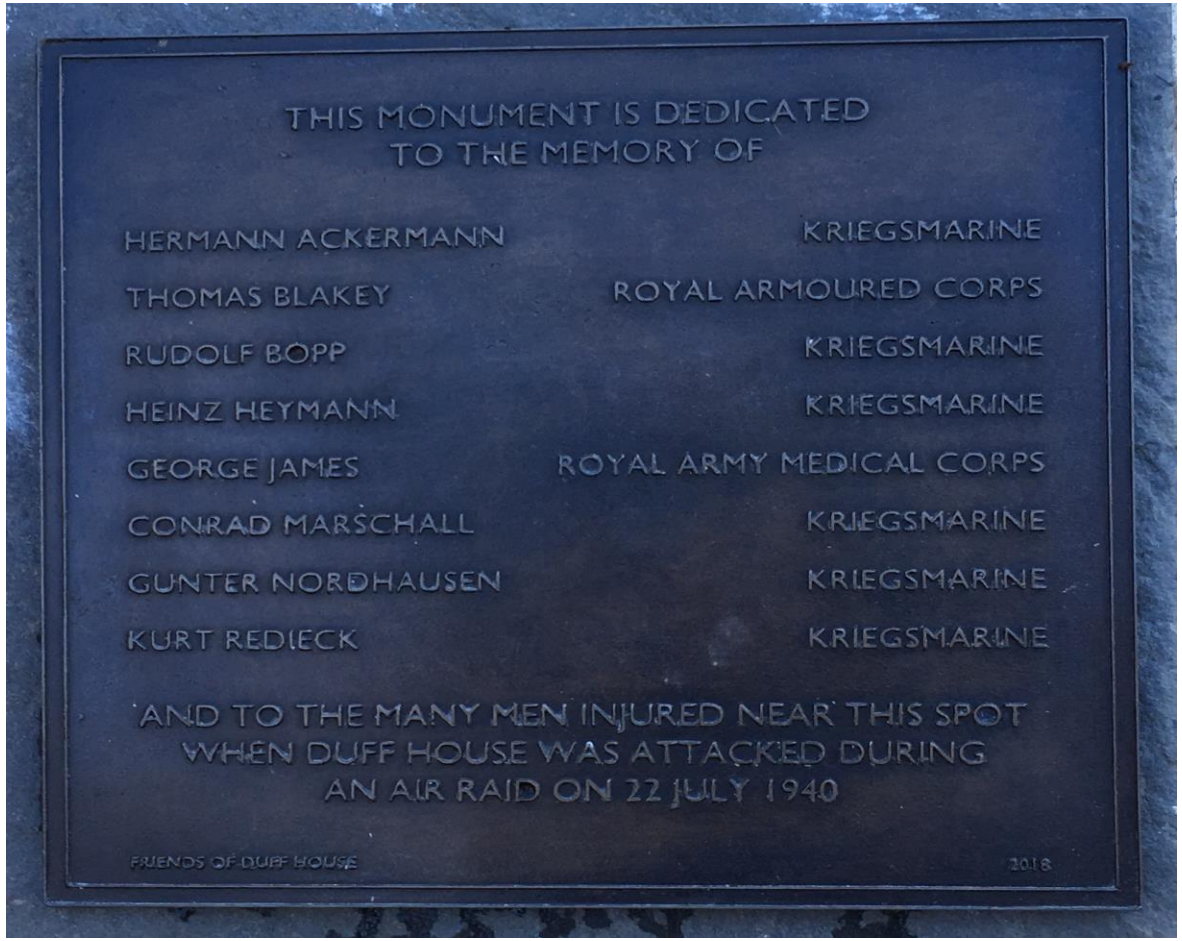
Duff House May 2021: An Exercise in 25-Year Testing of an automatic fire sprinkler system

The Property

- Category A Listed Georgian Mansion
- Constructed 1735 – 1740 by William Adam for the Earls of Fife
- Since 1956 in State Care through Historic Environment Scotland
- Since 1995 operated as a Country House Gallery by the National Galleries of Scotland
- The major restoration project included the installation of a modern fire detection and alarm system, automatic sprinkler system and a sophisticated security and access control system

During WWII the house was used as a PoW camp as well as the HQ for Polish and Norwegian Troops

Marker showing corner of wing of building destroyed in bombing raid on 22 July 1940




EXIT

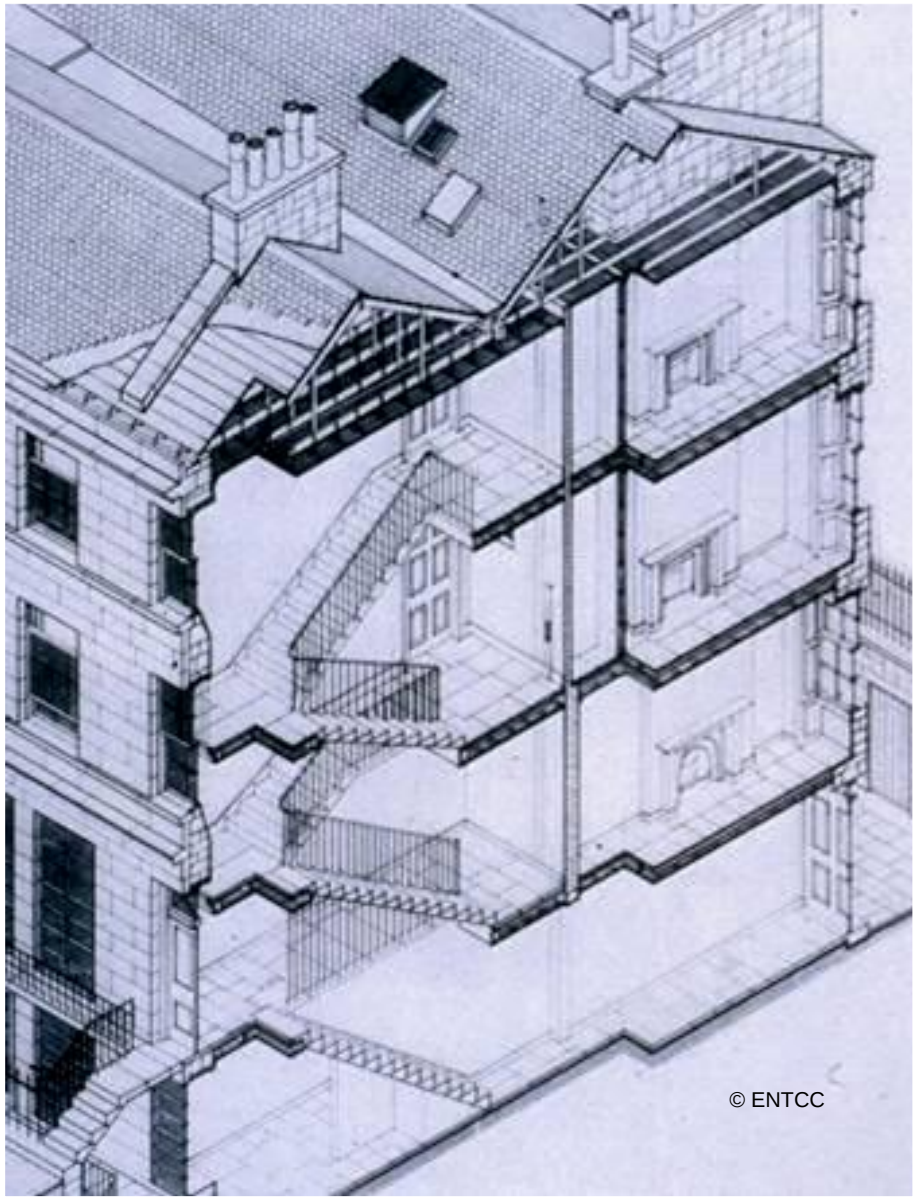
Sidewalls above picture rail level are very discreet

The Sprinkler Installation

- Property protection system
- Designed to Light Hazard BS 5306 Part 2 (1990) in 1993-4 as part of major refurbishment process to facilitate use of building as a major outstation of NGS
- Installation facilitated by removal of flooring on upper levels
- Sprinkler installation in steel with concealed, pendant and sidewall heads

Conservation Principles: Installation of New Systems

- Understand the historic fabric, its value and authenticity
- Be sympathetic in design
- Plan for and arrange full co-ordination of the work team
- Produce a method statement
- Employ specialist support trades and conservation skills
- Ensure adequate supervision and direction of work force.



Over-riding Installation Principles (The Maxwell Principles)

- Essential
- Appropriate
- Sensitive
- Integrated
- Minimally invasive
- Compliant
- Reversible

Be careful not to over-notch historic timber!

- Pipework in attics needs trace heating and insulation where ambient temperatures can regularly drop below freezing

Underground water storage is fine – pumphouses less so!

Annex K
(informative)

Twenty-five year inspection

After 25 years the pipes and the sprinklers should be inspected.

The pipework should be thoroughly flushed out and hydrostatically tested to a pressure equal to the maximum static pressure or 12 bar, whichever is the higher.

The pipework should be internally and externally inspected. At least one metre length of range pipe should be inspected per 100 sprinklers. Two pipe sections of at least one metre length of each pipe diameter should be inspected.

All defects which might adversely affect the performance of the system should be eliminated.

In the case of wet pipe systems at least one sprinkler installation per building should be checked. If sever wet control valve sets are installed in one building only 10 % need be inspected. In the case of dry pi systems, such a reduction of the number of installations to be checked is not allowed.

A number of sprinklers should be removed and tested to ensure that they are fully functional. Tab specifies the scope of sampling as a function of the total number of sprinklers installed.

Table K.1 — Number of sprinkler of each available type to be tested

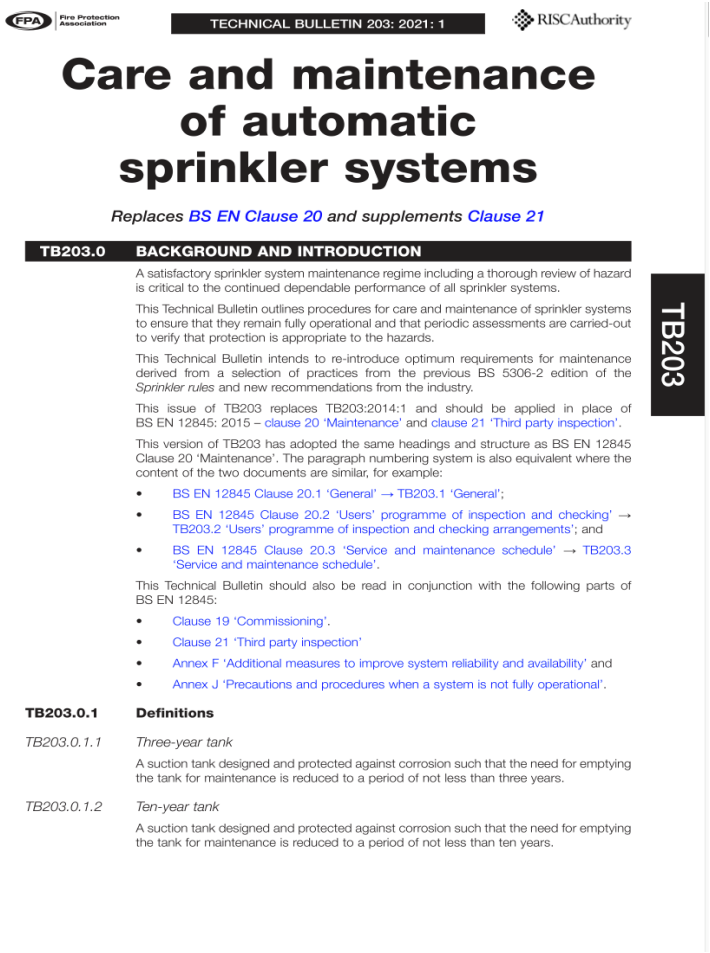
Total number of sprinklers installed	Number of sprinklers to be inspected
≤ 5 000	20
≤ 10 000	40
≤ 20 000	60
≤ 30 000	80
≤ 40 000	100

The sprinklers should be evaluated for the following:

BS EN 12845:2015

This will change in the proposed 2022/23 revision

LPC Rules: Long term maintenance requirements



FPA Fire Protection Association | TECHNICAL BULLETIN 203: 2021: 1 | RISCAuthority

Care and maintenance of automatic sprinkler systems

Replaces BS EN Clause 20 and supplements Clause 21

TB203

TB203.0 BACKGROUND AND INTRODUCTION

A satisfactory sprinkler system maintenance regime including a thorough review of hazard is critical to the continued dependable performance of all sprinkler systems.

This Technical Bulletin outlines procedures for care and maintenance of sprinkler systems to ensure that they remain fully operational and that periodic assessments are carried-out to verify that protection is appropriate to the hazards.

This Technical Bulletin intends to re-introduce optimum requirements for maintenance derived from a selection of practices from the previous BS 5306-2 edition of the *Sprinkler rules* and new recommendations from the industry.

This issue of TB203 replaces TB203:2014:1 and should be applied in place of BS EN 12845: 2015 – clause 20 'Maintenance' and clause 21 'Third party inspection'.

This version of TB203 has adopted the same headings and structure as BS EN 12845 Clause 20 'Maintenance'. The paragraph numbering system is also equivalent where the content of the two documents are similar, for example:

- BS EN 12845 Clause 20.1 'General' → TB203.1 'General';
- BS EN 12845 Clause 20.2 'Users' programme of inspection and checking' → TB203.2 'Users' programme of inspection and checking arrangements'; and
- BS EN 12845 Clause 20.3 'Service and maintenance schedule' → TB203.3 'Service and maintenance schedule'.

This Technical Bulletin should also be read in conjunction with the following parts of BS EN 12845:

- Clause 19 'Commissioning'.
- Clause 21 'Third party inspection'
- Annex F 'Additional measures to improve system reliability and availability' and
- Annex J 'Precautions and procedures when a system is not fully operational'.

TB203.0.1 Definitions

TB203.0.1.1 Three-year tank

A suction tank designed and protected against corrosion such that the need for emptying the tank for maintenance is reduced to a period of not less than three years.

TB203.0.1.2 Ten-year tank

A suction tank designed and protected against corrosion such that the need for emptying the tank for maintenance is reduced to a period of not less than ten years.

TB203.3.8.1.1 Pipework Inspection

As a minimum, a 1m length of each pipe diameter within each installation and from each area of the building(s) where different environments/conditions or where differing pipe specifications or finishes have been applied, which could affect the rate of deterioration/ corrosion of the pipework (e.g. office areas, ceiling voids, plantrooms, external areas, underside of exposed roof structures etc.) shall be visually inspected internally and externally for the presence of any foreign bodies or evidence of microbial activity (e.g. presence of tubercles).

TB203.3.8 After 25 years (or sooner if considered necessary by system condition) (replaces BS EN Annex K)

In addition to the routine service and maintenance activities specified elsewhere in this document, the provisions and activities specified in TB203.3.8 shall be undertaken as required and at intervals not greater than those specified herein. All defects detected which might adversely affect the performance of the sprinkler system shall be eliminated.

COMMENTARY AND RECOMMENDATIONS ON TB203.3.8

These requirements are considered to be minimum requirements. Where any deviation from these requirements is considered as may be appropriate to the circumstances, the insurer (and authority, if applicable) shall be consulted upon the acceptability of the proposed variation on a case-by-case basis.

TB203.3.8.3 *All sprinkler heads (replaces parts of Annex K)*

At twenty five years (or sooner if required by sprinkler head approval conditions or manufacturer's specification) a number of sprinkler heads shall be removed by a competent sprinkler maintenance provider. Dry drop pendant heads shall also be tested as follows, but at reduced intervals (see TB203.3.6). The sprinkler heads shall be inspected and tested by an independent test house. Table TB203.T1 specifies the minimum number of heads to be removed for testing, corresponding to the total installation sizes.

Table TB203.T1 Number of sprinklers to be inspected

Total number of sprinklers installed	Number of sprinklers to be inspected
≤5 000	20
≤10 000	40
≤20 000	60
≤30 000	80
≤40 000	100

Duff House
24 – 27 May 2021
25 Year test of Automatic Sprinkler System

Preparatory Work – started two years before!

Personnel Involved

- Historic Environment Scotland
  - District architect
  - Collections Registrar
  - Conservation staff
  - M&E Engineer
  - Property management and M&E staff
  - Crafts people
  - House Manager
- National Galleries of Scotland
  - Conservation manager
  - Art handling team
- Security Advisor: Museums and Galleries Commission
- Scottish Fire and Rescue Service
- Consultant

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

Notes of meeting

Duff House 25-year Sprinkler Test – Pre-start Meeting
Venue: Online – MS Teams Meeting
Date: Thursday, 6th May 2021
Time: 1400 - 1530

Present

David Blair (HES) Mike Pendery (HES) Corinna Leenen (HES) Lucy Vaughan (HES) – first 30 mins Ally Christie (HES) Malcolm Hutcheon (HES) Matt Pennell (HES)	Nicola Grant (HES) Ross Irving (HES) Maya Gilmour (HES) Mark Duddy (Compco) Doug McNab (Compco) Stewart Kidd (Loss Prevention Consultancy Ltd.)

	Item	Action
1.0	**INTRODUCTIONS**	
1.01	Introductions were carried out.	
2.0	**CONTRACT**	
2.01	Contract Information – David Blair will issue Contract Issue drawings.	David Blair
2.02	Works will start on site on 24th May 2021. Compco expect works to last 1 week.	
2.03	Insurances – Compco will forward details of their Insurance.	Mark Duddy / Doug McNab
2.04	Standards and Quality – Compco have a COVID-19 Statement and RAMS which will be forwarded to David Blair.	Mark Duddy / Doug McNab
2.05	HES have a COVID-19 Minimum Operating Standards document which was issued to Compco as part of the Tender information.	
3.0	**CONTRACTOR'S MATTERS**	
3.01	Compco will start works on the 24th of May 2021. Doug McNab of Compco will be on site on Tuesday, 11th May 2021 at 10am for an inspection ahead of the works. Doug will be meeting Mike Pendery and Malcolm Hutcheon of HES.	Doug McNab
3.02	Programme – HES have a Programme showing 2 weeks work. Compco have advised the works will take 1 week and they will issue a Programme for these works.	Mark Duddy / Doug McNab
3.03	Site Organisation, facilities and planning – HES have produced a Site Compound drawing which was issued with the Tender information. HES have installed a site compound. Compco are providing their own welfare and toilets which can be sited within the HES compound.	
3.04	Site Restrictions – Site inductions will be given by HES before work starts.	

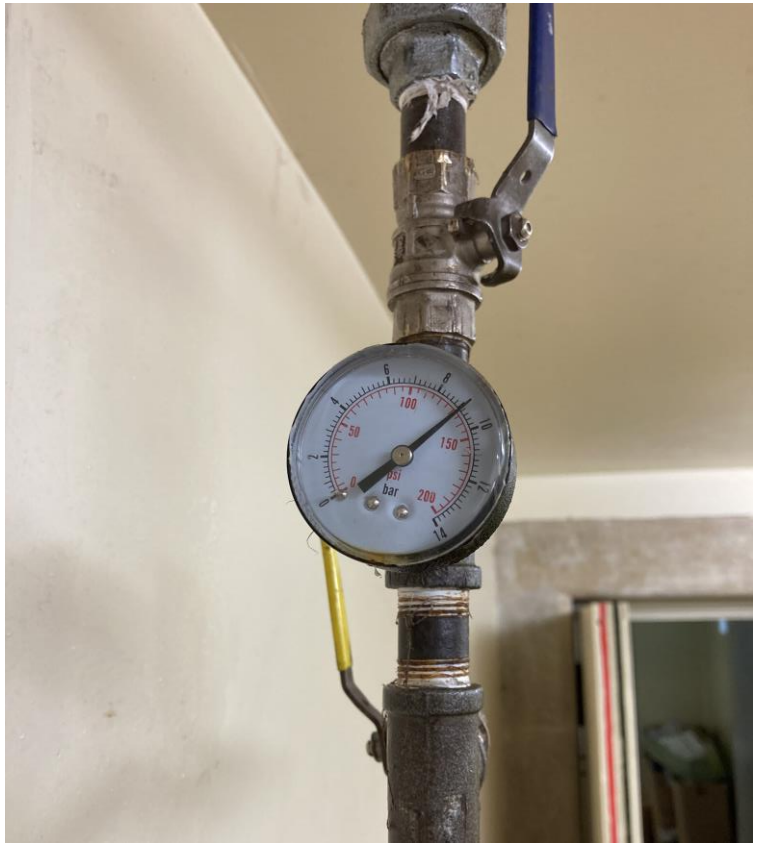
Pump House access to begin drain down

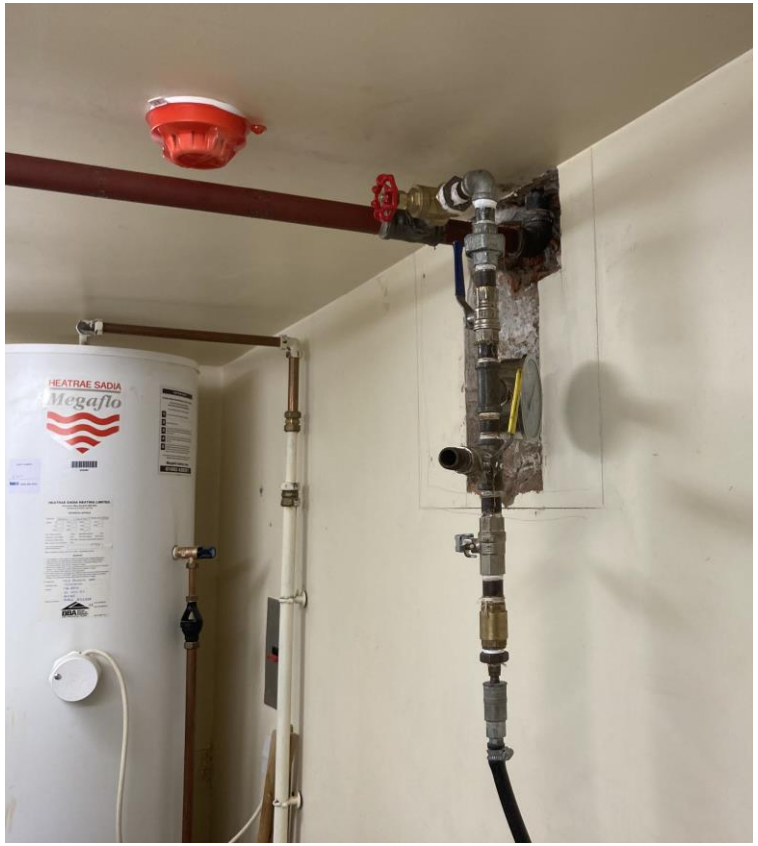
Protection of surfaces prior to work starting

Some heads had to be excavated to remove them. All chasing work done by HES craftspeople

Excavation of main water supply from pump house revealed extensive external corrosion. New pump house and feed planned.

The opportunity was taken to finally relocate a continuously obstructed sidewall





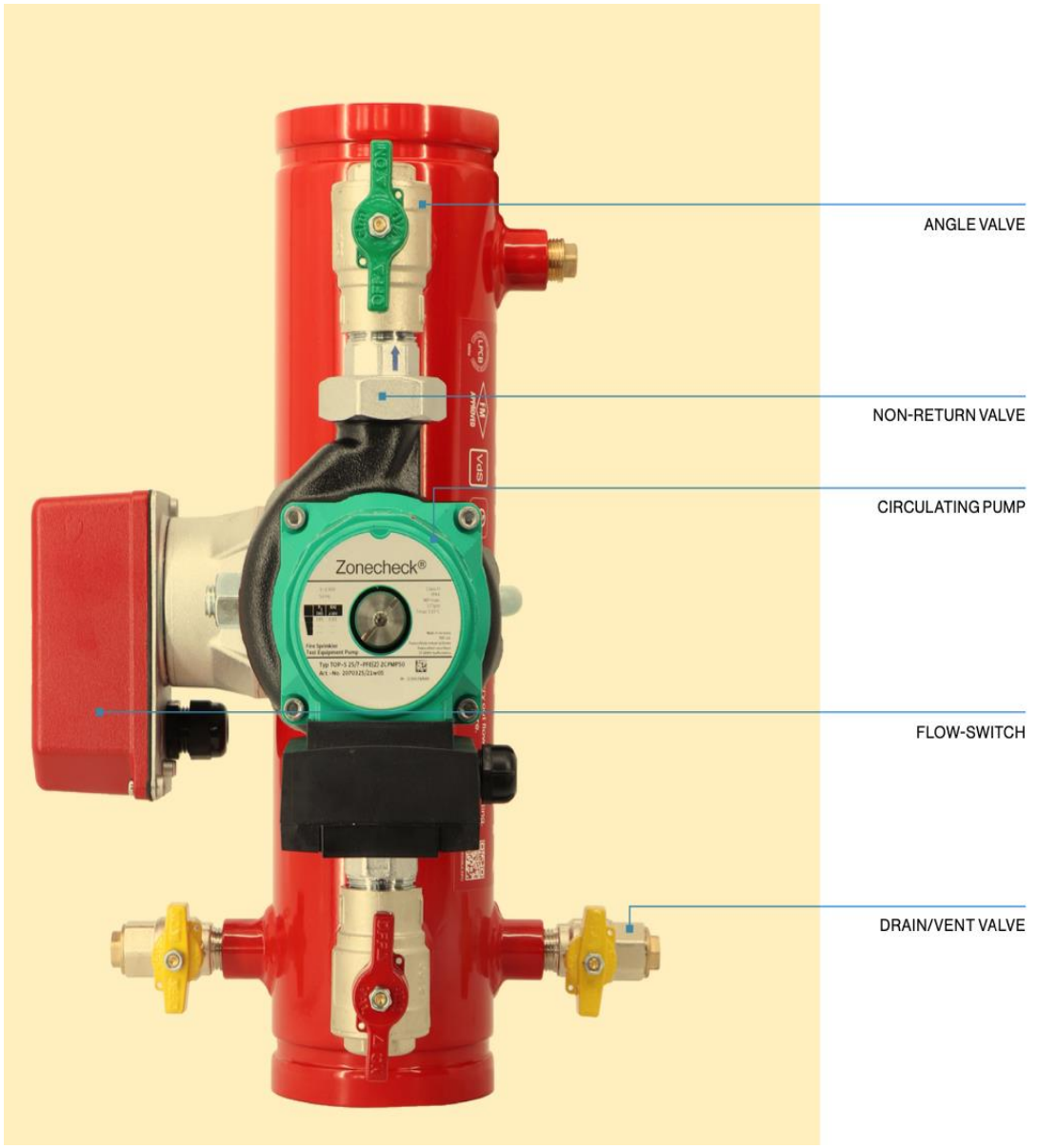
New drain valve installed at lowest point in pipework

Pressurisation unit installed early using new drain valve

Removing heads

Removal of attic sprinklers

Dry Store high level location for Zonecheck unit



Relocated sprinkler head in catering store

3 Results

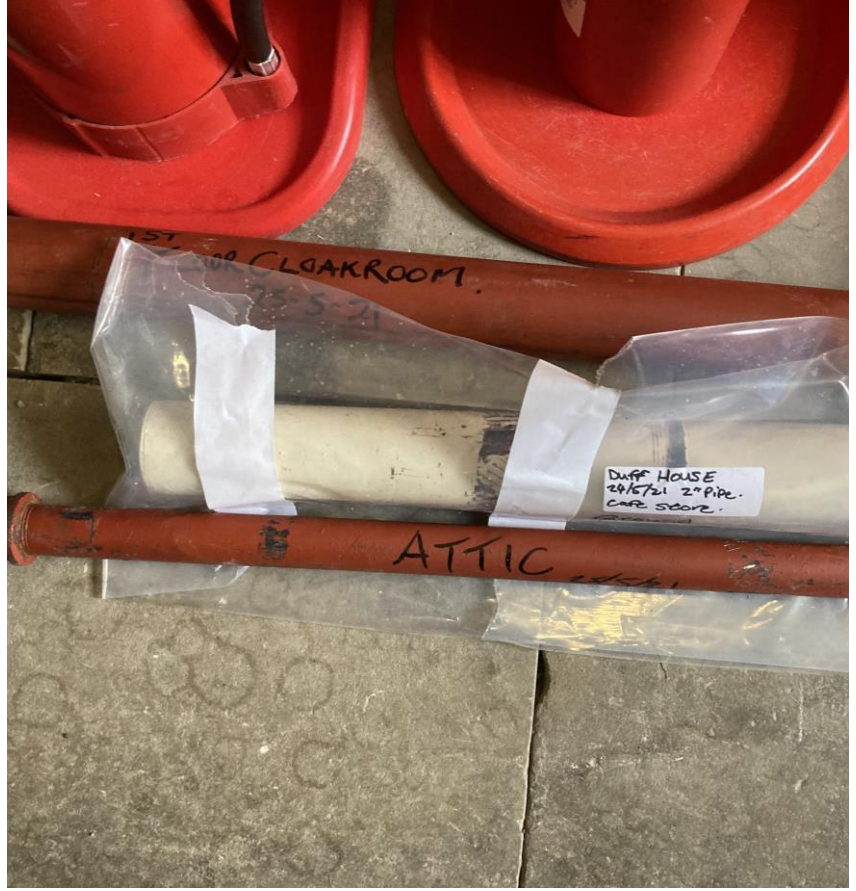
3.1 Visual Inspection

11 sprinkler heads were received for testing, as detailed below. For identification purposes the heads were labelled with specimen numbers 1-11.

Specimen Number	Manufacturer	Model	Date of Manufacture	Intended Operating Temperature (°C)
1 - 2	Rasco	F4FR	1994	57
3 - 7	Rasco	F1FR Sidewall	1994	57
8 - 11	Rasco	F1FR	1994	68

All details have been assumed based on the markings identified in the visual inspection

The Outcomes



Sample Heads and Pipe Sections for Testing

- Heads to be tested to original specification by FPA
- Pipework to be examined metallurgically

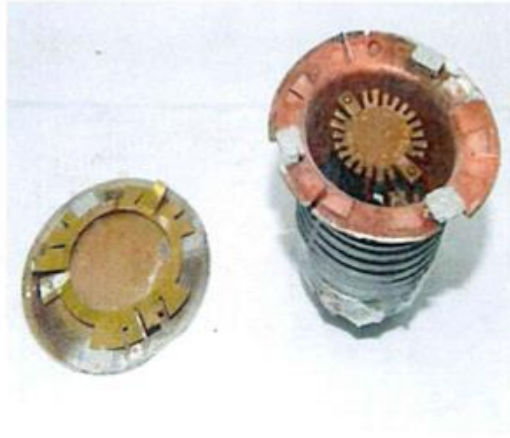


Figure 4 – Specimen 1
Ceiling plate broken off sprinkler body.

Figure 5 – Specimen 3
Build-up of brown deposits in the waterway

Figure 6 – Specimen 7
Paint daubed on the valve assembly and non-critical areas.

Figure 7 – Specimen 11
Build up of turquoise deposits on The deflector plate,valve assembly and non-critical areas

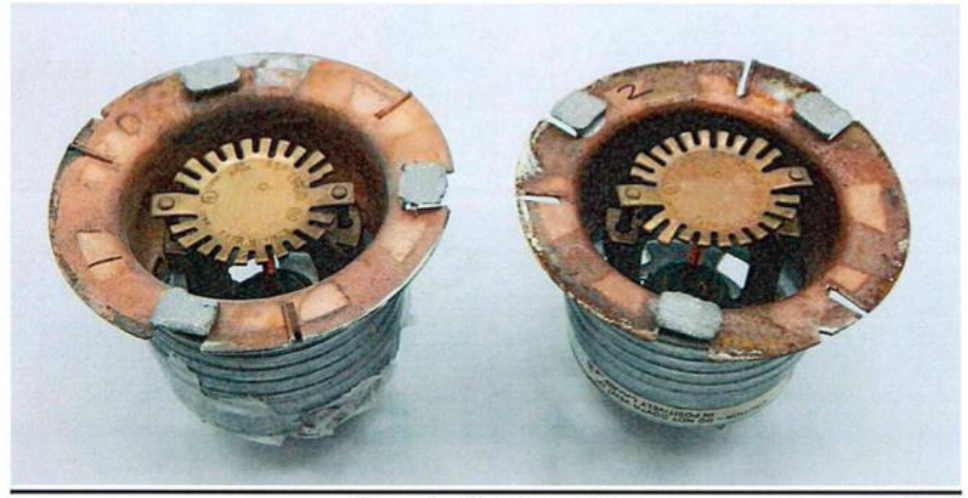


Figure 1 – Specimens 1-2

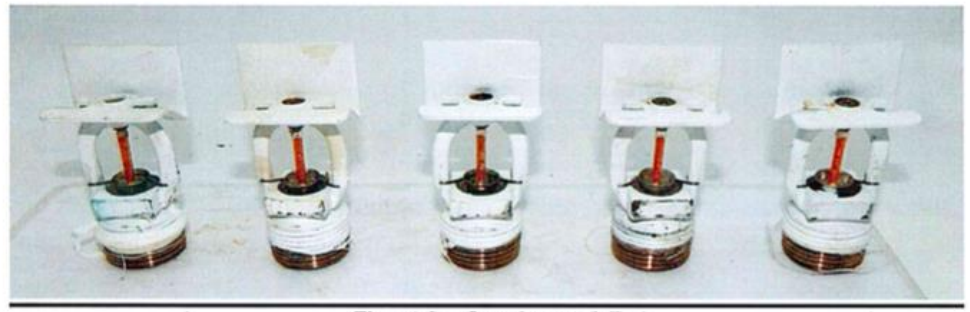


Figure 2 – Specimens 3-7

Figure 3 – Specimens 8-11

Specimen 8

Customer Label	Attic space, 25/5/21
Deposits and Paint	Slight build-up of dirt/dust.
Mechanical Damage	None identified.
Waterway	No significant foreign matter present.
Operating Mechanism	68°C, red, glass bulb, 3mm Ø.
Markings	Deflector plate: '1994', 'UL 701A', 'ULC', '68°C', '155°F', 'F1FR', 'Q.R. EC', 'PEND.'. Flats: 'RASCO', 'F1'.

Specimen 11

Customer Label	Attic space, 25/5/21
Deposits and Paint	Slight build-up of dirt/dust. Build-up of turquoise deposits on the deflector plate, valve assembly and non-critical areas (see Figure 7).
Mechanical Damage	None identified.
Waterway	Build-up of brown deposits.
Operating Mechanism	68°C, red, glass bulb, 3mm Ø.
Markings	Deflector plate: '1994', 'UL 701A', 'ULC', '68°C', '155°F', 'F1FR', 'Q.R. EC', 'PEND.'. Flats: 'RASCO', 'F1'.

Specimen 2

Customer Label	2nd floor, male toilet, concealed head 25/5/21
Deposits and Paint	Slight build-up of dirt/dust. Build-up of turquoise deposits on the valve assembly.
Mechanical Damage	Ceiling plate broken off sprinkler body. Distorted deflector plate tines.
Waterway	No significant foreign matter present.
Operating Mechanism	57°C, orange, glass bulb, 3mm Ø.
Markings	Deflector plate: 'SSP', 'U.S. PAT. NO. 4.880.063', 'ULC', 'Q.R. SPKR', 'UL 701A', '1994', 'F4FR', '135°F/57°C'.

3.2 Function Test

9 sprinkler heads were installed in a function test oven and tested at a pressure of 0.35 bar, the results are as follows:

Rasco F4FR

F4FR Specimen	Pressure (bar)	Orientation	Requirement Met
1	0.35	Pendent	Yes
2	0.35	Pendent	Yes

Rasco F1FR Sidewall

Specimen	Pressure (bar)	Orientation	Requirement Met
3	0.35	Horizontal	Yes
5	0.35	Horizontal	Yes
6	0.35	Horizontal	Yes
7	0.35	Horizontal	Yes

Rasco F1FR

Specimen	Pressure (bar)	Orientation	Requirement Met
9	0.35	Pendent	Yes
10	0.35	Pendent	Yes
11	0.35	Pendent	Yes

All 9 sprinkler heads tested met the requirements of the function test.

3.3 Operating Temperature Test

2 heads were heated in a circulating bath until the glass bulb ruptured. The temperature at which each sprinkler head operated was recorded.

For sprinklers with a temperature rating of 57°C (135°F) the contemporary lower and upper operating limits are:

Lower	54.4°C
Upper	59.6°C

For sprinklers with a temperature rating of 68°C (155°F) the contemporary lower and upper operating limits are:

Lower	65.0°C
Upper	71.0°C

The results are as follows:

Rasco F1FR Sidewall

Specimen	Specified Operating Temperature (°C)	Operating Temperature (°C)	Requirement Met
4	57	56.0	Yes

Rasco F1FR

Specimen	Specified Operating Temperature (°C)	Operating Temperature (°C)	Requirement Met
8	68	69.2	Yes

Both sprinkler heads tested were found to operate inside the limits set by the contemporary European test standard for the design of sprinkler components.

Examination of Pipework

Figure 1 – Specimen 1

Figure 2 – Specimen 2

Figure 3 – Internal view of specimen 1

Figure 4 – Internal view of specimen 2

Specimen 1

Markings	‘ATTIC’, ‘25/5/21’.
Description	1" Medium Gauge steel pipe, painted red and threaded at both ends with an elbow attached to one end.
External Condition	Generally clean and appeared to be in good physical condition.
Internal Condition	Layer of orange corrosion/sediment.
Length	68cm.

Specimen 2

Markings	‘1st Floor Cloackroom’, ‘25/5/21’.
Description	2" Medium Gauge steel pipe, painted red.
External Condition	Generally clean and appeared to be in good physical condition.
Internal Condition	Thin layer of black corrosion/sediment.
Length	100cm.

4 Summary of Results

2 pipe samples were received for evaluation. The visual inspection revealed that all cross-sections had a light build-up of rust or sediment on the internal surfaces. The measured thicknesses of these deposits are shown in the table below:

Specimen Number	Measured Mean Thickness of Deposits on the Internal Surface (mm)	Approx. Reduction in Cross Sectional Area of Pipe Due to Deposits (%)
1	0.2	2.9
2	0.2	1.4

Measurements taken of the external pipe diameter and pipe wall thickness have been compared to the dimensional requirements of BS EN 10255:2004 for medium and heavy series steel tubes as detailed in tables 3, 4 and 5 of the standards respectively and shown in Annex B of this report. The results are shown below:

Specimen Number	Mean Outer Diameter (mm)	Mean Wall Thickness (mm)	Meets the Dimensional Requirements of BS EN 10255:2004
1	33.7	3.1	1" Medium Gauge
2	60.3	3.4	2" Medium Gauge

3.3 Wall Thickness Measurement

Each sample was cut at a cross-section. The wall thickness was measured at the cross-section including any internal deposit. The internal surface was then cleaned back to bare metal and the wall thickness was re-measured.

At each cross-section, 8 measurements were taken at equidistant angles to determine the mean wall thickness, see Appendix A. The results are as follows:

Specimen Number	Average Wall Thickness Including Internal Deposits (mm)	Average Wall Thickness Following Removal of Deposits (mm)
1	3.3	3.1
2	3.6	3.4

Measurements taken of the external pipe diameter and pipe wall thickness have been compared to the dimensional requirements of BS EN 10255:2004 for medium and heavy series steel tubes as detailed in tables 3, 4 and 5 of the standards respectively and shown in Annex B of this report. The results are shown below:

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1	33.7	3.1	1" Medium Gauge
2	60.3	3.4	2" Medium Gauge

What's Next?

I believe Duff House is the first UK sprinklered listed building to be 25 year tested. These other buildings are all protected by AFSS

Duff House May 2021:

Thanks for your interest