normal minimum, the aim should be to display notices warning of the hazardous conditions before reporting the defect at the earliest opportunity with a request for immediate action to make the defect safe. Such action, including the filling of any cavities left following removal of the road studs, shall be completed within the **shortest possible time** and in any case within **24 hours** of notification.

Replacement of defective or missing road studs associated with road markings shall be carried out when there is greater than **25% loss** on straight or large radius curves, or greater than **10% loss** on bends. Replacement shall be completed within **3 months** of the appropriate defect threshold being exceeded, or within **24 hours** if the road studs are required to maintain the legality of prohibitory road markings.

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1.16 Road Markings

1.16.1 General

The requirements of this chapter relate to inspection regimes for the routine maintenance of road markings in paint or thermoplastic materials on trunk roads.

The inspection and maintenance requirements for road markings, which are summarised below, are set out in the Highways Agency's Design Manual for Roads and Bridges, Volume 8; TD26/86, Maintenance of Road Markings. Guidance on aspects to be inspected and defects to be noted are also given in the Highways Agency's RMMS Manual.

To be effective, road markings must not be obscured by erosion; they should not have spread appreciably from the original size; they must retain colour; they must have adequate skidding resistance; and, where appropriate, retroreflectivity. Where defects occur these will not always be apparent as a result of visual inspection and, if circumstances warrant, it may be necessary to carry out specific tests as laid down in TD26/86 to ascertain the condition of the markings.

Many road markings are used to give effect to regulatory provisions; it is important that their legal status is not affected by undue wear or damage.

1.16.2 Inspection Requirements

Detailed Inspections in respect of wear, spread, colour, skid resistance and retroreflectivity shall be undertaken at intervals of **1 year** for paint markings and **2 years** for thermoplastic markings.

Inspections for adequacy of reflective conspicuity shall be carried out during the hours of darkness and should be combined with other similar inspections for road and sign lighting, where practical.

Inspections shall initially be visual and condition shall be assessed against the criteria set out in TD 26/86. Any suspect areas identified by the visual inspections shall be noted and further testing as described in TD 26/86 shall be instigated.

1.16.3 Maintenance Requirements

Maintenance Requirements are as stated in 1.1.4.

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1.17 Road Traffic Signs

1.17.1 General

The requirements of this chapter relate to routine inspection and cyclic maintenance of permanent road traffic signs, including bollards, on trunk roads.

The inspection and maintenance requirements for road traffic signs, which are summarised below, are set out in the Highways Agency's Design Manual for Roads and Bridges, Volume 8; TD25/86, Maintenance of Traffic Signs. Guidance on the items to be inspected and defects to be noted are given in the Highways Agency's RMMS Manual.

A **schedule** of permanent traffic signs including details of any lighting is held on the RMMS database.

Satisfactory performance of a traffic sign can usually be achieved for a considerable period after erection. Routine maintenance procedures promote the continued effectiveness of the sign and monitor any deterioration in performance.

Many signs are required to be lit and their legal status is affected if the illumination has failed; it is important that such failures are detected and rectified promptly.

1.17.2 Inspection Requirements

Detailed Inspections shall be carried out **after dark**, at intervals of **28 days** to detect lamp failure and defects in the operation of photo-electric control units, detectors or timing control devices.

Detailed Inspections of moving parts of variable message signs and to detect obscuration of signs by foliage shall be undertaken at intervals of **1 year**.

Detailed Inspections of the security and efficiency of electrical installations shall be carried out at intervals of **2 years** by a qualified electrician.

Detailed Inspections shall be carried out at **5 years** after expiry of the maintenance period applicable to installation of the sign and thereafter at intervals of **2 years** in respect of:

- a) Target distance (in daylight and after dark)
- b) Legibility distance (in daylight and after dark)
- c) Average surface luminance (after dark)
- d) Surface colour (in daylight and after dark)
- e) Retro-reflectivity (after dark)
- f) Surface protective finish to posts and other structural condition
- g) Security of brackets, bolts and other fittings

All inspections of sign faces shall be made after the signs have been cleaned.

Inspections shall initially be visual and condition shall be assessed against the criteria set out in TD25/86. Further inspection methods, as described in TD25/86, may also be appropriate and shall be initiated where suspect areas are identified.

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1.17.3 Maintenance Requirements

The following Maintenance Requirements are in addition to those stated in 1.1.4.

Signs shall be **cleaned** at intervals agreed with the RO, to suit inspection frequencies and not exceeding **3 years**.

Moving parts of variable message signs shall be cleaned and lubricated once per year, at the time of inspection.

Brackets, bolts and fittings shall be tightened and adjusted at the time of inspection.

Sign luminaires shall be cleaned once per year.

Bulk lamp changes shall be carried out at intervals appropriate to the type of lamp used.

Defects affecting the legality of regulatory or mandatory signs shall be treated as **Category 1**.

Missing traffic cylinders across gaps in the central reserve safety fence at emergency crossing points on dual carriageways shall be treated as **Category 1** defects.

1.18 Road Traffic Signals

1.18.1 General

The requirements of this chapter relate to the routine maintenance of permanent traffic signal installations at junctions, or outside emergency vehicle stations, and at controlled pedestrian crossings, on trunk roads.

The inspection and maintenance requirements for road traffic signal installations and equipment, which are summarised below, are set out in the Highways Agency's Design Manual for Roads and Bridges, Volume 8; TD24/86, Maintenance of Traffic Signals.

Modern signal equipment is expected to operate correctly without regular routine adjustments. The purpose of the inspection regime is to detect defects, which might lead to failure or which might otherwise render installations ineffective, in order to keep traffic signal installations as fully operational at all times as is reasonably possible.

Some MAs will carry out the specialised maintenance on traffic signal installations themselves, others will rely on specialised contractors. In the latter case it is important to make sure that the contract reflects the Highways Agency's requirements.

Traffic signal installations may be equipped with remote monitoring facilities for certain aspects of operation, enabling more frequent inspection without the necessity for site visits. The required inspection intervals reflect the capabilities of these systems.

1.18.2 Inspection Requirements

Detailed Inspections in respect of operation of traffic signal installations shall be carried out at the intervals specified in **Table 1.18.1**.

Detailed Inspections of the physical condition of controller and auxiliary equipment cabinets, and of other site hardware shall be undertaken at intervals of **1 year**.

Detailed Inspections in respect of electrical safety shall be carried out at intervals of **5 years**.

Guidance on aspects to be inspected and on defect criteria is given in TD24/86.

Inspections shall be visual, by remote monitor or by approved test equipment as detailed in TD24/86.

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INSPECTION ASPECT	INSPECTION INTERVAL			
	With Remote Monitoring		Without Remote Monitoring	
	>30 mph road	30 mph road	>30 mph road	30 mph road
Power supply (or fuse) failure Failure of signals to change Lamp Failure Detector fault monitor failure Lamp dimming failure Inter-green, green time settings	24 hours	24 hours	1 month	3 months
Detector operation Signal lamp operation Controller operation Push-button operation Wait lamps operation Audible warning unit operation Red lamp monitor operation Cable-less link units and local links	1 month	1 year	1 month	3 months
Operation/illumination of regulatory and variable message signs	1 month	1 month	1 month	1 month
Operation of speed assessment / discrimination equipment	1 month	-	1 month	-

Table 1.18.1 Inspection Intervals for Traffic Signal Installation Operation

1.18.3 Maintenance Requirements

The following Maintenance Requirements are in addition to those stated in 1.1.4.

Bulk changes of **lamps** in signals and in push button units shall be carried out every **6 months**. Lamps in regulatory or variable message signs associated with signal installations shall be changed at intervals appropriate to the type of lamp and the mode of operation of the sign.

Electro-mechanical parts of controllers shall be adjusted or replaced at intervals of **1 year** or in accordance with the manufacturer's recommendations if a shorter interval is specified.

Signal lenses, regulatory signs and variable message signs shall be **cleaned** at intervals of **1 year**, coordinated with bulk lamp changes where practical.

Defects in operation of traffic signal installations shall be treated as **Category 1**.

Permanent repairs of **Category 2** defects in traffic signal installations shall be carried out within **6 weeks**.

1.19 Road Lighting

1.19.1 General

The requirements of this chapter relate to the routine maintenance of road lighting installations on trunk roads.

The following Maintenance Requirements are in addition to those stated in 1.1.4.

Requirements and guidance for the inspection and maintenance of road lighting, are set out in the Highways Agency's Design Manual for Roads and Bridges, Volume 8; TD23, Inspection and Maintenance of Road Lighting.

High masts, masts, structural wires and supporting attachments of catenary lighting systems are not covered by this Part.

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TRUNK ROAD MAINTENANCE MANUAL : VOLUME 2
ROUTINE AND WINTER MAINTENANCE CODE

PART 2 - ROUTINE MAINTENANCE OF HIGHWAY STRUCTURES

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2.1 Introduction

2.1.1 Background

This Part is introduced in order to formalise the procedures for routine maintenance of highway structures and to ensure that vital maintenance functions are carried out regularly. It sets out those operations, and their frequency, which are to be undertaken as routine maintenance and follows on from the recommendations of the Performance of Concrete in Bridges (Maunsell, 1989). The maintenance requirements specified will not necessarily be comprehensive but are nevertheless intended to provide sufficient guidance to enable MAs to develop the schedules described in 2.1.3.

Many of the tasks listed in this Part are fairly minor in themselves, but failure to carry them out may lead to deterioration of the structure, and the need for more serious and costly repair operations in the future. Generally, it is considered cost effective in whole life terms, to undertake timely routine maintenance. It forms an important component in developing a coherent ongoing bridge management strategy.

The maintenance requirements are grouped by structure type rather than by activity. This philosophy has been adopted in order to be consistent with the structure led inspection, record and bid strategy of the Highways Agency and because this is the way in which most Agents tend to plan routine maintenance works.

2.1.2 Routine Maintenance

The items of routine maintenance given in the subsequent chapters should be regarded as those which relate to servicing rather than repair and which will usually be undertaken regularly at pre-determined intervals.

Routine maintenance does not cover the repair or renewal of structural elements or components which have become unserviceable because of general wear and tear or have deteriorated for other reasons. Such work should be identified during the regular inspection process, and should be included in a planned structural maintenance programme.

2.1.3 Routine Maintenance Schedules

Maintenance Agents (MAs) should identify those items of routine maintenance which are appropriate for each particular structure, and prepare a **schedule** of operations which **should be agreed** with the Highways Agency (see **Annex 2.1.1**). Reference should be made to the Structure Maintenance Manual to ensure that any specific requirements are incorporated. This will be particularly necessary for large and complex structures and components. The schedule should be appended to the Maintenance Manual and will remain valid until an element or component is replaced or modified, or a particular need develops. Any need for a revision should be agreed with the Highways Agency.

For newly constructed structures, routine maintenance schedules should be prepared by the MA in association with the handover or initial principal inspection. Any special arrangements or requirements for routine maintenance should be included in the Maintenance Manual by the bridge designer. Schedules for existing structures can often usefully be prepared in association with programmed inspections.

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2.1.4 Routine Maintenance Frequencies

The frequencies with which routine maintenance operations are to be carried out are described in each chapter. The specified intervals shall be treated as recommended guidelines, but be adhered to as closely as possible, although it is appreciated that in order to plan the works efficiently slight variance from target dates may be necessary.

The specified frequencies may not be appropriate in all circumstances and may need to be modified to take account of local conditions and the needs of individual structures, eg. by reducing maintenance intervals. Such **local variations** shall be subject to the **approval** of the **Highways Agency's Regional Office (RO)**. Approval will only be given where the need for such a variation is **clearly** justified.

If there is a need to carry out routine maintenance operations more frequently than the recommended intervals (eg.drains regularly block), consideration should be given to the implementation of capital maintenance works, to reduce the necessity for such frequency. It may also be appropriate to combine routine maintenance operations with other works or bridge inspections, to minimise traffic management costs and delays.

2.1.5 Finance

This Part will form the basis for the Bidding and subsequent Allocation of funds for the routine maintenance of highway structures on both motorway and all-purpose trunk roads (APTRs).

Bids and Outturns should be included in Current Works Item 1: Routine Maintenance, (see Volume 1, Chapter 2.8).

2.1.6 Inspection

This Part does not incorporate requirements for inspection and therefore differs significantly from Part 1, covering routine maintenance of highways. The inspection of the structural elements of bridges and other highway structures is contained in the Highways Agency's Design Manual for Roads and Bridges, Volume 3; BD63, Inspection of Highway Structures. The inspection of the non-structural elements of subways, underpasses, underbridges and overbridges (e.g. footways, lighting and road drainage items) for which the Highways Agency is responsible should be carried out in accordance with the requirements of Part 1.

During the routine maintenance operation, MA's staff should be mindful of the requirement in BD63 to carry out superficial inspections and any defect representing an immediate or imminent hazard should be treated with the same priority as Category 1 defects in highways, as defined in Part 1 (see 1.1.4).

2.1.7 Maintenance Responsibilities

(a) Overbridges

The MA is responsible for the maintenance of all structural elements below and including the waterproofing membrane together with the parapet and any protective safety fence.

If a road carried by an overbridge is a trunk road then the Highways Agency's MA is also responsible for the inspection and maintenance of the highway elements in accordance with the requirements set out in Part 1.

If the road carried is not a trunk road then the maintaining authority for that road will be responsible for the highway elements (see also 2.3.3).

(b) Underbridges

If a road through an underbridge is a trunk road the Highways Agency's MA is also responsible for the highway elements of that road.

If a road through an underbridge is not a trunk road then the maintaining authority for that road will be responsible for its highway elements.

(c) Subways

The MA is responsible for the maintenance of structural elements of the subway.

The maintaining authority for the footway through the subway is normally responsible for all items of routine maintenance which relate to the finishings, footway surfacing and drainage and lighting. Failure to carry out regular maintenance of these items would not normally prejudice the structural integrity of the subway. However particular attention is drawn to the maintenance of drainage pumps in subways (and also underpasses). The responsibility for such maintenance should always be clarified by the MA in consultation with the Regional Office, and details included in the Maintenance Manual for the structure. Where it is the responsibility of the Highways Agency, arrangements should be made via the MA for regular servicing, and where it is not, the Highways Agency and MA shall ensure that the appropriate person or organisation is aware of their responsibilities.

(d) Footbridges

The MA is usually responsible for routine maintenance of all items on the footbridge, including those which on an overbridge would be deemed highway elements. However there may exceptionally be a special agreement with a local highway authority or other party, for maintenance of footbridge surfacing and/or lighting on the bridge. The maintenance responsibility should be clarified by the MA in consultation with the Regional Office and included in the Maintenance Manual for the structure.

(e) Retaining walls

The ownership and maintenance responsibility for all retaining walls should be clarified by the MA in consultation with the Regional Office, and included in the Maintenance Manual for the structure. Where this is the responsibility of the Highways Agency, then the MA shall arrange for all necessary routine maintenance to be undertaken. Where it is not, the Highways Agency and MA shall ensure that the appropriate person or organisation are aware of their responsibilities.

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(f) Special structures

Such structures include drainage sumps and chambers, service buildings with electrical and mechanical equipment, sign/signal gantries, high masts for lighting, television cameras and catenary lighting systems. The MA will be responsible for all routine maintenance.

2.1.8 Health and Safety

MAs shall ensure that all operations associated with routine maintenance of highway structures are undertaken in accordance with current Health and Safety legislation.

It should be noted that many structures, or parts of structures, will be classified as confined spaces. Common examples include culverts, box girders, bearing chambers and areas such as the access space below large expansion joints. For entry into confined spaces it will be necessary for MAs to prepare a Permit to Work in each case and introduce access procedures which have been developed to accommodate Health and Safety requirements.

Special procedures and requirements will apply to all routine maintenance work involving electrical and mechanical equipment, and reference should also be made to TRMM Volume 2 Chapter 1 dealing with the Routine Maintenance of Highways.

2.1.9 Scope

Highway structures falling within the scope of this Part are:

- (a) all structures of greater than 3 m span, over, under or alongside the Highways Agency's roads except:
 - (i) structures carrying railways
 - (ii) privately-owned structures;
- (b) culverts 1.8 m to 3 m span, or multi-cell culverts where the cumulative span is greater than 5 m, if their cover to road surface is less than 1 m;
- (c) corrugated metal culverts 0.9 m or more in span;
- (d) pedestrian subways, irrespective of span and cover to road surface;
- (e) retaining walls with a retained height of 1.5 m or more measured above finished ground level in front of the wall.
- (f) sign signal gantries, high masts for lighting, television cameras and catenary lighting systems;
- (g) highway tunnels, major or complex/moveable structures which may incorporate mechanical and electrical equipment and operators. These structures should have their own special and specific requirements for routine maintenance set out in a comprehensive manual.

2.1.10 Graffiti

It may be necessary to remove graffiti at more frequent intervals than detailed in the following chapters. The Highways Agency's policy is to remove obscene, blasphemous or offensive graffiti as soon as practicable after it has been observed. However discretion is required in the handling and timing of the removal of other graffiti. Non-contentious graffiti shall be removed at the intervals prescribed in the following chapters, or in combination with other work, where appropriate.

Where graffiti is persistent and widespread in environmentally sensitive areas, consideration shall be given to alternative options, other than frequent removal or obliteration. Possible strategies are initiatives involving local schools, Neighbourhood Watch, local councils and the Police. Physical measures include the use of anti-graffiti coatings, special cleaning materials, gritblasting, and the provision of alternative surfaces such as tiling, and murals. Care must be taken to ensure the compatibility of applied materials and cleaning techniques, with the structural substrate, and to avoid surface deterioration. The remedial action should not encourage further graffiti. Eg. overpainting with light coloured coatings is often seen as providing a 'new blank canvas'. More information is provided in 'The Appearance of Bridges and other Highway Structures' published by the Highways Agency.

In difficult or sensitive cases the MA must consult with the Regional Office.

2.1.11 Contractual Arrangements

For new Maintenance Agency areas, routine maintenance for structures is included within the remit of the Term Maintenance Contract. It may also be necessary to arrange separate contracts for specialist works.

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**Annex 2.1.1
Routine Maintenance Schedule**

Structure Name : Mill Bridge

Structure No : A909/56.50

MA (BARSETSHIRE)

ST Key : 99999

Maintenance Due : April 1994

MA Code : 2010

Region Code : 9900

Routine Maintenance Interval : 12 months

MA Structure Ref : B006

Activity No.	Chapter No.	Activity	Date Carried Out	Remarks
1	2.2	ABUTMENTS, CENTRE PIER : Remove graffiti	25.4.94	<i>Systems checked and working</i>
2		Remove vegetation	25.4.94	
3		Clear debris from bearing shelves	25.4.94	
4		Rod outlet pipes and check operation	25.4.94	
5		Clear drainage channels	25.4.94	
6		Repair joint sealant		
7	2.2	WING-WALLS : Remove graffiti	25.4.94	<i>Chestnut seedling removed, NE wall</i>
8		Remove vegetation	25.4.94	
9		Rod weep pipes, remove silt, debris	25.4.94	
10		Repair joint sealant	26.4.94	
11	2.3	BEAMS : Check fascia panels	25.4.94	<i>All secure</i>
12	2.4	DECK DRAINAGE : Clean and check operation	27.4.94	<i>Little debris present</i>
13	2.4	METAL PARAPETS : Tighten any loose nuts	27.4.94	<i>10 No. nuts tightened, E parapet</i>
14	2.4	BEARINGS : N. Abutment - clean, regrease rollers	25.4.94	<i>Severe rusting, reported to base</i>
15		S. Abutment - clean	25.4.94	
16		Pier - clean, regrease rollers	25.4.94	

Sheet No. 1 of 1

Explanatory Notes

Annex 2.1.1 is an example of a completed schedule which should be drawn up by MAs after referring to the Bridge Maintenance Manual. This schedule should be agreed with the Highways Agency and form part of the records for that structure. On completion of each routine maintenance cycle, a copy of the schedule should be completed and sent to the Highways Agency.

It is envisaged that separate pages will be prepared for each discreet Routine Maintenance Interval.

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2.2 Retaining Walls and Bridge Substructures

2.2.1 General

The routine maintenance requirements for retaining wall and bridge substructure elements are given below.

2.2.2 Piers, Abutments, Wing-Walls, Retaining Walls, Reinforced Earth Walls and Crib Walls

(a) Maintenance Requirements

Remove graffiti.

Remove any vegetation from the structure.

Clear debris from bearing shelves.

Clean drainage channels.

Rod outlet pipes to ensure effective operation and check on completion.

Clear drainage outlet manhole chambers.

Rod weep pipes and remove silt and debris.

Check operation of flap valves and grease where required.

Repair gap sealant to movement joints.

Check pedestrian protection measures.

Note: Access restrictions may prevent the effective rodding of all drainage pipes. This phenomenon must be recorded in order that the MA can assess the longer term maintenance implications of such a problem.

(b) Maintenance Interval

12 months.

(c) Time of Maintenance

All drains should be cleared after leaf fall and be working properly before the winter starts (December). All vegetation should be cleared before the growing season (April). In some areas it may be more appropriate and effective to spray the vegetation with a suitable chemical compound when growing strongly. Glyphosphate has been found to be effective in such situations.

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2.2.3 Columns

(a) Maintenance Requirements

Remove graffiti.

Remove debris and bird droppings.

(b) Maintenance Interval

12 months.

2.3 Bridge Superstructures

2.3.1 General

The routine maintenance requirements for bridge superstructure elements are given below. The works required are limited in nature because most will be categorised minor or major maintenance. It is therefore particularly important to ensure that routine maintenance work on adjacent structures is co-ordinated to maximise the use of any access plant and traffic management measures which are required.

2.3.2 Steel Beams, Girders, Trusses, Concrete Beams and Fascias

(a) Maintenance Requirements.

Remove graffiti.

Remove debris and bird droppings from flanges.

Clear drainage holes for box sections.

(b) Maintenance Interval

12 months.

2.3.3 Deck Carriageway, Verge and Parapet Cantilever

(a) Maintenance Requirements

Notwithstanding the advice given in 2.1.7(a) grass and weeds should be removed from verges and channels where their presence is considered to be detrimental to the satisfactory performance of the structure.

Repair gap sealant to movement joints

(b) Maintenance Interval

12 months

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2.4 Components

2.4.1 General

The routine maintenance requirements for common structural elements are given below. Additional requirements for more complex components will be specified in the Structure Maintenance Manual.

2.4.2 Expansion Joints

(a) Maintenance Requirements

Clean out debris and vegetation. For large expansion joints with provision for access from below the deck, low pressure water jetting should be used for cleansing purposes.

Clear drainage systems.

Check and tighten where necessary any loose nuts and bolts. Replace where appropriate.

Replace gaskets where this is a specific requirement detailed in the Structure Maintenance Manual.

(b) Maintenance Interval

12 months.

2.4.3 Deck Drainage

(a) Maintenance Requirements

The requirements for the routine maintenance of surface drainage in the carriageway, footway or verge are given in Part 1, Chapter 1.7.

Sub-surface drainage outlet pipes and below deck systems should be rodded, where accessible, to ensure satisfactory operation.

(b) Maintenance Interval

The complexity and accessibility of sub-surface and below deck systems will vary considerably. The MA should agree an appropriate maintenance interval with the Regional Office. Normally this interval will be between 12 months and 24 months.

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2.4.4 Metal Parapets

(a) Maintenance Requirements

Check and tighten where necessary any loose nuts or bolts. Replace as appropriate.

Clear hollow section drain holes.

(b) Maintenance Interval

12 months.

2.4.5 Masonry and Concrete Parapets

(a) Maintenance Requirements

Remove graffiti.

Remove any vegetation.

(b) Maintenance Interval

12 months.

2.4.6 Bearings (Elastomeric, Sliding and Roller)

(a) Maintenance Requirements

Remove general dirt and debris.

Where appropriate, clean sliding and roller surfaces if accessible and regrease to ensure satisfactory performance. (Additional advice relating to the bearing manufacturers' instructions should be included in the Structure Maintenance Manual).

(b) Maintenance Interval

12 months - remove general dirt and debris

10 years - clean and regrease

2.5 Subways

2.5.1 General

The maintenance requirements for those elements which relate to the structural integrity of subways are given below.

(a) Maintenance Requirements

Remove graffiti.

Clear drainage channels.

Clean drainage outlets. Rodding where required.

Check (and rectify where necessary) seating of drainage gratings or covers, replace any missing or defective items.

Repair gap sealant to movement joints.

Check and clean security mirrors.

(b) Maintenance Interval

12 months.

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2.6 Culverts

2.6.1 General

The routine maintenance of culverts described in this Part relates only to those culverts which are classified as highway structures (see 2.1.9). Smaller culverts and piped drainage systems are covered by Part 1, Chapter 1.7.

It should be noted that many culverts will be classified as confined spaces and general reference should be made to the advice given in 2.1.8.

The routine maintenance requirements for culverts are given below.

(a) Maintenance Requirements

Remove any vegetation and debris from within the structure.

Remove any silt build-up which is restricting flow through the culvert.

Repair gap sealant to movement joints.

(b) Maintenance Interval

12 months.

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2.7 Sign Signal Gantries, High Masts and Catenary Lighting

2.7.1 General

The maintenance requirements for the structural aspects of sign signal gantries, high masts and catenary lighting are given below.

(a) Maintenance Requirements

Tighten holding down bolts where necessary.

(b) Maintenance Interval

12 months.

2.7.2 Non-structural Aspects

The requirements relating to maintenance of lighting are given in Part 1, chapter 1.19.

Other non-structural items such as hoists, winches and electrical fixings shall be checked for correct operation, cleaned and lubricated as appropriate, in accordance with the manufacturer's recommendations and at a maximum interval of 12 months.

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PART 3 - WINTER MAINTENANCE

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3.1 Statement of Service

The Highways Agency aims to provide a winter maintenance service which, as far as possible, allows the safe movement of traffic on motorways and all-purpose trunk roads (APTRs) in England, and keeps delays and accidents caused by adverse weather to a minimum.

The Highways Agency's Maintenance Agents (MAs) shall undertake the operational management of the winter maintenance service and shall aim for a two hour treatment time for all trunk roads.

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3.2 Introduction, Roles and Communication

3.2.1 General

This Part sets out the requirements and advice for winter maintenance on the trunk road network.

Throughout this Part, reference to trunk roads shall be taken as meaning both motorways and APTRs.

3.2.2 The Role of the Maintenance Agent

The Highways Agency appoints Maintenance Agents (MAs) for the operational management of the winter maintenance service on its trunk road network.

Winter maintenance operations are undertaken by the MA's Direct Labour Organisation (in accordance with DLO Regulations) and/or private sector Contractors.

The Highways Agency supplies specialised plant and equipment for use on motorways and certain defined APTRs, including the winter maintenance vehicles, snowblowers, salt loading hoppers and loading shovels. It also provides compounds that act as bases for motorway operations or shares MA's depots where this is more convenient. All other labour, plant, equipment, materials, vehicles and depot facilities required for winter maintenance operations shall be provided by the MA and/or Contractor.

3.2.3 The Role of the Highways Agency's Operations Support Division

The Highways Agency's Operations Support Division (OSD) is responsible for national policy for winter maintenance on the trunk road network.

3.2.4 The Role of the Highways Agency's Regional Offices

The Highways Agency's Northern, Midlands and Southern Regional Offices are responsible for management of winter maintenance on the trunk road network and for the deployment and maintenance of the winter maintenance facilities and equipment provided by the Highways Agency. Southern Regional Office undertakes this function on behalf of the London Region.

Three Winter Maintenance Area Managers (WMAM) are stationed throughout each of the three Regions, reporting to a Regional Manager (WMRM).

A national Winter Maintenance Advisor and Co-ordinator is also appointed to advise on all winter maintenance matters, to co-ordinate operations in times of severe weather and to ensure that best practices are adopted throughout the Regions.

Each RO produces an annual "Winter Arrangements" publication for the Region, within which the Highways Agency's officers and the winter maintenance facilities for the Region are fully listed. Copies of the "Winter Arrangements" publication can be obtained from the RO.

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The WMRMs are primarily concerned with the continuing care and servicing of all the winter maintenance facilities throughout the motorway network in their Region. They also monitor the state of the trunk road network in their Region under winter conditions. Operational routes for winter maintenance vehicles shall be agreed with the appropriate WMRM.

WMAMs are primarily concerned with maintenance of the Highways Agency's winter maintenance vehicles and equipment and with implementing the deployment of the Highways Agency's reserves of snowplough/spreader vehicles and rotary snowblowers throughout their Region, to cover breakdowns.

Each Regional Office of the Highways Agency is responsible for managing the financial allocation to winter maintenance within the Region and for administration of the MA's agency agreements.

3.2.5 Liaison and Communications

Road conditions in winter can change very quickly over relatively short distances. This variability stresses the importance of effective liaison and communications between MAs and the Forecasting Organisation (FO), police, media, emergency services, public transport operators, freight transport, road haulage and automobile associations.

Personnel who co-ordinate winter maintenance activities for the MAs, and take the decision whether or not to treat, should develop direct personal contact with the local FO and avoid extended chains of information.

MAs are advised to discuss, with their local police force, ways of formulating guidance on the reporting of road conditions from police patrols. Close liaison between MAs and the police, and the resulting mutual understanding of respective problems, will enable MAs to take full advantage of police observations and reports.

MAs should make full use of the opportunities and advantages to be gained by broadcasting information about snow, ice and frost on roads, at both national and local level. In particular, the growth of local radio offers the facility of communicating emergency information of a purely local nature to the community with speed and directness.

MAs who do not yet have direct links with the broadcasting authorities should liaise with their local police and where convenient arrange for information to be passed to broadcasting authorities through police channels. Where MAs have direct links, these should continue, but it is suggested that these arrangements could usefully be reviewed and consideration be given to the police broadcasting officer for the area being nominated as the source of such information.

The highway code advises drivers not to use a hand-held microphone or telephone handset whilst their vehicle is moving, except in an emergency. Under no circumstances should MA's drivers stop on the hardshoulder to answer or make a call. During precautionary treatment it is unlikely that an emergency would arise requiring the driver to contact base, other than a vehicle breakdown. During snowploughing on the motorway, it may be necessary for a driver to call for assistance to keep the road open, if conditions deteriorate such as to constitute an emergency. In such circumstances a lone driver may use a hand held microphone to request assistance keeping the conversation as brief as possible. The Highways Agency advises that systems with fixed, neck-slung or clipped on microphones are to be preferred on road safety grounds and suggests that MAs will note this when considering purchasing or replacing communications equipment.

3.3 Cover for Operational Purposes

3.3.1 General

MAs are required to adopt the arrangements defined in this chapter but local variations can be approved by the RO. The requirements apply to all trunk roads.

In England, weather is unpredictable and the occurrence of wintry conditions varies considerably through the season and from year to year.

During the whole of the winter maintenance season, there shall be an experienced member of staff available at all times, (which need not be at their place of work), whose purpose is to monitor road weather conditions and to react to those conditions. This member of staff shall have direct access to either actual road conditions, or an ice prediction system, or updates and/or warnings from the road weather forecasting organisation, and shall have the authority to call out personnel for winter maintenance operations as necessary.

Special attention may be required for parts of the network that contain elevated sections, bridges, known areas of frost drainage, and/or where the local topography channels windborne cold air.

It is important for the business community, and the travelling public, to be able to rely on a consistent level of service across winter maintenance boundaries. Neighbouring MAs shall liaise closely on their winter maintenance activities to ensure a reasonable continuity of treatment. They shall ensure that, where responsibility passes from one to another, no sections of main carriageway or junctions, slip roads or service roads are left untreated.

MAs shall make arrangements to advise their neighbours of their decision to treat trunk roads (and to update at whatever time), to ensure that similar treatments are applied across boundaries for similar weather conditions. The Highways Agency acknowledges that MAs make their own decisions on treatments to be applied and therefore it is not advocating identical treatment. Liaison can however offer the opportunity for decisions to be assessed in the knowledge of the treatments that are being applied to adjacent roads.

3.3.2 Definitions

Three winter maintenance periods are defined for operational purposes in Table 3.3.1. The definition of any of these periods may be changed because of local conditions, but only after agreement with the Highways Agency's Regional Office (RO).

PERIOD	TIME (months)	WEATHER CONDITIONS
High	December, January, February	Severe - probable
Low	November and March	Severe - may occur
Marginal	October and April	Severe - not expected

Table 3.3.1 : Winter Maintenance Periods for Operational Purposes

Winter maintenance vehicles, plant and equipment shall be available for use in compounds/depots during all three periods. Annual servicing will commence during May, but enough vehicles shall remain operational to carry out precautionary treatment, if required.

Winter maintenance manning shifts are defined for operational purposes in Table 3.3.2. Only qualified personnel shall be employed (see 3.5.7).

SHIFT	DEFINITION
Normal	On duty during normal working hours (as agreed nationally or locally) based at the compound.
Continuous	On duty 24 hours based at the compound.
Stand-by	Personnel committed to be available for duty within a defined time period after being called out to the compound from home or elsewhere.
Call-out	Off duty personnel available for duty as demand arises but without prior commitment to be available.

Table 3.3.2 : Winter Maintenance Manning Shifts for Operational Purposes

3.3.3 Response and Treatment Times

Treatment routes and shift arrangements shall be organised to achieve defined standards of response and treatment times.

Response Time is defined as the time taken from the decision to begin treatment until the winter maintenance vehicles are loaded, manned and ready to leave the compound.

Treatment Time is defined as the time taken from leaving the compound, in order to begin the treatment of the trunk roads for which the MA is responsible, through to completion of the treatment.

To be most effective, a precautionary treatment should be undertaken before ice forms or snow settles on the road.

The precautionary treatment of all trunk roads shall be undertaken within a maximum response time of 1 hour and a maximum treatment time of 2 hours.

In exceptional circumstances an extension of treatment time may be justified in order to achieve more efficient methods of treatment. Such arrangements will require the approval of the WMRM (see 3.4.6).

Temporary relaxation of the defined standards can only be accepted in very exceptional cases, with the prior agreement of the WMRM.

MAs shall review manning arrangements annually, taking advantage of improved weather forecasting and ice prediction systems to reduce or eliminate continuous duty shifts wherever possible whilst maintaining the ability to meet the required response time. Continuous duty shifts shall not be operated as a matter of routine unless approved by the RO.

3.3.4 Manning Levels for Winter Maintenance Vehicles

MAs shall ensure that their trained driver availability for each operational spreading/snowploughing vehicle allocated by the Highways Agency is sufficient to provide continuous 24 hour manning during the winter season, with an additional 25% reserve for each vehicle to cover absence, illness or extra effort. A MA operating four vehicles with drivers on three 8 hour shifts would thus require a pool of fifteen qualified drivers.

Treatment of ice and snow on the network, at a few hours notice, constitutes an "emergency" and this work is exempt from EC and UK driver's hours regulations. However the following should be noted, where winter maintenance drivers undertake other driving duties and UK or EC regulations apply:

Time spent on "call out" and "standby" can be counted as rest time, if drivers are at home or otherwise freely able to dispose of their time, until such a time as they respond to a call; with the proviso that they are not under the direction of their employers or carrying out duties connected with the performance of a contract during this rest time.

Time spent on "emergency duty" cannot be counted towards a rest period; drivers should be aware of the effect of "emergency duty" on their mandatory rest periods in relation to the EC and UK driver's hours regulations.

A log of hours spent on "call out", "standby" or "emergency duty" shall be kept.

3.3.5 Emergency Driver Pool

The Highways Agency has an emergency driver pool to provide qualified winter maintenance drivers (see 3.5.7) in times of severe winter weather or to offset unforeseen staff shortages. Emergency drivers must be requested through the WMRM.

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3.4 Operational Techniques

3.4.1 General

This chapter principally concerns operational techniques for winter maintenance using rock salt, the de-icing material most often used on the majority of trunk roads (see Chapter 3.7). Alternative de-icing materials are available (see Chapter 3.8) but their use may require variation of these techniques.

3.4.2 Precautionary Treatment

To be most effective, salt should be spread before ice forms or snow settles on the road. Anticipating these conditions, and reacting correctly, depends on a mixture of local knowledge and experience, good weather forecasts, and an awareness of the current condition of the road (ie. is it wet or dry; is previous treatment sufficient?) It is recommended that MAs make full use of specialised road weather forecasting services.

The success or otherwise of the operation depends greatly on the good judgement of those who decide whether or not to treat. Good weather forecasts are essential, but local geographical idiosyncrasies or other factors may have to be considered in reaching a decision. It does however take time to acquire this kind of local knowledge, and therefore a high turnover of staff is not recommended.

A good rapport with the FO is essential if forecasts are to be used to best effect. Various services are now available which provide winter maintenance personnel with the kind of forecasts that help to make their job easier. Chapter 3.11 deals with the type of services available. A decision to treat will depend upon many factors but if road surface temperatures are predicted to fall below plus 1°C a precautionary treatment should normally take place unless:

- (a) no moisture is on or is expected to be on the road; or
- (b) there is sufficient residual salt on the road to deal with the expected conditions.

Road inspections should confirm residual treatment levels and other information about the road surface condition.

Elevated sections of roads, including bridges, and sections lying in low ground or where the topography channels windbourne cold air, are more prone to freezing and may need special attention.

Spread Rates for a precautionary treatment should be 10 g/m² for salt stored in a barn and up to 20 g/m² for salt stored in the open (to allow for increased moisture content) except in the following circumstances:

- (a) If freezing conditions are expected after rain, salt should be spread at 20-40 g/m² according to the amount of moisture present and temperature expected. Unless freezing conditions coincide with rainfall, treatment should be delayed as long as possible to reduce loss of salt by run off.
- (b) If continuous snow is forecast, salt should be spread at 20-40 g/m² according to the anticipated severity of the snowfall. It is essential that enough treatment is applied **before** the snow starts to stick to the road as the treatment will melt the initial snowfall and provide a wet surface beneath subsequent snow making the work of snowploughs much easier.

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3.4.3 Effectiveness of Salt

On a well-drained road during and after rain the thickness of the water film typically varies between 0.08 mm and 0.50 mm. Once rain has ceased to fall traffic quickly reduces the water film thickness. Thin films of ice formed by the freezing of water on road surfaces are usually less than 0.25 mm thick.

Tables 3.4.1 and 3.4.2 give guidance on the effectiveness of precautionary salt treatments in preventing freezing of the water film. Table 3.4.1 considers the effect of a treatment of 10 g/m² on the freezing point of the water/salt solution. Table 3.4.2 considers the spread rate required to ensure treatment is effective down to a temperature of minus 5°C.

WATER FILM THICKNESS (mm)	FREEZING POINT
0.08	-8.6°C
0.10	-6.5°C
0.20	-3.0°C
0.25	-2.4°C
0.30	-2.0°C
0.50	-1.2°C

Table 3.4.1 : Effect of 10 g/m² Precautionary Treatment on Freezing Point

WATER FILM THICKNESS (mm)	REQUIRED SPREAD RATE
0.08	7 g/m ²
0.10	8 g/m ²
0.20	16 g/m ²
0.25	20 g/m ²

Table 3.4.2 : Salt Spread Rates for Effective Treatment at -5°C

Assuming that the water film thickness will generally not be greater than 0.25 mm when precautionary treatment is being considered, a spread rate of 10 g/m² will thus prevent the formation of ice unless temperatures fall below minus 2.4°C. Should lower temperatures be anticipated however, a rate of spread of 20 g/m² will prevent freezing down to minus 5°C.

Salt is considerably less effective if not applied until after icy conditions have developed. If ice has formed, a spread rate of 10 g/m² will not be sufficient to ensure rapid melt and restore skidding resistance to the road quickly (see 3.4.4).

The density of fresh untrafficked snow is about one-tenth that of ice and the action of traffic assists in the process of melting and dispersal. Approximately 6 g/m^2 of salt is required for 10 mm of fresh snow for each degree celsius that the air temperature is below the freezing point. (N.B. The temperature is usually higher than minus 3°C when falls of snow of 10 mm or more occur). The use of salt to melt settled snow is not recommended once accumulations exceed 30 mm in depth (see 3.4.4).

3.4.4 Treatment of Settled Snow/Ice

If ice has formed salt should be spread at up to 40 g/m^2 , depending on the amount of ice present and the temperature, to ensure a rapid melt. Particular attention should be paid to lengths of road which are known to be susceptible to 'run-off' water from verges or central reserves. Although the road itself may be dry, accumulations of snow may melt, run onto the road and then re-freeze.

Snow accumulations exceeding 30 mm in depth are best removed by ploughing. Each pass of the plough should be supplemented by salt spread at 20 g/m^2 to prevent remaining snow from compacting and to aid dispersal by traffic and subsequent ploughing.

It is important to monitor air temperature and if the temperature drops to increase spread rates, up to 40 g/m^2 if necessary. Vehicle mounted thermometers can be misleading. Proprietary ice sensors (see chapter 3.10) placed at roadside sites, or thermometers at suitable open sites in compounds, or similar systems are generally preferred.

Even light snowfalls may call for ploughing where local drifting has occurred, or to remove snow not dispersed by traffic. This may occur where the traffic is reluctant to use lanes 2 or 3, or at night when traffic is light.

During prolonged falls of snow, ploughing should be continuous to prevent build-up and be supplemented by simultaneous salting at a rate of $20 \text{ g/m}^2 - 40 \text{ g/m}^2$.

If snow depths reach 120 mm, or when tackling drifts, or when working on gradients, it may be better to plough without spreading as the weight of the treatment load will aid vehicle traction. As soon as the situation is under control, spreading should be resumed. Use of a snowblower may also be considered for removal of deep snow.

Ploughing or snowblowing is not practical in built up areas. Repeated applications of deicer can remove heavy accumulations, but this type of treatment is not otherwise recommended as it is likely to provide an unacceptable surface for traffic. In this case consideration shall be given to the use of a snowblower with the snow being directed into an accompanying lorry, followed as soon as possible by salt spreading at 20 g/m^2 .

The formation of hard packed snow and ice should be rare if other recommendations are followed. If it does occur, provided it is no more than 20 mm thick and the air temperature is above minus 5°C , removal is possible by using successive treatments of salt at $20 \text{ g/m}^2 - 40 \text{ g/m}^2$.

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Great care must be taken as the use of deicers on the snow/ice can result in an uneven and slippery surface. If there is any danger the surface will be unacceptably slippery, then the addition of abrasives should be considered.

Reversion to the initial treatment technique shall be made as soon as possible since abrasives contribute little to the removal of snow/ice and may block drains and gulleys on thawing. Abrasives shall not be used on structures where there is any danger of blockage to drains.

The principal treatments for settled snow/ice are summarised in Table 3.4.3.

ROAD SURFACE CONDITION	TREATMENT	
	SALT SPREAD	PLOUGHING
Ice formed	20-40 g/m ² for rapid melting	Not possible
Moderate snow	20 g/m ² to supplement ploughing, up to 40 g/m ² if temperatures falling	Required (depth must exceed 30 mm)
Prolonged snowfall	20-40 g/m ² to supplement ploughing	Continuous (without salting if necessary to aid traction).
Hard packed snow/ice	Successive treatments at 20-40 g/m ² (supplemented by abrasives if necessary)	Not possible

Table 3.4.3 Summary of Principal Treatments of Settled Snow/Ice

3.4.5 Treatment in Sustained Low Temperatures

Sustained low temperatures are rare in England. For each degree drop below minus 5°C, the amount of salt needed to maintain the equivalent melting effect increases by about 14 g/m². But where traffic is reasonably heavy, little or no increase is needed until sustained temperatures fall below minus 10°C. When sustained temperatures do fall below minus 10°C, one method that has proved to be effective is the addition of calcium chloride mixed with 4 parts of salt. Calcium chloride is expensive and difficult to store however as it absorbs moisture freely.

3.4.6 Spreading Techniques

Purpose built winter maintenance vehicles offer the opportunity to achieve a substantial saving in labour costs. In particular, the use of powered systems to control spreading eliminates the need for a second man in the cab during precautionary treatment. The use of a driver and mate shall be restricted to snowploughing and to other occasions when conditions are hazardous, (eg. when precautionary or emergency treatment is required on particularly isolated stretches of road, when difficult manoeuvres are unavoidable or when visibility is poor). In compounds and depots where hoppers are provided, vehicles can be loaded by their drivers.

To be effective, salt should be spread evenly and at rates that suit the prevailing or expected conditions. Care should be taken to ensure that spread widths are neither too wide nor too narrow. The treatment should be spread by automatic machines, the controls of which shall be calibrated and clearly marked for distinct rates of spread, up to a maximum of 40 g/m². Higher spread rates are unnecessary, wasteful, environmentally harmful and shall be avoided.

Cross winds can affect the distance that treatment is spread and to compensate it may be necessary to spread from a lane upwind (if appropriate) from that normally chosen. In exceptionally strong winds it may be necessary to undertake a second treatment run with the spreader set asymmetrically into the wind.

Due consideration should be given to traffic conditions and the timing of winter maintenance operations. Wherever possible without detriment to the effectiveness of treatment, precautionary salting should be undertaken in off-peak periods when disruption to traffic and to proper distribution of the salt will be minimised. If precautionary treatment in heavy traffic is unavoidable it may be necessary to seek Police assistance (including motorway matrix signals) or to consider treatment in two runs (to ensure proper distribution of the salt).

Care should be taken at roadworks that in addition to areas currently being trafficked, all other areas likely to be opened to traffic are treated. Traffic management equipment, including cones and cylinders, may disrupt distribution of salt; contraflow systems should be treated in both directions.

Treatment of any special features such as vehicle arrestor beds should be agreed with the RO and procedures instigated to ensure compliance with agreed methods of treatment.

3.4.7 Routes

However well vehicle operational routes are planned, a certain amount of wasteful duplication (dead mileage) is inevitable because of network complexities and the siting of compounds and depots. Dead mileage should be kept to a minimum, but first consideration shall always be given to the need to achieve the required treatment time.

At those points on the trunk road network where responsibility passes from one MA to another, both MAs must liaise closely when defining routes, to ensure that there are no sections of the trunk road, slip roads or service roads that are not covered by either MA.

Operational routes shall be agreed with the Highways Agency's WMRM. Changes to existing or new routes should be similarly agreed and copies of the new routes shall be provided to the WMRM.

Routes should be reconsidered whenever major roadworks may affect the winter maintenance operation.

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3.4.8 Snowploughing

It is important to have a clearing policy that is easily understood; the technique used for multi-lane carriageways should be '**clearance by lane**'.

Due to differences in local weather conditions, snow depth, snow wetness and road topography, it is difficult to be precise on the order of lane clearance. Also, local traffic densities and movements vary from day to day and even within a day, and may affect lane clearance priorities.

In prolonged, heavy snowfall the priority will be to maintain a single lane open. In the majority of cases this will be the more heavily trafficked left hand lane (lane 1) and the first operation will be to plough snow from lane 1 to the hard shoulder, with clearance of other lanes continuing as conditions improve.

An alternative technique for a 3 lane carriageway with hardshoulders, particularly suited to echelon ploughing (2 or more vehicles moving in the same direction, one behind the other, in different lanes), is clearance in the following sequence:

- First : plough lane 2 snow to lane 1;
- Second : plough lane 1 to hardshoulder;
- Third : plough lane 3 snow to central reserve;
- Fourth : plough hardshoulder snow to verge.

More than 2 lanes ploughed onto the central reserve could be hazardous to traffic by inviting drifting and melt water problems later on. When clearing 4 lane carriageways consideration should be given to abandoning lane 4 rather than creating problems of excess snow on the central reserve.

Irregular windrows caused by ploughing passes, especially those that weave from one lane to another, are dangerous, as they may tempt drivers to overtake by squeezing into the partly cleared lane. Lanes should be completely cleared, and the windrows of snow remaining should form a smooth and continuous line without sudden encroachments into the cleared path. On motorways, windrows can be left on hardshoulders, but there should be intermittent clearings to provide refuge for broken down or abandoned vehicles.

Speeds of ploughing vehicles should be regulated, particularly at features such as underbridges where snow could be thrown over the bridge parapet and adjacent the central reserve where snow could be pushed into the opposing carriageway.

The aim is to clear all lanes and hardshoulders as soon as conditions permit. Clearance work shall therefore proceed continuously, since a pause during a snowfall could lead to a build-up, which would take a disproportionately long time to clear. Packed snow, glazed by the wind, can be particularly difficult to remove.

Care must be taken to avoid damage to road surfaces, road studs, roadside furniture and structures. At roadworks, traffic management equipment must not be disrupted. An accumulation of ploughed snow creating a ramp adjacent safety fences and concrete barriers should be avoided.

When ploughing, motorway warning signals can be displayed, so police co-operation is essential. It is not always possible to keep these signals free of snow, but every effort should be made to advise motorists of the snowploughing vehicles ahead.

3.4.9 Snowblowing

Heavy snowfall, drifting and ploughing operations may result in a build up of snow in the carriageway and hardshoulders. Snowblowers are particularly suited to clearance of blockages and to removal of accumulations from the hardshoulder and carriageway where snow may be safely directed onto the verge (or possibly a wide central reservation). The Highways Agency's snowblowers, which form part of the reserve fleet, have the capacity to clear up to 2,500 tonnes of snow per hour.

3.4.10 Slip Roads and Interchanges

It is important to maintain the free flow of vehicles at interchanges. At least one lane of each slip road or link road shall be kept open.

At grade separated interchanges, clearance methods should not result in a reduction of the number of lanes on the main carriageway between the exit and entry slip roads, unless this is a feature of the normal road layout.

Bulk removal of snow from multi-level interchanges (or even some conventional ones) may be necessary on occasions.

3.4.11 Safety of Operatives and Other Road Users

Drivers shall be instructed to take all possible precautions to protect their own safety and that of other road users at all times.

Winter maintenance operatives shall wear high visibility clothing incorporating retro-reflective markings at all times when out of a vehicle.

Under the provisions of Section 16(e)(i) of the Motorway Traffic Regulations 1982, the restriction on the use of central reserve crossovers can be relaxed where it is necessary to maintain or clear part of a motorway. However, in practice, this is a highly dangerous manoeuvre and drivers of spreading/snowploughing vehicles shall proceed to motorway interchanges rather than use crossovers. The only exceptions are when instructed by the Police or where the crossover is specifically designed for the purpose, including facility for the vehicle to be clear of the carriageway entirely, and appropriate procedures for its use have been agreed by the RO.

U-turns on APTRs shall be carried out only when there is no risk to spreading/snowploughing vehicle drivers or to other road users.

Close co-operation is essential between MAs and British Rail. MAs shall ensure that the strictest safety precautions are taken when spreading/snowploughing vehicles are negotiating level crossings. When snowploughing, care shall be taken that snow does not build up across the tracks or against gates, bridge parapets, fences and walls.

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3.4.12 Snow Gates

Procedures for operating snow gates shall be agreed with the RO and the Police.

MAs shall close and subsequently re-open snow gates only upon receipt of instructions from the Police. Should MAs consider that snow is rendering or has rendered the road unsafe to vehicular traffic, they shall request that the Police initiate procedures to close the snow gates.

3.4.13 Snow Fences

Powers to erect fences, and to ensure easements, are provided in the Highways Act 1980 where Sections 102, 249, 251 as modified, 291 and 292 as amended are relevant. Negotiations of terms for the gathering of easements by landowners and tenants shall be undertaken by MAs in consultation with the RO. Cases where agreement cannot be reached shall be referred to the District Valuer.

For guidance in the design and location of Snow Fences, MAs should refer to the Highways Agency's WMRM.

3.4.14 Porous Asphalt Road Surfaces

Under certain winter conditions porous asphalt requires more attention than comparable conventional road surfaces. This is due to different characteristics in respect of surface temperature, road humidity and the ability to retain salt on the surface.

In general, more salt is required for treatment of a porous asphalt road surface than for a dense surfacing material.

At high traffic intensities the behaviour of roads made from porous asphalt barely differs from that of dense road surfaces. At low traffic intensities however the loss of thawing agent into the voids of porous asphalt results in greater likelihood of freezing in the event of only a small amount of precipitation (condensation, freezing fog) and greater quantities of thawing agent being required to treat heavy precipitation.

Inadequate superelevation or gradient can also be more critical for porous asphalt roads. Precipitation in the voids of the material may collect and be retained at certain locations. The road surface thus remains damp and more likely to freeze in these areas. This action is exacerbated by the differing response of porous asphalt to temperature change; the temperature of a porous asphalt surface falls below freezing point more quickly than a dense road surface and rises above freezing more slowly.

Prompt snowploughing is recommended on porous asphalt road surfaces, but care is required to avoid damaging the surface. Ploughs shall be fitted with rubber skirts on the blades.

Annex 3.4.1 contains more detailed information on the performance and treatment of porous asphalt in winter conditions.

Annex 3.4.1

Treatment of Porous Asphalt Road Surfaces

1. Introduction

Porous asphalt behaves differently from other dense road surfaces, especially in respect of surface temperature, humidity and the retention of salt on the surface.

In winter conditions porous asphalt requires closer monitoring, particularly in the following situations:

- (a) roads with low traffic flow;
- (b) roads on an incline;
- (c) roads with a limited superelevation;
- (d) hard shoulders;
- (e) in the event of changes from cold to warm temperatures;
- (f) in the event of snow remaining on the road surface;
- (g) in the event of slipperiness caused by condensation;
- (h) in the event of slipperiness caused by freezing fog; and
- (i) at changeovers from porous asphalt to dense road surfaces.

2. Behaviour of Porous Asphalt with Temperature Change

As temperatures fall, the temperature of road surfaces made of porous asphalt falls below freezing point an average of half an hour earlier than that of dense road surfaces;

As temperatures rise, the temperature of road surfaces made of porous asphalt rises above freezing point an average of an hour later than that of dense road surfaces;

The temperature of road surfaces made of porous asphalt remains below freezing point about 5% longer than that of dense road surfaces;

In extreme weather conditions (little wind, clear sky), the surface temperature of roads made of porous asphalt is about 1°C lower than that of comparable roads made of dense road surfacing materials.

The behaviour of porous asphalt with temperature change can be explained by the relatively high insulation value of the road surface due to voids. As a result, heat is less easily transported from the mostly warm subgrade to the surface in the event of frost from above. The voids also ensure greater contact surface with the cold air; this greater heat/cold interchange also contributes to the lower

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temperature of porous asphalt in comparison with a compact road surface.

In view of the foregoing temperature characteristics, it is recommended that thermal mapping should be performed on new porous asphalt construction; the thermal mapping survey will assist with the re-siting of existing ice detection sensors and indicate the most favourable siting of new sensors to provide an accurate temperature profile of the road. Siting of at least one sensor on all porous asphalt sections is considered to be essential.

3. Behaviour of Porous Asphalt with Humidity

The voids in porous asphalt ensure that precipitation is slowly removed to the shoulder as a result of the superelevation of the road. Some of the precipitation remains behind in the pores. In summer the remnants quickly evaporate after a wet period, while in winter the road dries slowly. In the case of roads with a limited superelevation which are on an incline or which have a large number of traffic lanes, moisture remains on part of the porous asphalt for a long time. As a result of this residual moisture, road surfaces made of this type of asphalt also remain damp.

If the road surface temperature falls below freezing point after a period of precipitation, roads made of porous asphalt will require extra attention on account of the moisture present.

4. Behaviour of Porous Asphalt with Salt Treatment

Much of the thawing agent spread on roads made of porous asphalt disappears into the voids, and only a small amount remains on the surface. However, because of the 'air pumping action' effect of vehicle tyres, traffic will ensure that the thawing agent in the pores is brought back to the surface of the road. As a result of this vertical transport function performed by traffic, some of the salt which had disappeared into the voids will continue to contribute to the thawing process. This process will be disrupted if the traffic intensity is low (eg at night). Even if only a small quantity of moisture falls on the road at that time (condensation, freezing fog), this can result in non-compact road surfaces behaving differently from compact ones. As a result of the extra moisture in the pores of porous asphalt, a larger quantity of salt is required on these roads.

There is another important factor in the effectiveness of winter maintenance treatment, in addition to the drop in freezing point caused by the application of the thawing agents. On roads made of dense road surfacing, traffic readily leads to horizontal transport of the thawing agent (ie in the direction of the traffic). With porous asphalt this horizontal movement of the thawing agent is considerably less. As already mentioned, traffic also performs a vertical transport function on such roads. This means that the salt spread on porous asphalt roads is mixed with the moisture from the pores. In time a balance arises in which the salt is distributed as a solution over the pores and the surface as a whole. This solution is transported vertically and to some extent horizontally by the traffic.

Because the moisture in porous asphalt drains away to the shoulder only very slowly, the salt solution remains available for quite some time. If the vertical balance is disturbed however, less moisture from outside will be required to reduce the drop in the freezing point on the surface sufficiently enough to allow the formation of ice than in the case of comparable roads made of dense road surfaces.

Where a stretch of road made of porous asphalt is followed by one made of dense road surfacing, extra attention to the initial section of the dense road surfacing is required. Since the horizontal transport of salt on non-compact road surfaces is limited compared to that on compact road surfaces, there is a significant reduction in the amount of thawing agent in the initial section of dense road surfacing.

Traffic and dry conditions ensure that the quantity of thawing agent on a road made of dense road surfacing will gradually disappear even without precipitation. On a road made of porous asphalt some of the salt crystallises in the pores under dry conditions. This slow crystallisation ensures good adhesion to the asphalt, and as a result the salt remains available. If salting takes place several times in a dry period without the thawing agent being removed to the shoulder - eg if slipperiness occurs as a result of freezing fog or condensation - a salt buffer will be formed in the pores of porous asphalt. If, following a dry period, precipitation falls at a road surface temperature below freezing point, the salt buffer which has collected in porous asphalt becomes available again under the influence of the traffic.

5. Conclusions

To keep a road made of porous asphalt completely free of snow, more salt is required than for a comparable road made of dense road surfacing.

At high traffic intensities the behaviour of roads made of porous asphalt barely differs from that of dense road surfaces. At low traffic intensities extra attention is required.

The amount of salt required to keep a road made of porous asphalt passable will be 25% higher than for a dense surfaced road, depending on conditions.

The salt spread on the road ends up on the shoulder. On roads made of porous asphalt this is limited to the first few metres of the hard shoulder which should result in less environmental damage to trees and plants.

After a salting operation, the skid resistance of a porous asphalt road will decline at low traffic intensities in the event of a small amount of precipitation in the form of glaze ice, freezing fog or significant condensation. This can be avoided by prompt salting (sometimes several times).

Inadequate superelevation and inclines allow moisture to collect at certain places on roads made of porous asphalt. Wet sections of the roads are more likely to freeze in these places, partly as a result of the different behaviour of porous asphalt with temperature change.

At low traffic flows with a great deal of precipitation, extra thawing agent is required to make roads made of porous asphalt completely free of snow (following snowplough operations).

At high traffic flows and following a heavy snowfall, roads made of porous asphalt are generally more passable (higher skid resistance) than comparable roads made of dense road surfaces subjected to the same treatment.

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3.5 Use of Winter Maintenance Equipment

3.5.1 General

The Highways Agency owns the operational and reserve spreading/snowploughing vehicles and snowblowers used for motorway winter maintenance in England. MAs are notified each year of the operational vehicles based with them, from which compounds they should operate and on which roads they should be used. They are also notified of those compounds where reserve vehicles and snowblowers are normally kept (see 3.5.3).

MAs or their Contractors normally supply the vehicles and equipment for winter maintenance operations on APTRs.

The requirements of this chapter relate mainly to the Highways Agency's vehicles and equipment (but see 3.5.7).

3.5.2 Operational Vehicles

Except in the circumstances noted below, the Highways Agency's operational vehicles are for routine use on motorways only. During emergencies, reserve vehicles can be made available, and the procedure for obtaining them is set out in the Regional "Winter Arrangements" publication.

The motorway treatment routes, that have been agreed with the Highways Agency, sometimes result in vehicles travelling on non-motorway roads to minimise 'dead mileage'. As long as it does not delay or otherwise adversely affect the treatment of the motorway, treatment of these other roads may take place without incurring the vehicle hire charge. This is on the strict understanding that the agreed treatment routes are not changed to accommodate the treatment of other roads and that the Highways Agency is only charged for the treatment of any trunk roads.

Very occasionally, the Highways Agency will agree to the use of one of its vehicles on non-motorway roads on a routine basis, for example on major APTRs linking motorways. The operational and financial arrangements for use of these vehicles will be formally agreed with the RO.

Operators should note that the "overall width" of a vehicle, as defined in the Road Vehicles (Construction and Use) Regulations 1986, excludes "any snowplough fixed in front of the vehicle". Where width restrictions are imposed by a Traffic Regulation Order however the particular definition for the purpose of that Order should be determined.

3.5.3 Reserve Vehicles

Reserve vehicles are strategically placed in compounds along the motorway network for rapid deployment. They are not allocated to a particular MA, and cannot be used without prior approval, which must be sought from the WMRM or WMAM (see chapter 3.2).

Reserve vehicles may only be used for the following purposes:

- (a) on the motorway when operational vehicles have broken down; have been withdrawn from service for other reasons agreed by the WMAM; or when the operational vehicles alone cannot cope because of severe conditions.

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- (b) off the motorway when MA's vehicles alone cannot cope because of very severe conditions. (Reserve vehicles used off the trunk road network are subject to hire charges).

If a reserve vehicle is used for any reason, the conditions of hire must be strictly adhered to. The hire charges will be raised for the total length of time the vehicle is away from its allocated compound; so vehicles should be returned promptly.

3.5.4 Garaging of Vehicles and Availability for Inspection

The Highways Agency's winter maintenance vehicles, including snowploughs and related equipment, shall be kept properly garaged at the allocated compound unless other arrangements have been made by the Highways Agency. They must also be available for inspection by the WMAM at all reasonable times without prior notice.

3.5.5 Large Goods Vehicle Driver Licence Requirements

Spreading/snowploughing vehicles are classified as Class C, Large Goods Vehicle (LGV). Snowblowers are classified as Class B vehicles. Drivers shall hold a valid UK licence, or equivalent recognised licence issued by a state of the European Economic Area, for the relevant class of vehicle.

3.5.6 Use of Vehicles for Driver Training

Where a MA has no Class C LGV vehicles of its own, it may apply to utilise one of the Highways Agency's vehicles during April to October, as long as training is only for drivers expected to operate the vehicles. Applications shall be made in writing annually to the Regional Office, and should show the registration number of the vehicle requested. Full vehicle insurance cover shall be provided by the user.

3.5.7 Operator Training, Assessment and Registration

Winter maintenance vehicles shall only be operated by trained staff. MAs shall ensure that all winter maintenance operators and drivers on motorways and all purpose trunk roads are trained and assessed to meet the requirements of the Winter Maintenance Operators Qualification - awarded by the City and Guilds Institute (Scheme 6157) or equivalent recognised qualification awarded by a state of the European Economic Area; qualified operators and drivers shall be registered with the Local Government Management Board.

The 6157 qualification comprises units on operation of prime mover, operation of spreader and operation of snowplough - covering both Highways Agency and non-Highways Agency vehicles. For those drivers/operators on all purpose trunk roads, the units dealing with the prime mover and spreader can be assessed on the available level of vehicles and equipment, recognition as a registered Highways Agency operator on all purpose trunk roads will not be dependent on gaining units which refer only to the Highways Agency's vehicles. For maximum flexibility in severe weather conditions, however, it could be advantageous for all operatives to be able to use the Highways Agency's vehicles.

3.5.8 Vehicle Insurance

The Highways Agency's vehicles are deemed to be on Crown duty whilst operating on trunk roads and when:

- (a) travelling to and from such roads for operational use;
- (b) making servicing journeys;
- (c) on standby at their authorised station.
- (d) used for Winter Maintenance Operators qualification training/assessment.

Whilst on Crown duty they are exempt from the compulsory insurance requirements of Section 143 of the Road Traffic Act 1988 and 1991 by virtue of Section 183(1) as amended of that Act, and the Crown accepts liability for third party claims or damage to the vehicles.

The vehicles are not considered to be on Crown duty when operating on non-trunk roads, or when being used for LGV driver training. The hirer must be covered to meet all costs arising from any damage to the vehicles caused by an accident, and must ensure that he has sufficient cover to meet claims for which he may be liable.

3.5.9 Reporting of Vehicle Accidents

MAs shall report to the WMAM all accidents, however minor, involving vehicles. A fatal or serious injury accident shall be reported immediately by telephone.

A form DTp 20001, which is kept in the cab, shall be completed as soon as possible after the accident. The form shall, so far as possible, be completed at the scene of the accident. The driver shall also make out a written statement of the circumstances of the accident and sign it. The form, together with the driver's signed statement and any statements that have been made by witnesses, shall be forwarded immediately to the WMAM.

MAs shall ensure that drivers are familiar with the instructions for completion of form DTp 20001, and that all relevant information, including an estimate of the vehicle repairs, is given.

3.5.10 Grade of Fuel

To minimise the risk of immobilisation due to diesel engine fuel waxing at low temperatures, it is essential for vehicles to be fuelled with a suitable grade of fuel at winter's onset. In order to further reduce the risk of fuel waxing, vehicles should not be left standing in the open for longer than necessary.

3.5.11 Use of Rebated Fuel

Rebated fuel oil shall be used whenever possible, as its use is allowed in vehicles entitled to exemption from excise duty under Section 4(1)(i) or Section 7(3) of the Vehicles (Excise) Act 1971. Further details are given in the "Winter Arrangements" publication. Full licensed goods vehicles employed on winter maintenance work must use unrebated fuel at all times.

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3.5.12 Safety Precautions in Non-Operational Use

When winter maintenance vehicles are used on the highway for training or maintenance runs, the spinner disc at the rear of the vehicle shall be covered in such a way that damage by sharp edges, in the event of an accident, is reduced to a minimum.

3.5.13 Servicing of Winter Maintenance Vehicles

a) General

Throughout the year MAs are required to carry out routine maintenance of "Winter Maintenance" vehicles and equipments allocated to them. This is to include those vehicles and equipments nominated as national reserve and other vehicles on temporary loan.

To minimise the adverse effects of operating winter maintenance equipments within a salt laden environment it is essential that the instructions contained within the maintenance schedules are strictly adhered to.

b) Routine Maintenance

Routine maintenance is confined to "User Maintenance and Servicing" as defined and detailed in the equipment's Maintenance Schedule (WM-GF2-611). A copy of the schedule along with the Operator Information is provided in the vehicle cab.

The designated operator is responsible for ensuring that "User Maintenance and Servicing" is carried out in accordance with the Driver/Operators Checks. MA's are authorised to carry out the defined routine maintenance without reference to WMAM's.

The WMAM is responsible for monitoring the operator's compliance with the schedule.

A Vehicle Service Record (WM31) is to be kept in each vehicle. Service records for all Winter Maintenance Vehicles/Equipments are to be maintained by the operator including those on temporary loan.

c) Periodic Maintenance

Periodic Maintenance and Inspection of equipment is not part of Routine Maintenance and may only be carried out when specifically authorised by the WMAM.

Periodic Maintenance and Inspection of equipment is defined and detailed within the Equipment's Maintenance Schedule (WM-GF2-611). Copies of the Schedule and Operator Information are provided within the vehicle cab.

The WMAM is responsible for the proper application of Periodic Maintenance.

3.5.14 Salt Loading Hoppers

The Highways Agency provides salt loading hoppers at some motorway compounds. MAs may be responsible for the **routine** maintenance of the salt loading hoppers as instructed in WM31H. WMAMs are available to visit and advise on care and maintenance of hoppers.

During April, or at the end of winter use, MAs shall empty and clear away all salt from the loading equipment and adjacent areas. The equipment shall be washed down thoroughly, to avoid the salt solidifying in the equipment, and lubricated before a detailed examination and annual service is arranged by the WMAM.

3.5.15 Other Plant and Equipment

MAs are responsible for the maintenance and repair of all motorway compound plant and equipment, except where other arrangements are specified by the Highways Agency.

3.5.16 Emergency Power Supplies

MAs should prepare contingency plans to cope with power or communication cuts other than those of a very temporary nature. All the Highways Agency's compounds are wired to accept the installation of generators. The Highways Agency provides emergency standby generators at key depots during the winter maintenance season. Temporary hire of additional generators shall be agreed with the RO.

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3.6 Compounds and Depots

3.6.1 General

The Highways Agency provides a number of motorway maintenance compounds throughout England, and shares MA's depots in a few cases where this is more convenient for both parties.

3.6.2 Health and Safety

The Highways Agency's requirements for management of health and safety within trunk road compounds are detailed in Volume 3 of the Trunk Road Maintenance Manual.

MAs are responsible for co-ordinating health and safety within compounds on a day-to-day basis and for ensuring compliance with agreed policies, standards and procedures applicable to the compound. The MA shall report to the WMAM responsible for the compounds.

Compounds used for trunk road maintenance but not owned by the Highways Agency should adopt similar policies, standards and procedures thus engendering a uniform approach to health and safety in compounds.

3.6.3 Compound Design

Guidance on the design of motorway maintenance compounds and the facilities to be provided is given in the Highways Agency's Design Manual for Roads and Bridges (DMRB) Volume 2, Section 2; BD4/96 "Design Brief for Motorway Maintenance Compounds".

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3.7 Salt

3.7.1 General

Salt to be used for the winter maintenance treatment of trunk roads shall be a suitable grade so as to be fit for the purpose. Periodic sample checks and tests shall be carried out, as appropriate, to ensure continued suitability.

Generally, salt is also treated with an anti-caking agent, such as sodium ferrocyanide. Salt which has not been treated may solidify, leading to storage, loading and spreading difficulties. The density of salt ranges from about 1.2 to 1.5 Tonne/m³ according to origin and moisture content. Salt shall be kept as dry as possible to lessen the problems of caking, especially when loading and discharging from hoppers and vehicles.

3.7.2 Properties

Salt (sodium chloride NaCl) will melt ice and snow at temperatures as low as minus 21°C, but below minus 10°C the amount needed increases significantly so that it becomes environmentally and economically undesirable. For trunk roads, salt shall be used down to about minus 10°C. When temperatures fall below minus 10°C, it may be necessary for additives to be mixed with the salt (see 3.4.4 and 3.4.5).

3.7.3 Storage

Salt shall be kept as dry as possible by proper storage. Wet salt tends to attack spreading equipment more than dry salt and so increases maintenance costs. Dry salt can be spread more accurately and economically on the road.

Salt shall therefore be covered. An uncovered salt pile will form crusts on the surface, and wet salt, if subjected to prolonged low temperatures, may solidify (because of the formation of sodium chloride anhydrate), creating a risk of contamination through rainfall run-off.

Bases for salt storage shall not be made of earth, rubble, clinker, spent tarmac or other loose material as this can become mixed with the salt and cause obstruction and damage to spreading and loading vehicles. A hard, smooth, durable surface which is resistant to salt-induced spalling is recommended. Salt piles shall not be stored within the rooting area of trees or within 4.5 metres of hedges. Salt stored within 15 metres of tree rooting areas shall be on impermeable foundations.

Drainage of salt storage sites requires particular attention. Ideally, the salt base should be encircled by a cut-off drain. Run-off from other parts of the site shall not underwash the pile. It is important that the water content of a stockpile is not increased by ground water rising into it. The centre of the pile shall be higher than its perimeter so that any drainage moisture will flow to the outer edges and away. The surface of piles shall be convex and limited in height to avoid the creation of steep faces liable to sudden collapse. Where there are two or more piles closely situated, provision shall be made for adequate drainage between them.

Salt barns have clear advantages over salt stacked in the open, since no salt is lost to rainfall (large uncovered piles typically lose approximately 0.13% to 0.25% per year of the initial weight of salt for each inch of rainfall). Salt in barns stays dry, and drainage and pollution problems are reduced to a minimum. The cost of the barns can be kept down by careful design and the use of proprietary building

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systems. Guidance on the design of salt barns is given in the Highways Agency's Design Manual for Roads and Bridges (DMRB) Volume 2, Section 2; BD4/96.

Protective sheeting shall be used to cover salt not stored in barns. Sheeting should be placed over the pile in manageable sections and all joints over-lapped by about 2 metres. Sheeting should be arranged to encourage salt being taken from one end only, in order to limit moisture absorption. Ideally, the exposed end should be re-covered after each salt take. Sheeting should be held down by being covered with a suitable net. Weights, such as old tyres or railway sleepers should be placed on the top and around the base, leaving adequate drainage paths. Netting should be uniformly tense, keeping the sheets tightly in place even if the pile settles. A wall around the pile makes it easier to hang weights on the netting.

Salt hoppers make loading the spreading/snowploughing vehicles quick and easy, even when conditions are poor. They should be used to full advantage when provided.

3.7.4 Environmental Aspects

Salt accelerates the corrosion of metal when it is exposed to the air and especially when the moisture level is high. The corrosion of steel in reinforced concrete is particularly insidious as it spalls the concrete and eventually leads to its disintegration. Protection is often provided by impregnation treatments to exposed concrete and applying waterproofing membranes to bridge decks.

The corrosive nature of salt makes careful cleaning and maintenance of the vehicles and plant essential. They shall be regularly washed down and lubricated (see chapter 3.5).

A strong solution of salt in ground water can affect the properties of soils, resulting in the dehydration of plants, but, provided that the rate of spread is not greater than specified in chapter 3.4, the resulting salt solution will not be strong enough to unduly affect roadside vegetation, nor is run-off from the carriageway likely to threaten aquatic life or drinking water supplies.

Run-off from large salt stockpiles may however give cause for concern about pollution of watercourses and groundwaters. This can come from both the salt itself and the sodium ferrocyanide anti-caking agent which is often added to it.

3.7.5 Salt Stocks

An efficient service depends on the adequate stockpiling of salt before the winter starts and a close watch being kept on stocks to ensure that replenishment takes place, if need be, well before the salt runs out.

Unless other arrangements prevail, stocks of salt shall be ordered, and paid for, by MAs (or their Contractors as appropriate) in the first instance and quantities used on the trunk roads shall be charged to the Highways Agency. Some suppliers of rock salt offer price reductions if firm orders are placed at certain times of the year. Suppliers should be asked about such arrangements and full advantage should be taken of them, where possible.

3.8 Alternative De-Icers

3.8.1 General

This chapter gives general information on the principal types of commercially available de-icing materials which might be considered as an alternative to rock salt.

Alternative de-icers are usually more expensive and their use is subject to approval by the Highways Agency. Full and detailed substantiation of the benefits derived from use of the chosen de-icer in preference to rock salt will be required. It is anticipated that any use of an alternative de-icer will be restricted to isolated, very specific circumstances.

Alternative de-icing materials which might be considered include:

- (a) urea
- (b) acetate salts
- (c) acetate salts in solution
- (d) glycol
- (e) brine and pre-wetted salt

3.8.2 Urea

(a) General

Urea is a white, crystalline substance with a bulk density of approximately 0.74 Tonne/m³. It is normally supplied as spherical pellets and applied using a purpose built spreading vehicle, with wetting of the compound taking place immediately prior to its release onto the spinner of the spreading vehicle.

(b) Properties

The recommended spread rates for urea vary from 20 g/m² for a normal precautionary treatment to 50 g/m² in severe conditions. The de-icing action is not immediate and agitation by traffic is necessary for effective reaction.

The de-icing properties of urea depend on the temperature and on the proportion of urea present in the water (i.e. ice or snow). For example, a solution of 10% urea to water by weight prevents icing down to about minus 3°C; a 25% solution prevents icing to about minus 7°C. Below this temperature urea has little worthwhile effect and ceases to melt ice altogether at minus 11.5°C.

Urea remains effective for up to 12 hours in fair weather but repeat applications need to be more frequent in rain or strong winds.

Urea is spread in conjunction with a wetting agent (a mixture of water and anti-freeze) to improve spreading uniformity, increase adhesion to the road and resist the material being blown away. It increases the skid resistance of an icy road, but not as dramatically as salt, and the wetting agent can initially have an adverse effect on skid resistance.

(c) Storage

Urea should be stored, loosely or in 50 kg bags, in a dry, cool building, giving protection from the weather and free from appreciable temperature fluctuations so that condensation from the atmosphere is avoided. Bags, if used, should preferably not be stacked directly upon concrete floors and pallets should not be stacked more than two high as pressure tends to promote cracking and setting. The building should be well ventilated, to prevent the build up of ammonia fumes, particularly in summer. Forced ventilation may be necessary if all doors and windows are closed. Bulk urea can also be stored in purpose built, plastic lined timber hoppers.

When heated at or above its melting point, urea decomposes with the formation of biuret, cyanuric acid, ammeline and other related products. Therefore, no attempt to deal with substantial fires in urea storage areas should be made by anyone other than trained fire-fighters, properly equipped with breathing apparatus. Local Fire Fighting Services should be informed of urea stock sites.

Urea is safe to handle but the pellets break into powder easily; face masks and eye protection are recommended. It also becomes very slippery when spilt due to its high hygroscopic nature.

(d) Environmental Aspects

Urea is non-aggressive, but very soluble in water, and its aqueous solution may be hydrolysed to produce ammonia and carbon dioxide.

Ammonia is toxic to aquatic life. In addition ammonia further decomposes to nitrate which, as well as promoting growth of vegetation, creates an oxygen demand that may cause further harm to life.

Urea in solution is known to have been deleterious to steel, plastics and concrete in some circumstances. Vehicles should not be left full of urea for any length of time; particular problems with urea solidifying have occurred because of loads being left in the vehicles. Vehicles should be thoroughly washed down after use.

3.8.3 Acetate Salts

(a) General

Commercially available de-icing materials based on acetate salts are supplied as small granules or pellets, have a bulk density of approximately 0.75 Tonne/m³ and are applied either dry or with pre-wetting immediately prior to release onto the spinner of the spreading vehicle.

(b) Properties

Recommended spread rates for acetate salts vary from 20 g/m² to 40 g/m² depending on conditions. The de-icing action is not immediate and agitation by traffic is necessary for effective action.

The effectiveness of acetate salts decreases below minus 5°C and they are largely ineffective below minus 15°C. The residual effect of these materials is greater than for rock salt.

Acetate salts are usually applied dry from a conventional spreading machine although pre-wetting with an acetate salt in solution can improve the effectiveness of spreading, increase adhesion to the pavement surface and instigate immediate melting.

(c) Storage

Acetate salts are usually supplied in 600-1000 kg polythene lined bags which can be stored in a dry warehouse and handled by fork lift truck. Alternatively, bulk storage is possible in plastic-lined timber hoppers.

Gloves, eye protection and dust masks are recommended when handling acetate salts, although they do not constitute significant health hazards.

(d) Environmental Aspects

Acetate salts are significantly less corrosive than rock salt, have little effect on construction materials generally and are safe to aquatic life.

3.8.4 Acetate Salts in Solution

(a) General

De-icing materials based on acetate salts in solution have a density of approximately 1.25 Tonne/m³ and are sprayed directly onto the road surface.

(b) Properties

Recommended spread rates for these liquids vary from 10 g/m² for precautionary treatment up to 40 g/m² for de-icing. The solution acts almost instantaneously.

Acetate salts in solution may remain effective for up to 48 hours in suitable weather conditions. They are effective down to a minimum temperature of minus 15°C and have been shown to melt ice faster than rock salt and most alternatives.

Application of acetate salts in solution may be either by spray bar or via a spinner. The skid resistance of a wet road is not significantly affected by a precautionary treatment.

(c) Storage

Acetate salt solutions can be stored in bulk in steel tanks or supplied and stored in 210 litre drums.

Gloves and eye protection are recommended, although the solutions are safe to handle.

(d) Environmental Aspects

Acetate salts in solution are significantly less corrosive than rock salt, have little effect on construction materials generally and are safe to aquatic life.

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3.8.5 Glycol

(a) General

Glycol-based water-soluble de-icing fluids have a density of approximately 1.25 Tonne/m³ and are sprayed directly onto the road surface.

(b) Properties

Recommended spread rates for glycol-based de-icers vary from 10 g/m² for precautionary treatment to 40 g/m² for de-icing.

Glycol-based de-icers are effective down to minus 12°C and remain effective for up to 24 hours in light traffic and suitable weather conditions.

Application of glycol-based de-icing fluids may be either by spray bar or via a spinner. The skid resistance of the road surface is temporarily reduced immediately after application, but no adverse effect is apparent after approximately 10 minutes.

(c) Storage

Glycol-based solutions may be stored in bulk in steel tanks or in 210 litre drums.

Gloves and eye protection are recommended. Glycol based solutions are harmful if swallowed.

(d) Environmental Aspects

Glycol-based solutions have no noticeable effect on construction materials but in high concentrations they can be toxic to aquatic life.

3.8.6 Brine and Pre-wetted Salt

(a) General

A 25% reduction in rock salt usage can be achieved by pre-wetting the salt with water, or a 75% reduction can be achieved by producing brine; a fully saturated solution of salt in water.

(b) Properties

Pre-wetted salt and brine are effective over a similar temperature range to rock salt but adhere to the road better than dry salt and can be spread more uniformly with less wastage. A faster application rate is possible and the de-icing action is more immediate. Brine is more easily dispersed by rain.

(c) Storage

Pre-wetted salt is stored as dry salt; the water being added immediately prior to application. Brine may also be stored primarily as dry salt, with a batching plant in the compound producing the brine which would then be held in an appropriate tank.

3.9 Thermal Mapping

3.9.1 General

Thermal mapping of a road network identifies temperature profiles and particular problem areas, different climatic zones, and ice prediction sensor sites. A thermal map can be used to extrapolate information from specific sensors to the whole network.

The Highways Agency, in consultation with FOs and companies which carry out thermal surveys, has drawn up a specification for thermal mapping (see **Annex 3.9.1**). If a MA wishes to establish predictive thermal map facilities within its ice prediction system, then thermal maps produced from several surveys, made under different but representative weather conditions, need to be stored in digital form in the system's database.

Surveying is carried out using equipment mounted in either an aeroplane or road vehicle. As aerial surveying techniques are restricted to operating in clear conditions, they cannot provide a complete range of thermal maps for predictive displays. However, they are suitable for sensor location and have the benefit of surveying large geographical areas quickly. They also have the advantage over ground based surveying techniques of providing detailed information of roadside features that affect road surface temperatures, as well as surveying all lanes of multi-carriageway roads.

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Annex 3.9.1

Thermal Mapping Specification
(Ref. no. : HM-TM1, 1988)

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1. Introduction

The Highways Agency encourages MAs to install ice prediction systems as an aid to improve forecasts of road conditions, leading to a more cost effective winter maintenance service. Specification number TR2020 describes how such systems operate in the interests of a National Ice Prediction Network (see **Annex 3.10.1**).

This Specification details the parameters to which companies offering thermal mapping services must operate, the weather conditions under which they must be carried out, and the format in which the results must be presented to MAs if the Highways Agency is to recompense MAs for thermal mapping of the trunk roads. MAs should ensure that firms appointed to carry out thermal mapping do so in accordance with this Specification.

2. Definitions

Minimum Road Surface Temperature: The lowest temperature reached by the road surface at a given point during the night. (The minimum road surface temperature normally occurs at about the time of sunrise).

Route Survey: The observation and recording of all spatial and other factors on an adjacent carriageway that can significantly affect minimum road surface temperature. (eg. road construction, emissivity, orientation, slope, embankments, cuttings, trees, etc).

Thermal Survey: The measurement and recording of spatial variations of road surface temperature using passive infra-red sensors.

Thermal Map: The representation on a road map (typically at a scale of approximately 1:50,000) of the spatial variations of minimum night-time road surface temperature.

Thermal Mapping: The process of producing a thermal map. This includes the measurement of road surface temperatures, the application of any corrections required to calculate road surface temperatures at a particular reference time and the presentation of the results.

Reference Time: A single time to which observations from a thermal survey are corrected, so eliminating the influence of temporal changes in road surface temperature when surveys take a significant length of time.

3. Applications of Thermal Maps

Road surface temperature varies in both space and time. It is dependent on certain fixed factors such as altitude, topography, road construction and sky-view factor and on variable factors such as traffic density and weather conditions. For the way these factors control road surface temperature see Section 5 of this Annex. Thermal maps, which depict the spatial variations in minimum road surface temperature, have several applications which include either:

- (a) identification of those points on the road at which road surface sensors should be installed to provide the most complete and representative information on road surface conditions possible with a small number of sensors; or

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- (b) indication, for particular weather conditions, of how the minimum road surface temperatures at all mapped points on the road network are related to the minimum road surface temperature at those points where measurements and/or forecasts are available.

4. Specification

4.1 Thermal Surveys

- (a) Thermal surveys must be carried out between midnight and sunrise during the months November to March. Outside these periods ie. between sunrise and midnight during the winter months and at any time between April and October variations in roads surface temperature depend more on traffic density and the receipt of solar radiation during the day, than on the loss of terrestrial radiation at night. However in Scotland, it might be possible to continue surveying to mid-April.
- (b) Each survey shall be labelled with the date and time.
- (c) The resolution of recorded road surface temperature data shall be 0.2°C (or better) and the accuracy shall be 1.0°C as demonstrated in calibration checks. This accuracy must be maintained over the full operational range of the equipment used for the thermal survey.
- (d) The average road surface temperature for a given run shall not be greater than plus 5°C.
- (e) Measurements of road surface temperature must be made at least every 20 metres along the road, although it may be necessary to take closer readings (every 5 metres, say) in areas where sensor locations are being identified. Actual siting of sensors will be restricted by the availability of power and telephone services. Where possible sites should be chosen so that vandalism of roadside equipment is unlikely.
- (f) The value of emissivity of the road surface used to derive each road surface temperature shall be recorded.
- (g) The state of the road surface at the time of the thermal survey shall be recorded (ie. dry, wet, frost, ice or salt).
- (h) For each thermal survey a detailed description of the prevailing weather conditions shall be provided. This shall include:
- i) cloud type, amount and cloud base height (low, medium or high). This information may be obtained from the local FO;
 - ii) wind speed and direction. Actual height at which the wind is measured to be stated. Measurements to be corrected to a height of 2 metres using Table 3.9.1;
 - iii) air temperature (at a height of 1.25 m);
 - iv) dew point temperature (at a height 1.25 m).

Height of wind observation (m)	Multiplying factor to be used to obtain wind at 2 m height	
	cloudy and/or windy	clear, very light winds
1	1.2	1.3
3	0.9	0.9
5	0.5	0.5

Table 3.9.1 Wind Speed Correction Factors

The above measurements must be made at a point representative of the area of the survey and at the start and end of the survey. The local FO may be asked to provide supplementary weather details from the nearest weather station. Conditions shall be recorded at least hourly. The description shall also include text describing changes in weather conditions along the route which are not adequately defined by the above information.

- (i) When ground based thermal surveying techniques are used, surveys of both sides of a dual carriageway are not normally necessary but should be done if the two carriageways diverge significantly or differ in construction, as in the case of an 'old' road forming one carriageway of a dual carriageway. Where there is more than one lane, data is ideally required for the righthand lane which is normally colder. However, as no vehicle should run continuously in the righthand lane, measurements should be taken in the centre lane of a 3 lane carriageway or the lefthand lane of a 2 lane carriageway. Sample runs in the righthand lane should be made to establish the relationship. The police should be informed if surveying is likely to cause problems for traffic. Aerial surveys automatically include both carriageways plus hard shoulders, verges and adjoining land.
- (j) Survey times should not be greater than one hour, preferably less. However, if a thermal survey lasts more than 1 hour it is essential to survey parts of the route(s) twice to quantify changes in the road surface temperature with time, to enable all temperatures to be adjusted to a common reference time, preferably around the time of minimum road surface temperature.

4.2 Route Surveys

The route survey shall provide the following information:

- (a) Reference to the MA's CHART referencing system and to other major features such as bridges and main interchanges;
- (b) Changes in road surface type with reference points (eg. black top, concrete or elevated);
- (c) Presence or absence of trees, hedges, buildings, cuttings and embankments (if they dominate or have influence upon the road surface temperature).

Note: All the above should be identified within the MA's CHART referencing system.

4.3 Weather Conditions for Thermal Surveys

Thermal surveys may be required in any of the following conditions:

- (a) Calm and clear: wind speed less than 6 knots at 2 metres height, with negligible amounts of low and medium cloud;
- (b) Windy and cloudy: wind speed more than 6 knots at 2 metres height, thick low cloud;
- (c) Intermediate conditions: surveys here will require individual analysis but can be helpful to show the sort of variations which occur between the two extremes covered by (a) and (b). Particular care is required for non-uniform cloud situations as the cloud will be a significant factor. Preference should be given to windy and clear conditions or to calm and cloudy conditions, if possible.

The number of thermal surveys required and the weather conditions in which they should be carried out depends on the use to be made of the resultant thermal maps. If the thermal map is to be used only for sensor site selection, a single thermal survey made in calm and clear conditions may suffice, but this is a minimum requirement. One single run, even under clear calm conditions, will not necessarily give a representative thermal map, although one airborne survey will provide rapid synoptic imaging with high spatial resolution along an entire route corridor.

If a thermal map is required as an aid to the prediction of road surface temperature and the management of winter maintenance, a series of thermal surveys (usually 5) must be made under different weather conditions. MAs should consult their local FO to advise on how many runs are required. (eg. Extra surveys may be required for different wind directions where there are important local influences like conurbations or coasts and hills).

4.4 Results in Digital Form

For each survey, the results of all runs carried out are required in digital form as specified in Table 3.9.2. The following information shall be given at maximum intervals of 20 metres:

- (a) Position along road (in metres from CHART nodes);
- (b) Emissivity used to correct observations to road surface temperature, to 0.5%;
- (c) Temperature (°C), recorded with a resolution of 0.2°C;
- (d) Corrected temperature (°C), also to 0.2°C, at a common reference time, after correction to account for the duration of the survey;
- (e) Two further temperatures, (as required, referring to righthand lane as (a) to (d)).

This data shall be preceded by a file giving date, time and position (relative to MA's reference points) at the start and end of the survey. When a survey involves an out and back, or circuitous traverse, this information shall also be given for the turning points of the traverse. The file shall also include the survey reference point, the reference time to which the temperature measurements are corrected, and whether temperature data are given for both righthand and lefthand lanes of the road (righthand and middle lanes for a 3 lane carriageway). The file will also have a detailed description of the prevailing weather conditions at the start and end of the survey, and (for long surveys) at intermediate hours too.

Item No	Description	Character format
1	Route description, including location references at start and end of survey, and at intermediate points on the route. Place of measurement of air temperature, wind speed, cloud.	up to 1024 ch. in length
2	Survey date (DDMMYY)	I6
3	Start time (GMT) (HHMM)	I4
4	End time of survey (GMT) (HHMM)	I4
5	Height of dry bulb and dew point measurements (m)	F4.2
6	Height of wind speed measurement (m)	F5.1
7	Start air temperature (°C)	F5.1
8	Start dew point temperature (°C)	F5.1
9	Start cloud cover (0-8), cloud type+ and cloud base height (ft)	3(I1, Char, I5)
10	Start wind speed (knots), as measured, and corrected to 2 m height, and direction	2 I2 Char*3
11	End air temperature, dew point, cloud, wind speeds and direction	2F5.1, 3(I1, Char, I5), 2I2, Char*3
12	Number of intermediate (hourly) meteorological observations	I1
13	Start time of intermediate meteorological observations (HHMM)	I4
14-37	Hourly intermediate observations as 7-10 above	2F5.1, 3(I1, Char, I5), 2I2, Char*3
38	Reference point (8 figure National Grid Reference (NGR)) from which survey distances are measured	I8
39	Reference time to which survey temperatures are corrected (HHMM)	I4
40	Indicator for lane carriageway. 1. middle/lefthand lane only; 2. righthand and middle/lefthand lane surveyed	I1
41-??	Time (HHMM, every kilometre); Distance (in m); Emissivity used to correct observations to RST (%); Road temperature (°C) to 0.2°C; Estimated temperature at reference time after correction to allow for survey duration; 2 optional further temperatures if righthand lane data are also available	(I4,I6,5F5.1)
Note: + L = low cloud (base <8000 ft); M = medium cloud (base 8000-20000 ft); H = high cloud (base > 20000 ft)		

Table 3.9.2 Format of Digital Data

4.5 Tabular Data

The data from the route survey shall be given as specified in Section 4.2. For each survey, a detailed description of the prevailing weather conditions is required, as specified in Section 4.1 (h).

4.6 Results in Pictorial Form

The digital data, corrected to the survey reference time, shall be used to show the variation of temperature along the survey route in graphical form for each survey.

In addition, composite maps constructed from the individual survey shall be provided. These shall be drawn for each of the weather conditions in section 4.3. However, only one, depicting the first of the extremes, is required when thermal mapping is being done purely for sensor site selection.

All map data should be at a scale of approximately 1:50,000, or as otherwise specified.

Colours representing 1°C temperature bands should be used to identify variations in temperature on maps. The colour coding shall be clearly stated: it is recommended that the colours used should be from the sequence (coldest temperature first) blue, green, yellow, orange, red, with a further subdivision of dark and light blue and green when wide variations of temperature are encountered. The horizontal resolution should be 50 metres, or as otherwise specified.

4.7 Explanatory Text

The maps are to be accompanied by text explaining the variations of temperature along the routes, with long-sections provided to amplify the text. Further interpretation is required, giving areas which the surveys have shown to possess similar thermal climates and groupings of routes with similar temperature profiles.

4.8 General Notes on the Results

The number of copies of maps, 'fingerprints', drawings, reports etc shall be supplied in accordance with the MA's requirements.

When the MA has requested advice concerning the location of sensors, a list of representative sites shall be produced, ranked in order of priority. This will enable a final selection to be made, also taking into account other factors such as the availability of power and telephone lines and security considerations.

The information provided in Sections 4.4 to 4.6 should be sufficient to enable ice prediction systems to be designed and implemented.

5. Factors Controlling Road Surface Temperature

5.1 General

The surface temperature of a road is determined by its construction, its location, its surroundings, the traffic it carries, the weather (particularly the air temperature) and the time of day and season. This Section describes how these factors exert their influence on road surface temperature.

5.2 Temporal (diurnal) Variations in Road Surface Temperature

Road temperature is determined by heat exchanges between its surface and its surroundings. Generally the surface of the road gains heat by absorbing short-wave radiation from the sun and sky and long-wave radiation from the sky, clouds, buildings, trees, etc. The road surface loses heat by radiating long-wave radiation both day and night at a rate depending on its temperature. It also exchanges heat with the body of the road at a rate which depends on road construction and core temperature. Normally the radiation exchange results in a net gain of heat during the day and a net loss of heat during the night. The road surface also exchanges heat, by conduction and convection, with air in contact with it. The rate of this heat exchange depends on the temperature difference between the road and the air, the wind speed, the humidity and the road wetness.

The heat exchanges result in a diurnal regime of road surface temperature in which the maximum normally occurs in the early afternoon and the minimum usually around dawn. Immediately after sunset road surface temperature falls rapidly, but this decline levels off so that during the latter part of a winter night, road surface temperature falls at a lower rate. After sunrise it usually increases rapidly and this increase is often aided by increasing traffic flow.

The diurnal variation of road surface temperature at any point is affected by weather and traffic which influence the time of maximum and minimum temperature and also the amplitude of the diurnal change.

5.3 Altitude and Topography

Normally the lower part of the atmosphere is kept well mixed by the wind, and air temperature falls with height at an average 'lapse rate' of about 6.5°C per 1000 metres. On windy and cloudy nights, road temperature is very similar to the temperature of the air near its surface, and the lowest road surface temperatures are found on the highest hills.

However, on calm and clear nights the exchange of heat between the road and the air is much less efficient, and the road surface temperature can fall several degrees below that of the air above it. The lowest road temperatures then usually occur in the places where the wind is lightest, that is in hollows and valley bottoms. Further, the air temperature in the lowest layer of the atmosphere on these occurrences may increase with height; this is known as an inversion.

In some circumstances, where there is a large variation in altitude, the highest temperature may be experienced in middle altitudes between the cold hill tops and the cold valley bottoms.

5.4 Sky-view

An open level road with no adjacent buildings, hedges or trees is fully exposed to radiation from the sun and sky. It can also lose the maximum amount of heat by long-wave radiation to the sky. Radiation loss from the road is reduced by buildings, trees, hedges, cuttings, etc., all of which emit much more radiation towards the road at night than would the portion of the sky that they obscure. Hence, roads in cuttings, under bridges or lined with trees or buildings may stay warmer at night than more exposed roads.

Conversely, such sheltered roads may warm more slowly than exposed roads, if direct solar radiation cannot reach their surfaces in the early morning.

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5.5 Road Construction

Road construction is important because heat is absorbed, stored and released from a road according to its thermal properties. Depth of construction is important too - usually the greater the depth of construction the warmer the road. As a result motorways are normally warmer at night than other roads, and concrete roads are frequently warmer than bituminous roads.

Where a road crosses a bridge, it is likely to be colder due to its shallow construction. However, bridges over water may be less affected as a result of radiation received from the relatively warm water.

5.6 Urban Heat Islands

The centre of a large town or city is often several degrees warmer than the surrounding rural areas; this is known as the urban heat island effect. The relatively high temperature in urban areas is the result of industrial, commercial and domestic heat sources within the city allied to the facts that the fabric of the urban environment retains heat to a greater degree than rural areas, and the average sky-view factor for the roads is lower in an urban area.

On nights with light winds, warmer air drifting from an urban area may keep road surface temperature relatively high in the rural area just down wind of a city. Therefore wind direction can be crucial.

5.7 Traffic

Traffic tends to keep a road warm at night by reducing the sky-view factor, and stirring the air above the road, mixing cold air near the surface with warmer air from above, and so increasing the transfer of heat from the air to the road. Traffic also has a more direct heating effect by transferring heat by conduction to the road from tyres warmed by friction and by radiation from exhausts and engines. Vehicles tend to concentrate in the nearside lane of a road and so inside lanes are generally warmer than outside lanes at night. This phenomenon is most significant on motorways that carry a high volume of traffic at night and temperatures across a carriageway may vary by 1°C or more because of differences in the volume of traffic between lanes. "Peak time" traffic flows can also lead to variations between carriageways.

5.8 Weather

Unless a road is provided with an artificial source of heat, weather is the major factor controlling road surface temperature. All other factors modify the effects of the weather on different sections of a road network. When the weather is windy and there is a complete cover of low cloud, variations of road surface temperature across the road network are at a minimum and the road temperature is very similar to the air temperature. However, when the sky is clear and the wind is light, topography, road construction, sky-view factor, traffic and urban heat sources have their greatest effects, and the variations of road surface temperature throughout the road network at their maximum. In these conditions road surface temperature at night may be several degrees lower than the air temperature and during the day it is often more than 10°C higher than the air temperature.

3.10 Ice Prediction Systems

3.10.1 General

Many MAs have found ice prediction systems to be an effective aid to improving the economy and effectiveness of their winter maintenance operations, and the Highways Agency supports the use of such systems on the Trunk Road network. If a MA is properly organised to take advantage of the information that the systems provide, the need for extensive road inspections is reduced, as deteriorating road weather conditions are identified by the system and reported to the control centre. Treatment can be reduced to when and where it is required, and the decision to treat can be more safely delayed or even avoided altogether.

The Highways Agency's requirements for an Ice Prediction Network, are contained in the Department of Transport Specification TR2020 and these should ensure that ice prediction systems designed and installed by different companies communicate in a common language with the FO's weather forecasting data collection systems. Any ice prediction system installed by a MA must comply with such requirements if the Highways Agency is expected to contribute to its running costs. MAs who are in the process of purchasing a system should check with their suppliers that it will comply with the Highways Agency's current requirements.

TR2020 is reviewed regularly with FOs, equipment manufacturers and system users. (For the latest version refer to **Annex 3.10.1**). The Highways Agency's current requirements enable elements of road weather forecasting services to be sent directly to a computer screen. MAs with existing systems who wish to receive data by this method should contact their system supplier to obtain the appropriate software.

Before an effective ice prediction system can be installed, it is desirable for roads to be thermally mapped (see chapter 3.9) in order to identify their temperature profiles, and the environmental characteristics that lead to variations in road surface temperature, and to identify the optimum sites for temperature and other sensor locations.

It is vital that road sensors are installed in a uniform manner at sites representative of the road network and with regard to the immediate surroundings. Siting and installation of those sensors from which FOs propose to receive data, shall be agreed and effected to their satisfaction. It is also recommended that their advice be followed for all other sensor sites in a system. Calibration of road sensors is not covered by this Part. MAs should contact the sensor and system suppliers who will be able to give the necessary data to enable the calibration of the road sensors to be undertaken.

3.10.2 Site Selection of Road Surface Temperature Sensors

Road sensors should be sited after careful study of thermal maps. This section sets out those aspects of siting and inspection of road sensors that are dependent on the variability of those surfaces and elements in both time and space.

Before starting on the process of site selection, a MA should carefully consider the use that will be made of road sensor data. Possible applications are:

- (a) Monitoring the progress of weather changes and comparing actual conditions with those forecast. This is particularly valuable in marginal situations where small errors in the forecast can have significant impact on the needs for winter maintenance activities;

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- (b) Monitoring conditions at sites where road conditions may be significantly different from those on most of the road network or where there is a special need for accurate information on road conditions.

For application (a) the sites should be typical of the majority of the road network, well exposed to wind and weather and not on steep slopes. A full set of road surface sensors and road side meteorological sensors should be installed at such sites. The number of these 'representative' sites required will depend on the range of altitudes covered by the road network and its proximity to the coast and rivers. Measurements from representative sites (usually 3 to 5 in a typical ice prediction system depending on the size of the geographical area to be covered) comprise the necessary input to procedures for forecasting road surface conditions. Such services can be provided without data from sensors, but their inclusion improves the accuracy of the forecast and enables the MA to monitor the situation. The sensor measurements also provide useful feedback on the forecasts for all parties.

Application (b) is, in general, related directly to the needs of the MA. For example, it may be thought desirable to have accurate information on road conditions near a bus station or hospital (even if those areas are neither very well exposed nor likely to be particularly cold) or on a bridge that has a thermal response very different to the majority of the road network.

Application (b) also demands sensors at those points that are likely to be the coldest under particular weather conditions. (Thermal maps are valuable for locating such points and are recommended, see 3.9.1). In the absence of a thermal map, or as additional aids, orographic (elevation) maps and the experience of maintenance staff, local meteorologists and system suppliers should be used to select suitable sites. On calm nights the coldest sites are generally in low-lying areas into which cold air can drain from surrounding high ground. Such areas are particularly cold if they are shaded from the sun by high ground, or other obstructions, on the south side and are open to the north. A road running east-west through a cutting is likely to be much colder than a similar road in a north-south cutting.

In windy cloudy conditions the coldest areas will be near the tops of hills and on slopes facing north or east which have high probability of experiencing snow bearing winds. Whether it is necessary to put sensors in these areas will depend on the range of altitudes within the road network.

3.10.3 Positioning Road Surface Temperature Sensors in the Carriageway

The volume of traffic has a varying umbrella effect on road surface temperature. For example, the carriageway of a motorway will be 'warmer' than the adjoining slip roads. If only one lane of a multi-lane carriageway is monitored, generally the sensor should be sited in the right hand lane to record the lowest temperature. It is desirable that more than one lane is monitored at some sites. However, siting decisions need to be made on the merits of individual circumstances, including the consideration of safety for personnel when inspecting and checking, and expert advice, aided by thermal maps, may be necessary.

3.10.4 Site Selection for Road Side Meteorological Sensors

Sensors of the meteorological elements (ie. air temperature, dew-point, wind speed and wind direction) must be sited where they can make measurements representative of conditions over the road surface sensor.

Such siting will not usually be difficult to achieve at the 'representative' exposed sites and a full set of meteorological sensors should be deployed at such sites. The sensors should be close to the road surface sensors but well away from any buildings, trees or other obstructions. As a general guide, any obstruction that is more than half the height of the sensor above the ground must be at least twice its own height away from the sensors for air temperature and dew-point temperature; and at least four times its own height from the sensors for wind speed and direction. These distances must be increased if the object subtends an azimuth angle at the sensors greater than a few degrees (ie. if it is broad as well as high or is an artificial source of heat). In general, sensors should be at a height between 1.5 and 4 m above the ground at sites that are fully exposed. (Specialist guidance on siting must be arranged with a competent meteorological organisation).

At surface sensor sites chosen for special purposes it will usually be difficult to site meteorological sensors where they can provide measurements representative of conditions over the road surface sensor. However, where it is deemed essential to make such measurements (eg. wind measurements on an exposed bridge) guidance on appropriate siting must be arranged with a competent meteorological organisation.

At some sites it will be impossible to position road side sensors where they can make measurements representative of conditions over the road. At such sites road side sensors should **not** be deployed, because misleading information is worse than no information. In some cases this will result in the site being unsuitable for deployment of ice prediction equipment.

3.10.5 Safety Considerations

Whenever possible, inspection and calibration should be undertaken at the same time as other highway maintenance is carried out, so that advantage is taken of carriageway lane closures. Indeed safety considerations may dictate that inspection, checking and calibration can only be carried out with the protection of carriageway lane closures.

The safety of personnel working on carriageways is of prime importance. MAs are responsible for authorising any work done on roads within their area. Road sensor inspection contractors are responsible for ensuring that they have obtained proper authorisation from the relevant MA prior to personnel inspecting sensors and necessary work commencing. Signs Manual.

3.10.6 Organisational Changes to Maximise the Benefits of Ice Prediction Systems

Installing an ice prediction system and carrying out thermal mapping will not automatically lead to economies in winter maintenance. Consideration also needs to be given to treatment routes, staffing and shift manning arrangements. For example, a stand-by shift may be replaced by a call-out shift arrangement and inspection patrols reduced or eliminated.

To get the maximum benefit from an ice prediction system, MAs should monitor forecasts against actual weather conditions and actual temperatures reported by sensors. Careful use of feedback should enable a MA to identify those stretches of road that tend to be warmer than surrounding roads due to, for example, topography or the heavy volume of traffic they carry. In marginal conditions when indications are that temperatures will dip below plus 1°C, certain roads might remain above 1°C and therefore not require precautionary treatment.

When MAs submit proposals to install ice prediction systems, the RO will expect to see projected savings due to operational changes before agreeing to pay a share of the costs. Reports on monitoring of subsequent costs and savings will be required by the RO (see Volume 1, Part 5).

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Annex 3.10.1

**National Ice Prediction Network Specification
(TR2020B, 1991)**

Contents

Section

- 1. Preamble**
- 2. System Structure**
- 3. Data Communications Protocol**
- 4. Outstation Design and Installation Standards**
- 5. Sensor Installation**
- 6. Maintenance**

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1. Preamble

It is proposed that forecasting of road surface conditions should be enhanced by making road surface and roadside sensor information available to the road weather Forecasting Organisation (FO). Road surface and roadside meteorological sensors are commercially available as parts of ice prediction systems.

This Specification deals with the communication aspects of such a network. It is recognised that sensors may not be commercially available to measure all the parameters included in this Specification. The message formats and protocols relate to the range and resolution required for data transmission purposes; not necessarily the accuracy of measurement. These formats and protocols have been established and are not negotiable.

The accuracy and reliability of forecasts depends upon the accuracy and reliability of the sensors and their outstations for which the MA is responsible. It is strongly recommended that installation practices used by the Highways Agency are followed (see Section 4 of this Annex).

Forecasts are more meaningful if sensors are located over the widest possible area. This means they are likely to be placed on roads where the Public Switched Telephone Network (PSTN) is the most economical telecommunication connection.

The FO's regional weather centres are equipped with computers to communicate with ice prediction systems owned by MAs and to process ice prediction forecasts. (The MA's ice detection system installation is referred to as the MA Instation and the FO computer is referred to as the Forecasting Instation). The telecommunications circuit between the MA Instation and the Forecasting Instation shall operate over PSTN unless they are co-located such that direct interconnection may be used.

In addition to the exchange of sensor information and road condition forecasts this method of transmission may be used for further meteorological information. Where a MA requires such information the message formats and protocols to be used are described in Table 3.10.6.

Any requirement of the Specification for goods or materials to comply with the standard shall be satisfied by compliance with:

- (a) a relevant standard or code of practise of a national standards body or equivalent body of any Member State of the European Community;
- (b) any relevant international standard recognised for use in any Member State of the European Community;
- (c) a relevant technical specification acknowledged for use as a standard by a public authority of any Member State of the European Community;
- (d) traditional procedures of manufacture of a Member State of the European Community where these are the subject of a written technical description sufficiently detailed to permit assessment of the goods or materials for the use specified, provided that the proposed standard, code of practice, technical specification or technical description provides, in use, equivalent levels of safety, suitability and fitness for purpose.

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Any requirement of the Specification to use material or an article which is defined by reference to a named supplier or manufacturer shall be satisfied by using an equivalent material or article of another manufacturer or supplier of any Member State of the European Community, provided that this material or article is, in use, as safe, suitable and fit for the relevant purpose as material or an article complying with the requirements set out in the Specification.

Any requirement for any materials or articles to be designed, manufactured or supplied subject to a quality management scheme or product certification scheme or approval scheme shall be satisfied by compliance with any equivalent quality management scheme or product certification scheme or approval scheme acknowledged for use by a public authority of any member State of the European Community provided that the scheme ensures that the design, manufacture or supply offers, in use, equivalent levels of safety, suitability and fitness for purpose.

2. System Structure

A minimum structure for the ice prediction network is shown in Figure 3.10.1.

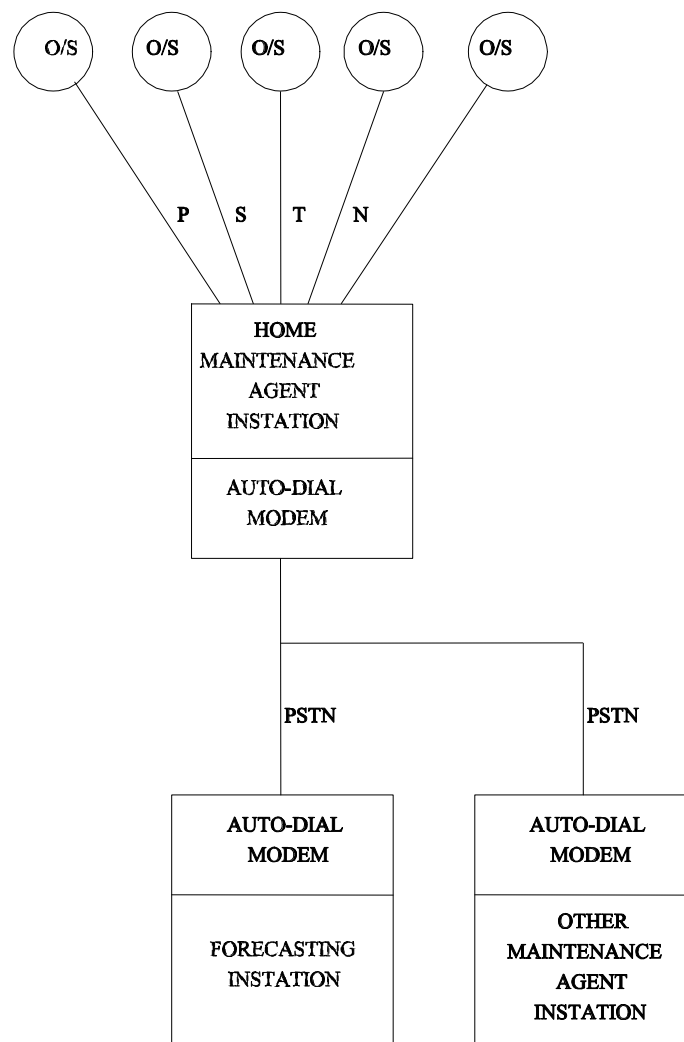


Figure 3.10.1 : Ice Prediction Network Structure

Each designated outstation shall be equipped with sensors as required by the FO and identified in Table 3.10.1. These shall be known as designated sensors and measurement shall be made hourly.

Sensor type	Range	Accuracy
Road surface temperature Depth temperature Air temperature *Dew point temperature	-25 to -15 C -15 to +15 C* +15 to +25 C	± 1.0 C $\pm 0.5^{\circ}\text{C}$ ($\pm 0.75^{\circ}\text{C}$)* ± 1.0 C
Wind speed	0 to 99 Knots	± 2 Knots at speeds > 5 Knots measured over 10 mins period. Gust values not required.

Table 3.10.1 : Parameters for Designated Sensors

MAs may share sensors by arranging for their MA instations either:

- (a) to communicate directly with the shared outstations where their instations are identical; or
- (b) to communicate with the shared outstations by means of the protocols in Table 3.10.4, where their instations are not identical. Protection of information may be achieved by the use of passwords agreed between MAs.

The FO will produce forecasts based on a number of designated outstations (normally 2 to 5) which will be sent to the MA Instation. All received forecasts shall be recorded by the MA Instation. One designated outstation is considered inadequate because in the event of its failure the FO would be denied data from designated sensors.

The MA Instation shall compile a record of all mandatory parameters required by the FO and faults for the designated outstations which it shall store for a 24 hour rolling period. Measurements are required on an hourly basis. The Forecasting Instation may request the designated/sensor measurements from the MA Instation at any time. Data available within the specified period will be sent, but in addition a request to the outstation should be made if the latest data available is more than 1 hour old. The system does not require ice warning systems.

3. Data Communications Protocol

All communications system equipment shall operate in accordance with BS 6301 : 1989, Specification for electrical safety requirement for apparatus for connection to telecommunications networks and BS 6328 - Apparatus for connection to private circuits run by certain public telecommunication operators. All equipment connected to the PSTN shall be approved by the British Approvals Board for Telecommunications or appropriate National Approvals Board for Telecommunications for such connection.

The MA Instation and the Forecasting Instation shall communicate with each other in error-correcting mode. This shall be done by means of modems which comply with Consultative Committee for International Telecommunications and Telegraphy (CCITT) Recommendation V22 bis and use error correction in accordance with CCITT Recommendation V42. In order to accommodate systems installed prior to this version of the Specification, such communication in error correction mode may be by means of Dacom or Scicon 2123 GT intelligent modems, or a compatible equivalent, such that under controlled circumstances the call may only be terminated by the DTE dropping DTR. Such older

systems may be upgraded by the MA so that MA Instations may communicate with the Forecasting Instation by using V22 and V42 standards.

Information exchange shall use the message formats and protocols in Tables 3.10.2 to 3.10.5. The Highways Agency will maintain an up to date central list of approved values of the FO Identity Code, MA Identity Code, Outstation Identity Code and Manufacturer's Code. An appropriate national body may maintain this list for other Member states. At the end of each transmission the Forecasting Instation shall send:

Header	(STX)	MA ID Code	(2 bytes)
FO ID Code	(5 bytes)	Terminator	(EOT)

This shall be echoed back by the MA Instation. In the event that the Forecasting Instation does not receive this echo within a reasonable time period an alarm shall be raised to alert the forecaster.

The initiating instation shall establish the call connection and disconnect the circuit at the end of the dialogue. In the event that the receiving instation does not respond, the initiating instation shall disconnect the circuit before 50 seconds has lapsed and shall display a fault message to the user. The initiating instation should also display call progress messages.

Code	Reference	Forecast numeric data formats
A B C D	Data request Data demand Forecast Time	
E F	Forecast road surface temperature (realistic) Forecast road surface temperature (pessimistic)	in tenths of a degree Celsius with leading sign (\pm) eg. 10.1 deg C road temp = E + 101
G H	Forecast road wetness (realistic) Forecast road wetness (pessimistic)	0 = dry 1 = wet with no precipitation 2 = wet with precipitation
I	Thermal map type	This protocol shall be transmitted by the Forecasting Instation and used by the MA Instation to generate thermal maps. This protocol facilitates the transmission of up to 7 thermal map types but only 3 are currently defined: 0 = no thermal map choice 1 = damped 2 = intermediate 3 = extreme Byte 1 shall be used as follows: Bit 0 = Least significant bit of realistic map type Bit 1 = Middle bit of realistic map type Bit 2 = Least significant bit of pessimistic map type Bit 3 = Middle bit of pessimistic map type Bit 4 = Most significant bit of pessimistic map type Bit 5 = Not used Bit 6 = Not used Bit 7 = Most significant bit of realistic map type Bits 5 and 6 shall be set such that byte 1 does not appear to be a control character.

Table 3.10.2 : Data Transmission Codes (Continued over page)

Code	Reference	Forecast numeric data formats
J K L	Free text Reserved Data not ready	
M N	Data ready Data	

Code	Reference	Sensor data formats
O P Q R	Road surface temperature Depth temperature Air temperature Dew point temperature	in tenths of a degree Celsius with leading sign (\pm) eg. 10.1 deg C air temp. = Q + 101
S	Wind speed	eg 25 Knots = S0025
T	Wind direction	in degrees within range 0 to 360 (optional)
U	Spare	
V	Precipitation	the second and third bytes shall define the Manufacturer's Code with the fourth and fifth used as follows: 0 = precipitation not available 1 = not raining 2 = raining now 3 = there has been precipitation within the previous hour 4 to 99 rainfall used in accordance with manufacturer's specification
W	Surface condition	the second and third bytes shall define the Manufacturer's Code with the fourth and fifth used as follows: 0 = surface condition not available 1 = dry 2 = wet 3 = icy 4 to 99 salinity used in accordance with manufacturer's specification
X Y Z	Reserved Reserved Reserved	

Table 3.10.2 : Data Transmission Codes

Notes: Sensor data formats shall be transmitted in 5 byte sequences of ASCII characters.

FO Instation to MA Instation	
(establish call) Header FO identity code MA identity code Data request Outstation identity code Number of hourly measurements required (the latest being the previous whole hour) Terminator	(STX) (5 bytes) (2 bytes) (A) (3 bytes) (2 bytes) (ETX or EOT for last message)
Repeat message for remaining outstations	
MA Instation to FO Instation	
Header FO identity code MA identity code Data not ready or ready Outstation identity code Terminator	(STX) (5 bytes) (2 bytes) (L) or (M) (3 bytes) (ETX or EOT for last message)
Repeat message for remaining outstations. In the event that there is no data for the period specified in the request message, the MA Instation shall send Data not ready. Data available within the specified period shall always be sent, but in addition a request to the outstation should be made if the latest data is more than 1 hour old.	
FO Instation to MA Instation	
Header FO identity code MA identity code Data demand Outstation identity code Number of hourly measurements required (the latest being the previous whole hour) Terminator	(STX) (5 bytes) (2 bytes) (B) (3 bytes) (2 bytes) (ETX or EOT for last message)
Repeat message for remaining outstations. Data demand messages shall only be sent in response to a Data ready message.	
MA Instation to FO Instation	
Header FO identity code MA identity code Data Outstation identity code Date/time data was measured Data Terminator	(STX) (5 bytes) (2 bytes) (N) (3 bytes) (10 bytes) (40 bytes)(5 bytes/sensor) (ETX or EOT for last message)
Repeat message for each hour specified in the Data Demand message. The MA Instation shall send whatever parts of the requested data it has available. Repeat message for remaining outstations.	

Table 3.10.3 : Procedure for Forecasting Organisation obtaining Sensor Measurements

Home MA Instation to Other MA Instation	
(establish call) Header Home MA Identity Code Other MA Identity Code Data Request Outstation Identity Code Number of Hourly Measurements Required (the latest being the previous whole hour) Terminator	(STX) (2 bytes) (2 bytes) (A) (3 bytes) (2 bytes) (ETX) or (EOT for last message)
Repeat message for remaining outstations	

Other MA Instation to Home MA Instation	
Header Home MA Identity Code Other MA Identity Code Data Not Ready or Ready Outstation Identity Code Terminator	(STX) (2 bytes) (2 bytes) (L) or (M) (3 bytes) (ETX) or (EOT for last message)
Repeat messages for remaining outstations. In the event that there is no data for the period specified in the request message, the MA Instation shall send Data Not Ready. Data available within the specified period shall always be sent, but in addition a request to the outstation should be made if the latest data available is more than 1 hour old.	

Home MA Instation to other MA Instation	
Header Home MA Identity Code Other Identity Code Data Demand Outstation Identity Code Number of Hourly Measurements Required (the latest being the previous whole hour) Terminator	(STX) (2 bytes) (2 bytes) (B) (3 bytes) (2 bytes) (ETX) or (EOT for the last message)
Repeat message for remaining outstations. Data demand messages shall only be sent in response to a Data Ready Message	

Other MA Instation to Home MA Instation	
Header Home MA Identity Code Other MA Identity Code Data Outstation Identity Code Date/Time Data was measured Data Terminator	(STX) (2 bytes) (2 bytes) (N) (3 bytes) (10 bytes) (40 bytes) 5 bytes/sensor (ETX) or (EOT for last message)
Repeat message for each hour specified in the Data Demand message. The Other MA Instation shall send whatever parts of the requested data it has available. Repeat messages for remaining outstations.	

Table 3.10.4 : Procedure for Obtaining Sensor Measurements from other MA Instations

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FO Instation to MA Instation	
(established call) Header FO identity code MA identity code Forecast Date/time of issue Outstation identity code Terminator	(STX) (5 bytes) (2 bytes) (C) (10 bytes) (3 bytes) (ETX)
Header Time Value	(STX) (D) (2 bytes) 00 to 23 hrs
Road surface temperature realistic Value Road surface temperature pessimistic Value Road wetness realistic Value Road wetness pessimistic Value Thermal map type Value Terminator	(E) (4 bytes) (F) (4 bytes) (G) (1 byte) (H) (1 byte) (I) (4 bytes) (ETX)
This message shall be repeated 23 times to enable a two-dimensional 24 hour table or graph to be produced by the MA Installation. The 24th block will normally be followed by a text message using the following format:	
Header FO identity code MA identity code Free text Text Terminator	(STX) (5 bytes) (2 bytes) (J) (64 bytes) (ETX)
This message shall be repeated until free message (with a maximum of 4096 bytes) has been sent. If there are further forecasts to be transmitted, to the same location, at the same time these will follow directly.	
The final block of the final forecast shall be terminated with EOT	

Table 3.10.5 : Procedure for sending Forecast Messages to MA Instations

Notes: The following notes apply to Tables 3.10.3 and 3.10.5:

FO identity code shall be the 5 character code used by the FO to identify their regional weather centre. The first character shall always be I.

MA identity code shall be a 2 byte code

Outstation identity code shall be a 3 byte code

Date/time codes shall be 10 bytes in the format ddmmyyhhmm

FO Instation to MA Instation	
(established call) Header FO identity code MA identity code Meteorological information code Date/time of issue Terminator	(STX) (5 bytes) (2 bytes) (X),(Y),(Z) or (K) (10 bytes) (ETX)
Header MO identity code MA identity code Free text Text Terminator	(STX) (5 bytes) (2 bytes) (J) (64 bytes) (ETX)
<p>This message shall be repeated until the meteorological information message has been sent. If there are further meteorological information or forecast messages to be transmitted to the same location, at the same time, these will follow directly.</p> <p>The final block of the final message shall be terminated with EOT</p>	

Table 3.10.6 : Procedure for sending further Meteorological Information to MA Instations

Notes: Meteorological Information Codes

- X - 2 to 5 day MA forecast
- Y - 24 hour MA forecast
- Z - MA morning summary
- K - radar image

The radar image shall be transmitted as 128 blocks of 64 bytes (these forming a 128 x 128 3-bit pixel image).

A coastline definition shall always be transmitted with a radar image using the 7th and 8th bit of each byte. The 7th bit shall be set to indicate coast present in the first 3-bit pixel of the byte and the 8th bit set for coast present in the second 3-bit pixel of the byte.

The 128 blocks of radar image shall be followed by a free text message with a maximum size of 4096 bytes.

Further details of the radar image message can be obtained on request from the FO.

4. Outstation Design and Installation Standards

It is recommended that outstation equipment should be designed and installed in accordance with the following European Standards to obtain a design compatible with the required life and reliability for the environment in which it is expected to operate. The accuracy of the ice prediction system should comply with Table 3.10.1 under all conditions.

BS 5750/EN29000, Quality Systems has been established as a recognised management tool necessary to ensure good design with good backup service. In particular it is recommended that BS5750 Parts 1 and 2 should be applied where the manufacturer is responsible for installation.

It is recommended that components used in the equipment should be tested in accordance with BS 9000-TR1100-90/0174/UK - General requirements for a system for electronic components of assessed quality and that all outstation equipment, including meteorological sensors, is tested in accordance with European Standard BS 2011/HD323 - Environmental testing.

The Highways Agency's Cabinet 600 and Post 75 are tried and proven housings which will protect electronic outstation equipment from the expected environment and from unauthorised access. Details of these housings may be obtained from the Highways Agency. It is recommended that outstation equipment is installed in accordance with BS 5750 Part 2. Additionally the electricity supply main shall be terminated in such a manner as to comply with the Institution of Electrical Engineers (IEE) Wiring Regulations or equivalent National Wiring Regulations.

5. Sensor Installation

Sensor installation is the responsibility of the MA and is the most critical feature of ice prediction systems. Sensors shall be installed such that the accuracy and reliability of the system complies with Table 3.10.1 under all environmental and traffic conditions. Waterproof seals for road surface temperature sensors shall have thermal characteristics, and be of a colour, similar to the road surface. Failure to comply in this respect may result in considerable errors in road surface temperature measurement. Depth temperature sensors shall be at sub-base level. For siting of sensors see chapter 3.9.

6. Maintenance

As a minimum the condition and calibration of the ice prediction system of the designated outstations, shall be checked and corrected at the start of the winter maintenance season. At least one further check during the winter maintenance season is recommended. Faults shall be repaired within a period specified by the MA.

Annex 3.10.2

Field Inspection and Performance Checks of Road Sensors

Contents

Section

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2. Systematic and Random Errors in Field Checks
3. Inspection of Road Surface Temperature Sensors
4. Inspection of Meteorological Air Temperature Sensors
5. Inspection of Meteorological Dew-Point Temperature Sensors
6. Inspection of Meteorological Wind Speed and Direction Sensors
7. Choice of Acceptance Limits and determination of the Field Observations required to check those Limits
8. Conclusions
 - 8.1 General
 - 8.2 Road Surface Temperature Sensors
 - 8.3 Meteorological Air Temperature Sensors
 - 8.4 Meteorological Dew-point Sensors (direct or indirect)
 - 8.5 Meteorological Wind Speed and Direction Sensors
9. Sample Calculations to determine Field Observations required to check Sensors to TR2020 Standard

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1. Background

The current version of the Highways Agency's Specification "National Ice Prediction Network", TR2020 (see **Annex 3.10.1**) requires that the condition and calibration of an ice prediction system shall be checked at the start of the winter maintenance season. At least one further check during the winter maintenance season is recommended and users may institute more frequent checks when a system has been recently installed and/or when the sensors are to be used in the Summer. In the latter case, sensors should only be calibrated or checked when stable temperature conditions are present, eg. at night.

Tolerance on the accuracy of field checks of road sensors depend upon the representativeness of the measurements and their applications. There is little point in measuring the temperature of a small section of road to a very high accuracy (better the ± 0.1 C say) if it cannot be relied on to represent the temperature of the road surface a short distance away to better than ± 1 C; similarly for air temperature, dew-point temperature and wind. The instruments calibration standards do not need to be more than a factor of two or so better than the limits of representativeness and the tolerances allowed by the current version of TR2020 represent desirable and achievable performance for road surface and roadside meteorological sensors.

The following sections give only general guidance on inspection and checking procedures. It is essential that inspectors' instruments are of acceptable quality and are themselves regularly maintained and calibrated and that inspectors are adequately qualified to judge the effects of buildings, trees, etc on exposure. Professional inspection services are available from several competent meteorological organisations.

2. Systematic and Random Errors in Field Checks

All measurements are subject to random errors and those in the field may have errors as large as the desired tolerance of the system under evaluation. Therefore it is necessary to carry out statistical analysis of the results from the field checks to determine the magnitude of random errors. The inspectors' report should include the results from such analysis to demonstrate the accuracy of the field checks.

The 'systematic' error at any site may have two components:

- (a) the real error of the sensor at the particular site;
- (b) any components of the error in the check reading that is constant for the series of readings made at the site.

There is no simple statistical test that will separate the two parts of the systematic error. Only good practice during the field checks and careful analysis of the results can reduce the systematic errors of the check readings to an acceptable level.

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3. Inspection of Road Surface Temperature Sensors

A road surface sensor shall be in good condition and not heavily contaminated by deposits of dirt, oil or rubber. The sensor shall not be above or below the level of the road around it. Coloured photographs should be taken of any sensor that is not in a satisfactory condition.

The accuracy of a road surface temperature sensor can be checked with a surface contact probe provided there are not large temperature gradients within the top few centimetres of the road or in the air above it.

It is strongly recommended that these checks should be carried out during the hours of darkness and in cloudy and windy conditions. If it is not possible to do this, a technique should be used to eliminate large temperature gradients. This can be achieved, even in sunny conditions, by screening the road sensor from direct solar radiation. A modified form of the type of screen used by meteorologists for the measurement of air temperature has been found satisfactory. In cloudy conditions measurements may be made within about 10 minutes of screening the sensor but in sunny weather a period in excess of 30 minutes may be required before the road temperature reaches equilibrium under the screen and accurate comparisons can be made between the road sensor and the check instruments. There should be an interval of at least 10 minutes between check readings so that any trend in the differences between sensor and check data can be identified.

Checks of road surface temperature sensors, by experienced inspectors using accurate high resolution equipment, have random errors with a standard deviation of about 0.14 C in sunny conditions. In cloudy conditions the errors are smaller, the standard deviation of difference between the road sensors and the check instrument is about 0.1 C.

4. Inspection of Meteorological Air Temperature Sensors

Inspection of an air temperature sensor should ensure that it is in a screen recommended by a competent meteorological organisation that protects it from direct solar radiation but allows an adequate flow of air over the sensor. The thermometer screen must be correctly exposed.

Road side sensors of air temperature are typically 3 to 5 m above ground level (to reduce damage by vandals) and in sunny conditions with light winds there is often a difference in temperature of several tenths C between the air at the Meteorological standard level of 1.25 m above the ground and that at 5 m. For accurate checks the reference instrument must be exposed at the same height as the road side sensor.

If difference in exposure of the road side sensors and the check instruments are eliminated it is possible to make reliable checks under all conditions in the field. There should be an interval of at least 10 minutes between check readings so that any trend in the differences between the sensor and check data can be identified. When the check instrument is correctly exposed the random errors in the field checks should have a standard deviation less than 0.14 C.

5. Inspection of Meteorological Dew-Point Temperature Sensors

Inspection of dew-point temperature sensors should ensure that it is well exposed within its radiation screen and mounted in accordance with the manufacturers' requirements.

Changes in dew-point with height above the ground are usually smaller than those of temperature except when the surface is wet following rainfall. However, it remains desirable that measurements are made at the same height. Dew-point is usually measured less accurately than air temperature and field checks to date have shown the standard error of the difference between any pair of sensor and check readings should typically be about 0.26 C. There is no evidence that the differences are related to sunshine or wind speed. There should be an interval of at least 10 minutes between check readings so that any trend in the differences between sensor and check data can be identified.

6. Inspection of Meteorological Wind Speed and Direction Sensors

Wind speed increases rapidly with height above the ground so that check readings must be made at the same height as the roadside sensors. Wind speed can vary rapidly with time and so to prevent random errors wind speed measurements from the check instrument must be averaged over a period of ten minutes. The method of sampling and averaging the data must be the same for both the check instrument and the operational instrument. Analysis of variance of instantaneous wind speed measurements suggests that the standard error is about 1.2 mph but is much reduced if road sensor systems average the wind speed and direction over a period of 10 minutes.

The wind vane should be checked by manually aligning it with the cardinal compass points and verifying the direction produced by the system. It may not be possible to gain access to the vane but the directional reference should still be checked by estimating the direction in which the vane is pointing and comparing it with that produced by the system.

7. Choice of Acceptance Limits and determination of the Field Observations required to check those Limits

It is necessary to be confident that a sensor that has a mean error with magnitude greater than some specified Maximum Tolerable Error (MTE) will be rejected while running a low risk of rejecting a sensor that has a small mean error. Values of MTE are specified in the TR2020 for the various sensors.

The confidence which can be placed in acceptance or rejection depends upon the errors in the check measurements and the number of check readings made at each site. A method of calculating the number of check readings required to achieve a given confidence level is in Section 9, together with some results from such calculations.

8. Conclusions

8.1 General

Inspectors shall ensure that all sensors are well exposed, that no trees or bushes have grown to shelter or shade them since the previous inspection and that no new structure make the measurements unrepresentative of conditions above the road. Any requirement for maintenance work such as repainting or cleaning the screens should be noted.

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A sufficient number of checks of each sensor must be made at every site to allow the random and systematic errors of the sensor and check readings to be established or confirmed. The results from field checks to date allow the following tentative conclusions to be drawn.

8.2 Road Surface Temperature Sensors

Provided road temperature is allowed sufficient time to reach equilibrium under a radiation screen, road surface temperature sensors can be checked to TR2020 standard with 4 readings at each site.

8.3 Meteorological Air Temperature Sensors

It is essential to expose the check instrument at the same height as the station sensor when checks are made in bright sunshine and light winds or on calm clear nights because of the very large super adiabatic lapse rates or sharp surface inversions which can occur under those conditions respectively. If that is done, checks to TR2020 standard can be made with only 4 readings at each site.

8.4 Meteorological Dew-point Sensors (direct or indirect)

Large random errors in some station measurements of dew-point make it impossible to check the sensors to TR2020 standard with a reasonable number of readings at each site. If 4 readings were made at each site and the acceptance limits were set at ± 0.75 C there would be less than 5% probability of accepting a sensor with an error of more than 1.0 C and less than 5% probability of rejecting a sensor with error less than 0.5 C. This is the best that can be done with a small number of readings at each site.

8.5 Meteorological Wind Speed and Direction Sensors

To avoid large random errors and so ensure a satisfactory check with a few readings at each site, check instruments must be at the same height as the sensors. However, wind speed changes more rapidly than the other elements so more independent readings can be made in a short period. Averaging data from the road side sensor, as specified in TR2020, also reduces random errors.

9. Sample Calculations to determine Field Observations required to check Sensors to TR2020 Standard

- (a) Values of MTE are the accuracies specified for the various sensors in TR2020.
- (b) The recommendations and their derivations for checking sensor accuracy in the field are as follows:
 - i) A tolerable risk of accepting a sensor which has an error equal to MTE is 5%. There will be a lower risk of accepting a sensor with a mean error greater than the MTE;
 - ii) From a table of the cumulative normal distribution, obtain the Standard Normal Variate (SNV) corresponding to the chosen risk ie. 1.960 for 5%;

- iii) Calculate the Standard Deviation (SD) of random errors from the differences between sensor and check readings taken at all sites. N.B. Care must be taken to remove significant systematic errors from this data before calculation of SD. Calculate the error of the sensor, that has a 50% chance of being Accepted (A50) with a given number of check readings (n). n is a variable, generally between 1 and 6, but it can be larger if the random errors are large.

$$A50 = MTE - \left[SNV \times SD \sqrt{(n)} \right]$$

This value is used as the rejection limit. Any sensor that shows mean difference from the check instruments greater than the A50 value in a series of n field checks must be rejected.

- iv) The error of a sensor that has a 95% chance of being Accepted (A95) is given by

$$A95 = MTE - \left[2 \times SNV \times SD \sqrt{(n)} \right]$$

Alternatively, 5% of sensors with errors smaller than this value will be rejected. The choice of n is governed by the need to achieve a sensible value of A95, which does not reject highly accurate sensors.

- v) The above relationships may be used to draw up a table showing A50 & A95 for various values of n, and a number of check readings that is likely to give satisfactory results may be chosen, as shown in the following worked example.

- (c) An example of the results of such calculations for checks of roads surface temperature when $MTE = \pm 0.50$ C, the tolerable risk of accepting a sensor with that error is 5% and $SD = 0.14$ C is:

Number of check readings		1	2	3	4	9	16	25
A05 (MTE)	±	0.5	0.5	0.5	0.5	0.5	0.5	0.5
A50 (Rejection limit)	±	0.23	0.31	0.34	0.36	0.41	0.43	0.45
A95	±		0.11	0.18	0.23	0.32	0.36	0.39

The figures above shows that with only 1 check reading the rejection limit (A50) would have to be set at ± 0.23 C and that a sensor with zero error would be accepted on less than 95% of occasions. An acceptable compromise between precision and work load is achieved when 3 check readings are made at each site. A sensor would then be rejected if the magnitude of the mean difference between sensor readings and check readings exceeded 0.34 C and there would be less than 5% chance of rejecting a sensor with mean error 0.18 C or less.

Note: The above is a worked example to demonstrate the techniques to be used in determining the field observations necessary to check to the limits stated in TR2020. Sensor and system suppliers should supply relevant information for their individual equipment.

3.11 Road Weather Forecasting

3.11.1 General

The Highways Agency supports the use of road weather forecasting systems in the operational management of winter maintenance. Accurate forecasting of road weather can lead to a more efficient and cost effective operation.

Road weather forecasting services are available from a number of commercial organisations. **Annex 3.11.1** contains a suggested specification for the provision of road weather forecasts.

The Highways Agency will contribute to the cost of obtaining such a service for the management of winter maintenance on trunk roads, providing that the service complies with the specification in Annex 3.11.1.

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Annex 3.11.1

Specification for Road Weather Forecasting

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1. Introduction

A road weather forecasting service should provide an adequate level of information to enable Maintenance Agents (MAs) to determine whether roads in their area will require treatment to prevent the formation of ice, or settling of snow, such as might impede or endanger traffic on these roads.

This Specification details the component elements required of a road weather forecasting service.

The method of communication of forecasts between the forecasting organisation and the MA shall be determined by the MA; where road weather information systems using the Highways Agency's National Ice Prediction Network Specification (TR 2020, 1991) are operated, the methods set out in that specification should be used.

2. Forecasts

2.1 General

The road weather forecasts described below shall be provided daily (including weekends and public holidays) throughout the winter season specified by the MA. The name of the forecaster, the date and the time of issue shall be given with all forecasts.

2.2 24 Hour Forecast

A forecast for the following 24 hours shall be issued between 1200 hours and 1600 hours, or at an alternative time where specified. The text of this forecast shall include:

- a) A general synopsis, with timings, over the following 24 hours;
- b) Minimum air and road surface temperature predictions for agreed climatic/administrative zones and the timing of zero crossing if appropriate;
- c) Likelihood and timing of precipitation or deposition on road surfaces;
- d) If snow is forecast, its timing, amount and type and the direction from which the snow will develop, the likelihood of drifting and the height above which accumulation is likely;
- e) Visibility - Danger of thick fog (<200 m visibility) or freezing fog formation, location and timing;
- f) Wind speed and direction; Gale warnings and timing;
- g) Confidence level in the forecasts (low, medium or high).

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2.3 2-5 Day Forecast

A 2-5 day forecast shall be issued with the 24 hour forecast. The text of this forecast shall include:

- a) A general synopsis and anticipated trends over the period;
- b) Specific condition reports for day/night of days 2 and 3;
- c) Confidence level in the forecasts (low, medium or high).

2.4 Site Specific Forecasts

Where information is received from road weather sensors, detailed 24 hour site specific forecasts shall be issued between 1200 hours and 1600 hours, or at an alternative time where specified. These forecasts shall include:

- a) Graphical representation, against time, of predicted road surface temperatures and surface condition.
- b) Textural site specific forecast, including thermal map type and confidence in the forecast.

2.5 Evening Update of Forecasts

If minimum overnight road surface temperatures are expected to be below 3 degrees celsius, an update of the 24 hour forecast and of the site specific forecast, including advice of "no change" if appropriate, shall be issued between 1800 hours and 2200 hours or as otherwise specified. An update may be appended to the end of a previous forecast.

2.6 Further Updates of Forecasts

Any significant change in predicted conditions, as previously forecast, shall be notified specifically, and as necessary, to the MA by the forecasting organisation. In particular any change relating to snow, be it an improvement or a worsening of predicted conditions, shall be reported immediately and all the forecasts shall be updated, including the 2-5 day forecast.

2.7 Morning Summary

A morning summary shall be issued by 0900 hours. The text of this report shall include:

- a) A morning summary of weather over the previous 16 hours (1500 hours to 0900 hours);
- b) A brief forecast for the following 24 hours, valid until issue of the 24 hour forecast (see 2.2);
- c) Notification of any suspected faults in the road weather information system, if such a system is in operation.

2.8 24 Hour Consultancy Service

A forecaster shall be available by telephone 24 hours a day, 7 days a week for consultation on the weather conditions and details of forecasts. The forecaster shall respond within five minutes to any enquiry from the MA.

3. End of Season Analysis

For those MAs with a road weather information system, the forecasting organisation shall provide an end of season analysis of the accuracy of forecasts. This analysis shall include, for each forecast site:

- a) A graph of actual versus forecast minimum road surface temperatures;
- b) A pie-chart detailing the frost prediction accuracy by comparing frost⁽¹⁾ forecast against actual frost conditions (i.e. frost/frost, frost/no frost, no frost/frost or no frost/no frost);
- c) The bias and root mean square error in the forecast of minimum road surface temperature.

4. Level of Accuracy

The accuracy of road weather forecasts shall be no less than 86%. Calculation shall be on the basis of the percentage of predictions in the "no frost/no frost" or "frost/frost" categories for the winter nights considered when the observed minimum road surface temperature at a forecast site was 5 degrees celsius or below. If an update has been issued before midnight it should be used in the analysis even if it is less accurate than the original forecast. In the case of a dispute the Highways Agency shall act as arbitrator.

⁽¹⁾ For the purpose of this specification a 'frost' is defined as when the road surface temperature falls to zero degrees celsius or below.

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