

The image features a dark blue background on the left side, transitioning to white on the right. The BRE logo is positioned on the blue background. The entire page is decorated with a complex pattern of thin, light-colored lines that curve and overlap, creating a sense of motion and depth. The lines are more densely packed on the left and become sparser towards the right.

**bre**

**DCLG Final Research  
Report**

**Effectiveness of sprinklers in  
residential premises – an  
evaluation of concealed and  
recessed pattern sprinkler  
products**

Section 6: Design, installation  
and maintenance

Section 7: Recommendations  
for further work

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The authors of this report are employed by BRE. The work reported herein was carried out under a Contract placed by the DCLG. Any views expressed are not necessarily those of the DCLG.

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## Contents

6	Design, installation and maintenance	1
6.1	Introduction	1
6.2	Current guidance	2
6.3	Features identified in this study	3
6.4	Other work and anecdotal evidence	3
6.5	Discussion about design and installation features	5
6.6	Discussion about maintenance features	6
6.7	Checklist	7
6.8	Summary and conclusions	8
6.9	References for design, installation and maintenance	8
7	Recommendations for further work	9

## 6 Design, installation and maintenance

### 6.1 Introduction

'Concealed' sprinklers are a type of sprinkler pattern. They are recessed into the ceiling and are covered by a concealer plate which is designed to detach and fall away under the influence of heat produced by a fire, prior to sprinkler activation.

The sprinkler body and all other working parts are mounted inside a cup and covered by a concealer plate and concealer plate retainer. This concealer plate is attached to the concealer plate retainer by solder tags on metal lugs designed to detach at a lower temperature than the sprinkler itself.

Some concealed models employ pendent residential sprinklers within the recessed cup and often a domed concealer plate is necessary to accommodate the deflector which is just below the ceiling line. Special pendent sprinklers are sometimes used in concealed sprinkler models with drop down deflectors and a different arrangement of heat sensitive element and sprinkler valve allowing a flat concealer plate.

The sprinkler itself operates when the glass bulb or the fusible link reaches a required temperature due to heat from the smoke produced by a fire. Once this has occurred, the water flow is released.

Concealed sprinklers are claimed to be one of the most commonly used residential sprinkler patterns because of aesthetics. There are numerous designs. A note in British Standard BS 9251 - Sprinkler systems for residential and domestic occupancies - code of practice<sup>1</sup> indicates that concealed sprinklers may only be used with the approval of the 'authority having jurisdiction'.

There are a number of issues that concern concealed pattern sprinklers for use in residential and domestic premises which need investigation. Some of these issues are potential design, installation and maintenance features that could detrimentally affect their performance.

The purpose of this part of the project was to review these design, installation and maintenance features. This has involved identifying, gathering and reviewing information. The information was gathered from BS 9251, anecdotal experience with this type of product installed in real buildings, other studies, visual examination and experience of the BRE project team members obtained during the course of the experimental fires and wind tunnel work in this study.

## 6.2 Current guidance

Guidance on design, installation and maintenance of a residential sprinkler system can be found, for example, in BS 9251.

It is important to properly design, install, commission and regularly maintain a residential sprinkler system so that it will work properly in the event of a fire. Design, installation, commissioning and regular maintenance should be carried out by suitably qualified and experienced sprinkler contractors.

Commissioning includes: testing for leakage, correct water flow rates at specified pressures and a particular location and that alarms work at required flow rates and can clearly heard in all the relevant rooms in the property. After satisfactorily commissioning a system, the sprinkler contractor should issue a signed approval certificate. See BS 9251 clause 6.2 for further details about commissioning.

The sprinkler contractor should provide the building owner or occupier with spare sprinkler heads of the same design as those used in the system together with an appropriate tool for fitting them. In the event that replacement of a head is required, these spare heads should not be fitted by the owner or occupier but should be fitted by a suitably qualified and experienced sprinkler contractor.

The sprinkler contractor should also provide the building owner and occupier with the relevant documentation specified by the installation standard. This might, for example, contain a general description of the system, a layout of the sprinklered property showing the extent of protection, details of the water supplies, a list of components used and a log book containing inspection, checking and maintenance documents.

This documentation might also include essential information for the user e.g. “do not paint, cover or in any way impede the operation of a sprinkler head”, “no modification should be made to any sprinkler equipment except in accordance with British Standard BS 9251”. See BS 9251 clauses 6.3.2 and 7, for further details about maintenance inspection, testing and documentation.

It is recommended in BS 9251 that residential sprinkler systems are annually inspected, tested and maintained by the sprinkler contractor, to ensure: the sprinklers’ heat sensing capacity and their spray pattern is not impeded; the minimum flow rate recommended in the standard is achieved at the drain and test valve; the alarm is effective and can be heard in all parts of the building; the system has not been modified except in accordance with the standard. The annual inspection involves:

- A visual inspection for pipework leaks and if a leak is suspected a pressure test is carried out
- Audibility tests for internal and external alarms
- A flow test to ensure the minimum required water flow rate is achieved
- Operation of stop valves to determine free movement
- Operation of trace heating is present
- Completion and signing of the log book.

### 6.3 Features identified in this study

During the course of this study, in the stylised fires in section 3, the realistic fires in section 4, and the thermal sensitivity work in section 5, the following features were identified:

- The concealer plates were very delicate and easily damaged.
- At the manufacturer's maximum recommended recess distance, in some cases, it was difficult to attach the concealer plate assembly securely and it fell out.
- After one test, it was observed that there had been a small leakage of water from pipework above one of the sprinklers which collected inside the concealer plate. No water was observed dripping from the concealer plate assembly. This could happen in a real installation and with evaporation could remain unnoticed. This would have a detrimental effect on the concealer plate operation time and consequently, the sprinkler operation time.
- One of the concealed sprinklers, at maximum recess distance, with unfavourable frame arm orientation, did not meet the acceptance criteria of the fire test of BS DD 252<sup>2</sup>. The test was prematurely terminated to protect the experimental facility. This failure was due to a combination of the alignment of the frame arm shadow and the concealer plate retainer lug, causing a detrimental effect on water distribution at the fire location.
- It was noted that a concealed sprinkler with a drop down deflector gave an uneven water distribution. Upon investigation, some 'play' in the operated position of the deflector was discovered and the deflector appeared to stabilise under water flow at a non-horizontal angle.
- The proximity of the residential sprinklers to any high level obstructions e.g. smoke alarms, light fittings that could detrimentally affect the sprinkler water distribution need to be taken into account. Concealed sprinklers may be particularly susceptible to ceiling mounted obstructions in close proximity to the sprinkler.
- Unfavourable frame arm/deflector attachment pins orientation, maximum recess distance and unfavourable concealer plate position had a detrimental effect on the thermal sensitivity of the concealed sprinklers.
- Water in the concealer plate, blocked vent holes and glued concealer plates resulted in a significant delay in thermal response.

### 6.4 Other work and anecdotal evidence

Some recent work<sup>3</sup> studied the potential for paint and other applied coatings to have a detrimental affect on the thermal response characteristics of residential sprinklers, including concealed pattern sprinklers.

In summary, this study involved 42 steady state kerosene fires, burnt in a rectangular tray of size 0.35 m by 0.30 m. These fires were conducted inside a test facility of dimensions 2.45 m by 1.04 m by 2.2 m high. The facility was essentially a plywood frame and had a 0.27 m plasterboard downstand on each of the long sides and a plasterboard wall on one short side and was open on the other short side. This facility was built inside a room of dimensions 4 m by 4 m by 2.35 m high. Residential sprinklers, thermocouples and a thermal imaging radiometer were fitted. The purpose of the fire tests was to compare the thermal response of one pendent, one flush pendent and one concealed residential sprinkler model, each painted using a decorator's brush with either 1-3 layers of emulsion paint or sprayed with paint from a gun or unpainted.

The unpainted concealed sprinklers operated at significantly later times and at higher temperatures (404 to 432 s and 148.5 to 151<sup>0</sup>C) than unpainted pendent sprinklers (66 to 80 s and 96 to 112<sup>0</sup>C). In the worst cases, painted concealed sprinklers resulted in further delayed operation (480 to 757s and 144 to 156<sup>0</sup>C). In these worst cases, the paint restricted the air gap between the concealer plate and the concealer plate retainer. Also the paint 'glued' the concealer plate in place during the fire after the solder on the concealer plate had melted.

Also, as part of the study, a letter was sent to registered residential sprinkler installers. This letter asked for information, including asking for their experience of painted over residential sprinklers. A summary of the parts of the responses relevant to concealed pattern sprinklers is as follows:

- The air gap between the concealer plate and the concealer plate retainer filled/covered up with silicone or painters caulk, to prevent spiders crawling through the gap, draughts blowing through on windy days, rattling covers and to stop dust getting trapped
- Painted over sprinkler concealer plates
- Gaffer tape over concealer plate to secure it due to the plate being knocked off by the owner
- Concealer plates painted to match the surrounding décor
- Mastic, caulk and paint applied to seal the concealer plate air gap to improve aesthetics.

In addition, anecdotal and other evidence suggests the following scenarios:

- Glued concealer plates
- Ceiling lining or decorating covering concealed sprinklers
- Sprinkler assemblies inside concrete cups, blocking any vent holes
- Positive pressure voids above concealed sprinklers could delay their thermal response
- Concealer plates visible from below the ceiling disconnected from the rest of the sprinkler assembly above the ceiling. The plates may be covering the hole, for example, following a change in sprinkler layout.

This list is not exhaustive of potential undesired alterations to concealed sprinklers.

## 6.5 Discussion about design and installation features

Discussion about the identified design and installation features, their consequences and recommendations for designers and installers are presented, as follows.

- a) Sprinkler concealer plates are necessarily thin and delicate for heat transfer reasons. However, they are easily dented and if dropped are likely to become damaged. It is recommended that they should be handled with care and damaged concealer plates should not be used in an installation.
- b) Relatively small amounts of torque should be applied by hand to the sprinkler concealer plate assembly during installation otherwise the integrity of the solder joint may be compromised or lost. If a concealer plate assembly is being attached and it 'seizes' before reaching the desired recess distance, no attempt should be made to 'force' it on. It is recommended that the sprinkler concealer plate is removed and replaced if too much torque has been applied and/or any of the solder joints lost.
- c) The concealer plate retainer attached to the concealer plate was also found to be easily damaged. Any deformation caused during installation could affect the attachment of the concealer plate or the sprinkler water distribution characteristics. It is recommended the concealer plate retainer is replaced if it becomes damaged during installation. It is also recommended that concealed sprinklers be handled with care during installation.
- d) It was not always possible to attach the concealer plate assembly securely to the sprinkler recessed cup at the manufacturer's maximum stated recess distance and in some cases it fell out. It is recommended that manufacturers re-examine their product and the maximum recess distances and if necessary, revise them or make modifications to the concealer plate retainer attachment method.
- e) Leaks of water from the pipework will detrimentally affect the performance of the system. Leaks should be identified during commissioning and annual maintenance, see section 6.2.
- f) A small leakage of water collecting inside the concealer plate could go unnoticed from below. More water could collect inside a domed concealer plate but inside a flat plate water could directly cover the solder lugs. This water leakage would have a detrimental effect on the concealer plate and the sprinkler operation time. It is recommended that the sprinklers are inspected for leaks.
- g) A concealed sprinkler model with a 'push on, thread off' design was found not to easily 'thread off' on some occasions. It was not possible to access the sprinkler for removal after operation until the concealer plate retainer was removed.
- h) It was noted that a concealed sprinkler with a drop down deflector gave an uneven water distribution. Upon investigation, some 'play' in the operated position of the deflector was discovered and the deflector appeared to stabilise under water flow at a non-horizontal angle. It is recommended that manufacturers of sprinklers with this deflector design examine this issue.
- i) Concealer plate assemblies attach internally or externally to the sprinkler recessed cup. Those attaching externally require the surrounding ceiling hole cut into the ceiling during installation to be located with higher precision than those which attach internally. It is recommended that internal attachment is considered by manufacturers.

- j) A combination of the effect of the alignment of the frame arm shadow and the concealer plate retainer lug at maximum recess distance can cause a detrimental effect on water distribution at a potential fire location. It is recommended that manufacturers consider this scenario and, if necessary, revise the maximum recess distance and reduce the lug dimensions.
- k) The proximity of the residential sprinklers to any high level obstructions e.g. smoke alarms, light fittings that could detrimentally affect the sprinkler water distribution need to be taken into account. Concealed sprinklers may be particularly susceptible to ceiling mounted obstructions in close proximity to the sprinkler. This should be addressed by specifications in manufacturer's data sheets and/or in the BS 9251 standard. It is recommended that installers take high level obstructions into account and position sprinklers accordingly.
- l) It should not be assumed that visible concealer plates are connected to the sprinkler assembly. Concealer plates may be covering a hole, e.g. following a change in sprinkler layout. It is recommended that the sprinkler housing is inspected to see whether it is connected to the water supply and the concealer plate. This may not be easy to inspect.
- m) Positive pressure voids in the space above the ceiling line in the proximity of the concealed sprinkler could delay the sprinkler thermal response. It is recommended that sprinklers without vent holes are considered for these applications.
- n) Unfavourable frame arm/deflector attachment pins orientation and maximum recess distance can have a detrimental effect on the thermal sensitivity of the concealed sprinklers. It is not easy to recommend what can be done about this.

Some of the above features could be addressed as part of the commissioning and annual maintenance inspection.

## 6.6 Discussion about maintenance features

It is important that people involved with residential premises with installed sprinkler systems are aware of any potential maintenance problems so that when they are identified they are properly dealt with.

Guidance e.g. manufacturer's data sheet or BS 9251 should highlight potential problems which will detrimentally affect the performance of the sprinkler system in the event of a fire.

Discussion about the identified maintenance features, their consequences and recommendations for designers and installers are presented, as follows.

- Painted, glued or silicone sealed concealer plates (or plates subjected to any other form of tampering) could result in a significant delay in the thermal response of the sprinkler and at worst, non operation. It is recommended that if any of these situations occur, the affected sprinklers should be replaced and the air gap between the concealer plate and the concealer plate retainer must be maintained at all times.
- Ceiling lining or decorative coatings applied to or over concealed sprinklers could result in a significant delay in the thermal response of the sprinkler and at worst, non operation. It is recommended that if either of these situations occurs, the affected sprinklers should be removed and the sprinklers/concealer plates replaced.

- Blockage of or concreting around any vent holes in a sprinkler recessed cup could result in a significant delay in the thermal response of the sprinkler. It is recommended that any holes should be unblocked or the sprinkler replaced.

These features could be addressed as part of the commissioning and annual maintenance inspection, and also on a continuing basis by the owner/occupier/authority having jurisdiction.

## 6.7 Checklist

There are a number of potential problems relating to the design, installation and maintenance of concealed sprinklers. These potential problems are avoidable through awareness and improved installation practices.

As an aid, a simple checklist of how to avoid, identify and rectify installation and maintenance problems identified during this project has been prepared, as follows.

- Always handle concealed sprinklers with care.
- Remove and replace defective or damaged concealed sprinklers.
- Apply relatively small amounts of torque by hand to the sprinkler concealer plate assembly during installation and do not attempt to force it on if it seizes.
- Remove and replace the sprinkler concealer plate if too much torque has been applied and/or any of the solder joints lost.
- Take into account any high level obstructions in the proximity of residential concealed sprinklers e.g. smoke alarms, light fittings, that could detrimentally affect the sprinkler water distribution and position sprinklers in accordance with guidance on manufacturer's data sheets and/or BS 9251.
- Identify and rectify any water leakage, including small leaks when water collects inside the concealer plate.
- Do not paint, glue, silicone, mastic or 'make good' concealer plates (or subject plates to any other form of tampering).
- Remove and replace any sprinklers that have been tampered with.
- Always keep the air gap between the concealer plate and the concealer plate retainer clear.
- Do not apply ceiling linings or decorative coatings over the sprinkler concealer plate.
- Remove and replace any sprinklers that have been decorated or covered over.
- Do not block or concrete around vent holes in a sprinkler housing.
- Unblock vent holes in a sprinkler recessed cup that have been blocked and replace the sprinklers, as appropriate.
- Check concealer plates are connected to the sprinklers above the ceiling.

It should be noted that this list is not exhaustive.

Rectifying any of the above problems should be carried out by a specialist sprinkler contractor.

## 6.8 Summary and conclusions

Design, installation and maintenance features that might detrimentally affect the performance of concealed and recessed pattern sprinklers have been reviewed.

This has involved identifying, gathering and reviewing information on design, installation and maintenance issues. The information was gathered from BS 9251, anecdotal experience with this type of product installed in real buildings, other studies, visual examination and experience of the BRE project team members obtained during the course of the experimental fires and wind tunnel work in this study.

The main conclusions of the review of design, installation and maintenance issues are:

- There are a number of potential problems relating to the design, installation and maintenance of concealed sprinklers.
- For example, unfavourable frame arm orientation, maximum recess distance and unfavourable concealer plate position and a combination of these can delay the thermal response of concealed sprinklers.
- For example, maximum recess distance, alignment of the concealer plate lugs, and frame arm/deflector attachment pins orientation, proximity to high level obstructions and a combination of these can be detrimental to the water distribution of the concealed sprinkler.
- For example, water in the concealer plate, blocked vent holes, glued and painted concealer plates can delay the thermal response of concealed sprinklers.
- These potential problems are avoidable through awareness and improved installation practices. As an aid, a simple checklist of the potential problems identified during this project has been prepared.

## 6.9 References for design, installation and maintenance

1. British Standards Institution. BS 9251 - Sprinkler systems for residential and domestic occupancies - Code of Practice, January 2005.
2. British Standards Institution. Draft for Development DD 252 – Components for residential sprinkler systems. Specification and test methods for residential sprinklers, July 2002.
3. M Hutton, The effect of applied decorative coatings on the thermal response characteristics of residential sprinklers, University of Central Lancashire, Department of Built Environment, Faculty of Design and Technology, May 2004.

## 7 Recommendations for further work

Further work is recommended, predominantly experimental in nature, to study outstanding issues relating to the effectiveness of residential sprinklers, as follows:

- a) An evaluation of residential sidewall sprinklers and other types of residential sprinklers.
- b) A study of the effect of installation practices on the effectiveness of residential sprinklers. For example, sloping ceilings, proximity to ceiling mounted obstructions, beam/sprinkler spacings, potential fire penetrations around sprinklers through floor voids, 'boxing in' of sprinklers.
- c) Further work on the measurement of the thermal sensitivity of concealed residential sprinklers. This would involve improvements to, modifications to and some required specifications for the test method. For example, investigating alternative pressure differentials and flows through the sprinkler head, maintaining the sprinkler mount temperature at 30<sup>0</sup>C, pressurising the sprinkler water bore particularly for the prolonged exposure ramp test, in a similar way to the pendent sprinkler wind tunnel test.