Guide to the Inspection of Single Flue Industrial Steel Chimneys

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FORWARD

The Health and Safety Executive welcome this guide prepared by the Association of Technical Lightning & Access Specialists that builds on the existing HSE document GS53.

This guidance document provides good advice on the inspection of single flue chimneys. Of note is the need for those who commission chimney inspections to ensure that those undertaking the inspections are competent and that they are provided with adequate information on the chimneys design, construction and the nature of any flue deposits. Additionally the guide highlights the important role of designers to ensure that the designs of new chimneys address the need for safe erection and subsequent maintenance.

Construction Division
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TECHNICAL GLOSSARY

Cyclic loads: Loads which occur at regular intervals. To affect a chimney they must last long enough to set up vibrations in the chimney. They may be superimposed on steady-state loads, e.g. gusts in a windstorm.

Natural frequency: The frequency at which a chimney will resonate. Each chimney has an indefinite number of natural frequencies, set by its cross section. At resonance, the chimney will vibrate with large amplitudes.

Chimney shell: The actual body of the chimney which incorporates the exhaust flue and provides the load bearing capacity.

Abrasion: A type of attack brought about by grit particles travelling in a fast moving exhaust gas stream, it is a mechanical process.

Condensate: The liquid by-product of a hot gas cooling.

Acid dew-point: The temperature at which a hot acid gas returns to liquid phase.

Service life: The nominated life expectancy of a chimney when it was designed.

Downdraft: The cooler, less buoyant, exhaust gases that fall into the region around the top of the chimney.

Non-destructive test: A method of testing the chimney to discover surface and sub-surface defects without damaging the fabric of the chimney.

INTRODUCTION

1 In 1992, the Health and Safety Executive (H.S.E.) carried out a national survey to find out about the condition of single-flue steel chimneys (See Appendix A). This highlighted that there was a lack of information relating to their inspection and maintenance. As a direct result of the survey the H.S.E. produced a guidance note (Ref. GS53) to review the necessity for, and methods of, carrying out inspections of single-flue steel industrial chimneys.

2 This booklet is designed to further expand upon the points raised by the H.S.E. and provide a source of reference to those responsible for the upkeep of structures of this nature. This will include chimney owners, chimney inspection contractors and consulting engineers.

3 Owners, operators and users of steel industrial chimneys have a duty to protect the health and safety of their employees and others affected by the operation of the chimney. To satisfy this requirement it is imperative that the chimney is maintained in a satisfactory condition.

THE HAZARD

Frailty of single-flue steel chimneys

4 Single-flue steel chimneys rely on the structural integrity of the flue for their stability. They are vulnerable structures because the flues vent agents, which cause rapid deterioration of steel (See Appendix B). In addition, they are dynamically sensitive and complex structures. They are different from conventional structures because they respond to cyclic components of everyday loads, especially wind. If the frequency of the cyclic component is within 10% of one of the chimney's own natural frequencies, this response is magnified, sometimes with catastrophic results.

5 This susceptibility to cyclic loading means that the design of a chimney is a specialist process. It requires the provision of sufficient material to ensure structural integrity, which needs to be balanced by the material requirements for desirable dynamic behaviour. If a chimney is to behave in the way that the designer wants it to, its shell thickness must be maintained above a specific minimum.

Appearances may deceive

6 Current insulation methods, which use corrosion resistant casings, cover the flue and give a false impression of its condition. Quite often, the shiny exterior of the casing for the insulation can hide a badly corroded shell. While current design requirements ensure that steel chimneys have an inherent factor of safety, some have collapsed and there is plenty of evidence of 'just-in-time' repairs.

Consequences of a collapse

7 The consequences of a chimney collapse could be very serious because the potential drop-zone may cover a large area and could put people and hazardous processes at risk.

CAUSES OF DETERIORATION IN STEEL CHIMNEYS

Lack of inspection and maintenance

8 The susceptibility to deterioration of many items of plant is well known. Consequently, they are subject to regular maintenance/repair programmes. However, in the majority of cases, steel chimneys are treated differently because it is not widely appreciated how much wear and tear they are actually subject to. This failure to recognise the potential for deterioration has led to a significant number of steel chimneys not being included in planned preventive maintenance programmes.

9 In recent years, other developments have contributed to the deterioration of steel chimneys by making proper inspections difficult. For instance, aluminium sheeting encasing mineral wool has become a common form of insulation used for steel chimneys, but it allows only limited access for inspection of the load bearing steel work. Consequently, advanced corrosion can take hold before it is noticed. In addition, the appearance of the aluminium cladding can be misleading, giving the impression that all is right with the chimney.

Poor design

10 Poor design also promotes deterioration by creating conducive conditions including:

- Details which may lead to local overstressing, e.g. sudden changes in section thickness which concentrate stresses at the interface. On their own, such local failures may not be so serious but they may create a crease or ledge within the shell that traps dirt and moisture.
- Use of steel in inappropriate conditions, e.g. to vent processes that burn sulphurous fuels.
- Incorrect sizing of chimney flues etc.
- Inadequate damping to resist wind induced oscillation
- Use of dissimilar metals without adequate isolation promoting electrolytic corrosion e.g. aluminium helical strakes secured directly to mild steel support lugs.

Designers must ensure that avoidable risks associated with the erection of the chimney and subsequent maintenance activities are designed out where possible. This will include avoiding details which trap dirt and moisture, prevent air circulation or make access for maintenance difficult.

INSPECTION AND MAINTENANCE OF STEEL CHIMNEYS

The need for inspections

11 Chimneys need inspecting because they operate in harsh conditions and deterioration of the steel shell is inevitable but the degree of damage depends on how long the process of deterioration is allowed to continue unchecked. In inadequately maintained chimneys, it may progress undetected until it is at the point which it may affect or compromise the integrity of the chimney. This may result in collapse of the chimney or require an unplanned chimney shutdown of unknown duration.

Preliminaries to commissioning an inspection

12 Collect and assimilate all relevant Documentation and Records

- An Identification Plate should be fitted to the base of each stack to show basic information about the structure such as manufacturer, date of erection, design code followed etc. all in accordance with the recommendations shown in BS 4076 Specification for Steel Chimney's. ID plates fitted to new chimneys or retro fitted to existing chimneys should also have a facility for recording the date of last inspection.
- The chimney owner has a duty of care to gather and hand over adequate information and the as-built design drawings to the appointed Inspection Contractor to allow them to fully understand the nature of the structure of the chimney and any ancillary fitments. If this documentation is not available the Inspection Contractor should be advised and the inspection planned to enable the required information to be compiled for future use. Inspection of a chimney without design and construction information will require a particularly detailed risk analysis and may require the use of access techniques not normally associated with works of this nature.
- An inspection log should be maintained by the chimney owner summarising previous inspection results. This should clearly state the date of next inspection, modifications undertaken to the process plant, boiler, fuel or other changes, which may effect the operation and stability of the chimney, along with details of previous remedial works. Relevant information within this log should be made available to the selected Inspection Contractor as appropriate.
- Obtain and make available to the Inspection Contractor copies of previous inspection reports
- In addition to modifications to the chimney structure the documentation pack should also detail any changes to the environment surrounding the chimney, which may create conditions not envisaged at the time of design. e.g. tall structures built in close proximity likely to have an effect on the wind load to the chimney.
- Details on the type of fuel being burnt by the plant served by the chimney should be available with particular emphasis on sulphur content. In addition details of the gas temperature at the point of entry to the chimney and the boiler running conditions, i.e. steady state or non-steady state, will help the contractor or consultant determine if the stack is operating in such a way as to allow corrosive deposits to condense on the internal face.
- Recently, a chimney was found to have asbestos insulation. While this is considered to be unusual a check must be made to ensure that asbestos is not present. If it is present then compliance with all the current legislation associated with controlling the hazard of working with, or close to, asbestos must be assured.

13 Determine appropriate inspection intervals

- All new stacks should be accessed and inspected 12 months after entering service to ensure anticipated performance under load.
- Chimneys that are both un-insulated and unlined should continue to be accessed and inspected every 12 months, as this type of structure is particularly vulnerable to short-term damage caused by changes in operating conditions. This interval may be reduced on the recommendation of the inspection contractor if defects are noted which cannot be satisfactorily repaired and give concern over the future integrity of the structure in service.
- Insulated and/or lined chimneys should be inspected every 24 months or at a lesser interval if recommended by the Inspection Contractor if defects are noted, which cannot be satisfactorily repaired immediately, giving concern over the future integrity of the structure in service.
- Alternative chimney inspection schemes may be drawn up by the owner or user of the chimney or some other independent party, provided they have the competence to do so and the data to support the change. This scheme should be in written form and should aim to prevent the problems associated with chimneys, which are highlighted in this guidance note. When preparing an alternative inspection scheme give due regard to the fact that enforcing officers may well ask you to demonstrate that it is at least as effective as the schemes described above. In addition, you must inform the appointed inspector of any changes in use or other conditions that may affect the assumptions behind the inspection scheme either where:

  a) These changes have occurred since the last inspection; or
  b) Are expected to occur before the next inspection is due.

14 Before proceeding with an inspection give careful consideration to the following;

- The possible consequences of the inspection report and ways of dealing with the findings. For example, if the recommendation is for extensive repairs, these may require a plant shutdown. If so, at what cost and when is the ideal time for carrying out the repairs? Consider planning some routine maintenance works to be undertaken at the same time as the inspection.
- Who will do the inspection? This is important because an inspection is only as good as the organisation that carries it out. If the inspectors lack the necessary knowledge, then there is a good chance that they will miss some important points, rendering the inspection of little value.

Competencies of inspectors

15 Inadequate inspections and low standards of workmanship can be costly and may well reduce the service life of a chimney by causing damage and promoting deterioration. For example, careless replacement of insulation after an inspection may create cold-spots; bolts removed for inspection may be incorrectly re-installed; butt-welds may be replaced by fillet-welds, etc.

16 It is, therefore important to establish the competencies required of the organisation that will have responsibility for:

- the inspection;
- interpretation of the inspection report;
- the maintenance of the chimney.

17 An organisation competent to inspect and carry out the maintenance of a chimney should:

- Be able to demonstrate they are competent to both undertake the inspection using appropriate access techniques and are also able to correctly interpret any information obtained.
- Hold membership of an approved trade body and/or hold membership of an approved engineering body and/or have a documented history of carrying out works of a similar nature.
- Be able to make available on request copies of previous chimney inspection reports and references from clients for whom they have undertaken similar works.
- Provide detailed method statements and risk analyses for the proposed chimney works. (The standard of these items may be used as an additional indicator when assessing the competency of the inspection company)
- Indicate the level of formal training undertaken by their staff in N.D.T. techniques where N.D.T. forms part of the required work scope

18 Information about suitable inspection and maintenance companies may be obtained from organisations such as the Association of Technical Lightning & Access Specialists.

EFFECTIVE INSPECTIONS AND MAINTENANCE OF CHIMNEYS

19 When commissioning an inspection, it is advisable to involve a suitably qualified organisation at an early stage and let them help to plan the inspection.

Preliminaries

20 Draw up a list of organisations that are competent to:

- Inspect the chimney; and
- Evaluate the results of the inspection, based on the guidelines given earlier (see paragraph 17)

21 In order to plan the maintenance and repair of a chimney, it is necessary to assign a realistic value to its expected service life.

22 To assist the inspectors, mark at the base of the chimney the north, east, south and west aspects of the stack, which should then be followed in orientating defects found and referred to in any subsequent documentation produced.

23 It is important that adequate access for inspections and maintenance is provided. If there is not enough space to reach an item or of it is inaccessible, it is likely that it will not be inspected and, consequently, not maintained. Discuss the requirements of the inspection and maintenance teams with the inspector and try to ensure their requirements are met, e.g. power sources, exclusion zones, etc. If a different company is used to carry out inspections each time, the findings of the previous inspection must be made available.

24 Chimneys should be out of operation during the period of the inspection. Only if this is not possible and the hazards of inspecting a chimney on-line are known, so as to allow the inspection teams to provide proper protective equipment, is it acceptable to inspect a live chimney. Clients or those that procure chimney maintenance must provide information about any hazards, e.g. composition of deposits on the chimney shell especially with regard to toxicity or flammability before works starts.

Access for Inspection

25 Access systems should be installed in accordance with accepted trade guidelines and current codes of practice.

26 Ladder hooks, where fitted, should be closely examined during initial ascent for security of attachment and suitability for use.

27 If ladder hooks are to be retrofitted to an existing chimney then this work should only be carried out using an approved welding procedure by a certified welder working from a suitable means of access.

28 Care should be taken to ensure that insulated and clad chimneys are adequately sealed against water ingress at each ladder hook attachment point on completion of the inspection.

29 Consideration should be given to installing a permanent safety rail to existing chimneys to improve safety. If fitted then design implications must be adequately addressed to consider imposed dynamic loadings, expansion, formation of cold spots and sealing from weather ingress if clad.

Specification for Inspection

30 The type of inspection to be undertaken will, to some extent, vary with the nature of the chimney and known inspection history, but the tables shown overleaf give guidance on the general standards expected by HSE for the various types of single flue chimneys

Table 1 – Recommended Inspection Scheme for Unlined, Un-insulated Chimneys

(See also paragraph 13, point 4)

Annually

- Clean out any flue deposits from base of stack whilst assuring compliance with COSHH Regulations (can be done by chimney owner).
- Carry out close visual examination over the complete surface of the external face of the shell.
- Carry out ultra-sonic survey of chimney shell in sufficient detail to allow any significant loss of section to be detected.
- Tap all flange bolts & holding down bolts with a hammer to "sound" for any evidence of cracking.
- Check torque settings on flange & holding down bolts
- Examine any installed lightning protection system for compliance with current standards and carry out electrical tests for continuity and resistance to earth.

4 Yearly

All Annual items +

- Remove 2 bolts from each flange (or from most stressed flanges where adequate design drawings are available) for microscopic examination for defects. Bolts should then be tested for ultimate tensile failure for comparison against rated value of new bolts.

8 Yearly

All Annual and 4 yearly items +

- Carry out ultra-sonic survey on bolts securing stack to foundation to determine the extent of any corrosion present.

Table 2 – Recommended Inspection Scheme for Externally Insulated Chimneys

(See also paragraph 13, point 4)

Annually

- Remove all accumulated deposits within base of stack whilst assuring compliance with COSHH Regulations (can be done by chimney owner).
- Carry out electrical continuity checks and resistance to earth measurements on any installed lightning conductor system.

Biannually

All Annual items +

- Carry out a detailed inspection of the insulation and cladding to determine its overall effectiveness and resistance to rainwater ingress.
- If internal access is possible, carry out a full inspection and take ultra-sonic measurements at sufficient locations to determine if any significant loss of section has occurred. (Confined Space Regulations may apply).
- If internal access is not possible cut out apertures through cladding and carry out ultra sonic thickness survey. Locations to be selected to coincide with known vulnerable areas (above flange joints, insulation collars, base plates and duct entries) and also at random intervals throughout the height of the structure. Thickness readings to be carefully plotted to match each inspection window for future comparison. Ensure that inspection apertures are adequately sealed against water ingress on completion of inspection.
- Remove flange cover boxes, where fitted, and inspect flange joints for leakage.
- Tap all flange bolts and holding down bolts with a hammer to “sound” for any evidence of cracking.
- Check torque settings of all bolts.
- Closely examine any installed lightning protection system for compliance with current standards and signs of physical damage.

4 Yearly

All Annual and Biannual items +

- Remove 2 bolts from each flange (or from most stressed flanges where adequate design drawings are available) for microscopic examination for defects. Bolts should then be tested for ultimate tensile failure for comparison against rated value of new bolts.

8 Yearly

All Annual, Biannual and 4 Yearly items +

- If internal access to stack is not possible remove all external cladding and insulation to enable a detailed ultra sonic thickness survey to be undertaken throughout the full height and circumference of the structure. ***Note.** This procedure should also be considered if no design details are available and/or the stack has not been inspected to the required detail in accordance with the recommended time periods described in this document.
- Carry out ultra-sonic survey on bolts securing stack to foundation to determine extent of any corrosion present.

Table 3 – Recommended Inspection Scheme for Lined Chimneys

(See also paragraph 13, point 4)

Annual

- Carry out electrical continuity and resistance to earth checks at ground level.

Biannual

All Annual items +

- Carry out a detailed survey of the shell including for ultra-sonic thickness measurement at sufficient locations to determine any areas of significant loss of section.
- If internal access is possible carry out a full inspection to determine the overall condition of the lining system. (Confined Space and COSHH Regulations may apply).
- If internal access is not possible consideration should be given to carrying out an internal inspection using a remote camera system.
- Any defective areas noted within the lining system should result in a particularly detailed examination of the shell in this area.
- Defects within the lining system exposing the shell to flue gases should be rectified prior to returning the stack to service.
- Tap all flange bolts and holding down bolts with a hammer to "sound" for any evidence of cracking.
- Check torque settings to all bolts.
- Closely examine any installed lightning protection system for compliance with current standards and signs of physical damage.

4 Yearly

All Annual and Biannual items +

- Remove 2 bolts from each flange (or from most stressed flanges where adequate design drawings are available) for microscopic examination for defects. Bolts should then be tested for ultimate tensile failure for comparison against rated value of new bolts.

8 Yearly

All Annual, Biannual and 4 Yearly items +

- Carry out ultra-sonic survey on bolts securing stack to foundation to determine extent of any corrosion present.

Guyed Chimneys

31 All of the types of chimney described in the above tables may incorporate guy ropes to retain the structure in the vertical axis. If guy ropes are fitted normal ground based maintenance (tension monitoring and adjustment, verticality checks etc.) should be undertaken at the manufacturers recommended intervals and the following additional checks should be carried out each time access to the structure is provided.

- Look for excessive corrosion in the guy ropes and ancillary fittings.
- Ensure that the ropes are adequately coated with an appropriate dressing.
- Check that any rope grips installed to the system are of the correct type & number, set at the correct spacing, correctly fitted and are adequately tightened.

Inspection Reports

32 Careful selection of the Inspection Contractor to carry out the inspection works should ensure that the report produced as an end result will be of an adequate standard.

The Inspection Report should contain as a minimum:

- Clear and annotated photographs of all defects.
- Written description of all defects and a defects plot where appropriate.
- Reasons for occurrence of the defects if known and any proposed repair specifications.
- The name of the inspection company, signature of the inspector and date the works were undertaken.
- Test certificates for lightning conductor systems containing all of the information recommended within British, European or International Codes of Practice. This information is clearly shown on the prescribed tests certificate recommended by A.T.L.A.S.
- Relevant certificates of competence for inspection staff.

Act on the Findings

33 It is essential that the findings of the inspection are acted upon. Keep a record of all the actions taken and when they were carried out.

Remedial Works

34 Remedial works should be carried out to an agreed specification compiled to reflect the existing materials in use and the nature of the defects observed.

35 The repair specification should ensure that the stack is returned to a condition, which is at least equal to original design or to alternative design calculations to be provided by either the Inspection Contractor or the Contractor selected to carry out the works.

36 Substantial scaffolds temporarily installed for remedial works may also have an adverse effect on the structure and due consideration of both imposed and dynamic loadings should be demonstrated by the contractor to the client company.

37 When carrying out repairs to lined steel chimneys due consideration should be given to the fact that the lining material itself may impart a degree of strength to the overall structure and removal of part of the lining may leave the stack in an unstable condition.

CONCLUDING COMMENTS

38 Chimneys are usually key elements in the processes to which they are linked. The consequences of their failure could be very costly.

39 Like most other structures, chimneys are subject to defects that may shorten their expected life. These defects may include in-built faults due to poor design and workmanship, abuse during their service life, misuse and lack of maintenance. However, their effects can be minimised by a condition survey at hand-over and through the implementation of a planned maintenance programme, of which effective inspections, properly interpreted, should be an essential part.

40 To maximise the effect of the inspection and maintenance programme, it is always best to involve the inspector and the technical specialists from the start.

41 For inspections to be effective, they must be done systematically and regularly – not just when there is a breakdown or failure.

42 Inspections should be carried out only by organisations that can demonstrate competence in this type of work (see paragraph 17).

43 Inspectors should have adequate access to the parts of the chimney which need to be inspected.

44 It is very important that repairs are carried out within the period stated in the report.

45 As chimneys are complex structures, interpretation of the information in the inspection report – an essential part of the inspection process – should be carried out by specialists who are able to demonstrate that they are competent in this type of work (see Paragraph 17).

APPENDIX A, Analysis of H.S.E. survey responses

A1 The survey covered a sample size of approximately 700 steel chimneys.

A2 A significant number of steel industrial chimneys were in a condition which led to a report suggesting repairs were required, either immediately, or within one year.

A3 In many cases, inspections were carried out in response to an obvious failure.

A4 Only a small proportion of chimneys were inspected as part of the planned programme.

A5 A large percentage of inspections carried out were minimal, amounting to nothing more than a number of thickness tests on one side of the chimney only.

A6 Inspection reports were ignored.

APPENDIX B High risk chimneys

Chimneys can be attacked from the outside and from the inside.

B1 External attack of which corrosion is the main form, is caused by acids. These acids are formed when pollutants containing acid gases dissolve in atmospheric moisture; they are deposited onto the chimney either as condensates or rain. But the process is slow and not one which should cause concern, especially with insulated chimneys. However, in highly contaminated atmospheres, uninsulated chimneys may be at risk.

Guidance about which are high risk environments is given in Table B1.

B2 internal attack is of major concern, because it is not immediately apparent. It can cause rapid deterioration if it is not detected. There are two main causes, as follows:

Corrosion is the most common form. Sulphuric acid, formed out of the condensates of fuels containing sulphur, is the most corrosive agent. Generally, the higher the sulphur content of the fuel the greater the chance of sulphuric acid condensing out inside the steel chimney. The sulphur content of some of the commonly incinerated products is given in table B2.

To initiate corrosion the acids must be in solution, i.e. the temperature at the surface of the steel chimney must be below the acid dew point. For sulphuric acid, this is between 120°C and 160°C, depending on the sulphur content. If the heat source which the chimney is venting is switched off regularly, the temperature in the chimney will, unavoidable, fall below dew point temperature, allowing the acid to condense out on the inside surface of the steel chimney. As long as the chimneys exposure to acid attack is limited, the fact that the temperature is below the acid dew point need not be serious. Table B3 relates off-load periods to susceptibility to acid attack.

Abrasion can also cause rapid deterioration, but it is limited to chimneys burning solid fuels and usually at positions where the flow in a chimney changes direction. But beware; if it acts in combination with corrosion, it can cause an even more rapid loss of section.

Table B1 Information about environments for external attack

Environment category	Environment	Description of environment	Steel corrosion risk
A	Normal inland	Most rural and urban areas. (Note: Some rural and urban areas may be polluted from industrial areas close by, depending on prevailing winds).	Low
B	Polluted inland	Areas with high airborne SO_2 and other contaminants from industrial sources.	Significant
C	Normal coastal	High airborne salt (Cl^-) levels. (The salt contaminated zone may extend inland as far as 2-3 km from the coast).	High
D	Polluted coastal	As with B but with high airborne salt levels. (The contaminated zone may extend inland as far as 2-3 km from the coast).	Very High
E	Heavily polluted, industrial	Aggressive industrial environments such as areas adjacent to acid plants, salt storage, electroplating shops, chemical works, etc.	Very high

Table B2 Classification of commonly incinerated products by sulphur content

Sulphur content	Classification of risk to chimney in terms of fuel sulphur content	Examples
0% to 0.3%	Low	Natural gas, domestic refuse
0.4% to 1.5%	Medium	Diesel
Greater than 1.6 %	High	Industrial coal, heavy oil.

Table B3 Relating time below acid dew-point to risk of corrosion

Operating hours per year below acid dew-point	Risk of corrosion
<30 hours	Low
30-100 hours	Medium
>100 hours	High

*Chimneys should be maintained at 20°C above the acid dew-point.

APPENDIX C Recording defects

C1 Defects should be classified according to their **type**, **extent** and **severity**. It is very important that there is no ambiguity in the inspection report and that they are consistent in the way that the information is presented. A suggested method of reporting which may be adopted is as follows:

Type includes:

- Corrosion (or other thickness losses);
- Cracks in steel shell, flanges or welds;
- Local deformation or distortion;
- Wear;
- Accidental damage;
- Insulation breakdown;
- Loss of tension (guy-ropes), etc.

Extent

A No defects noted
B Not significant: Not more than 5% of the area affected by the defect.
C Significant: Between 5% and 30% of area inspected affected by the defect.
D Very significant: Over 30% of the area inspected was affected by the defect.

Severity

1 Not notable.
2 Minor.
3 Notable.
4 Severe.

C2 Once identified, it is necessary to give advice about how the effects of defects are to be minimised, to ensure the chimney achieves its service life. Table C1 suggests courses of action which may be taken.

Table C1 Recommendation for action following inspection

Severity	Extent of defect		
	B	C	D
2	Discuss reasons for defect and implications	Discuss reasons for defect, possibility of spread and time-scales for repairs.	Discuss reasons for defect, possibility of spread and monitor progress.
3	Carry out repairs within recommended time scales, monitor effectiveness of repairs.	Repairs to be carried out within stated time scales and discuss possibility of a fuller inspection to determine full extent of defect.	Repairs to be carried out immediately, possibility that full extent of defect not established discussed with view to carrying out a fuller inspection.
4	Repairs to be carried out immediately.	Repairs to be carried out immediately and further inspections of additional 20% of areas local to defect to be carried out to determine full extent of defect.	Repairs to be carried out immediately and reinspection of larger areas of chimney, as specified by a suitably qualified organisation.