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RESEARCH REPORT

Minimum Invasive Fire Detection for Protection of Heritage



by

COWI

on behalf of



in support of



Cover illustration

Sanctuary ceiling dated 1608, at the Lom stave church built around 1240. A 6 mm capillary tube protrudes - invisibly from floor level - through an existing hole in the ceiling and connects to an aspirating air sampling pipe run in the attic. The pipe terminates in the detector unit in a remote service room, outside of the church yard.

Photo by Arvid Reitan

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Minimum Invasive Fire Detection for Protection of Heritage

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ACRONYMS

AAFD	Automatic area fire detection
ASD	Aspirating smoke detector
ASDHS	Aspirating smoke detector, high sensitivity
ASP	Aspirating smoke detector
BFPSA	The British Fire Protection Systems Association
BSD	Beam smoke detector
CACFOA	The Chief and Assistant Chief Fire Officers' Association
CW	Compact wireless all-in-one detector
EN	European Norm
FD	Flame detector
G-JET	Smoke detection design tool
HDP	Point heat detector
HS	Historic Scotland
KP	Compact wireless all-in-one detector
LHD Pair	Line heat detector, short-circuiting type
LHD Tube	Line heat detector, pneumatic type
LHD Wire	Line heat detector, melting wire type
LHD	Line heat detector
LO	Beam smoke detector
NFPA	National Fire Protection Association
NIST	National Institute for Science and Technology
ODPM	UK Government Office of the Deputy Prime Minister
ORD	Point smoke detector, optical
OSDP	Point smoke detector, optical
RNDCH	Riksantikvaren: Norwegian Directorate for Cultural Heritage
RTI	Rate of Temperature Index
SFPE	Society of Fire Protection Engineers
SK	Visual imaging fire detector
SV	Sound and vibration fire detector
SVFD	Sound and vibration fire detector
TIFD	Thermal imaging fire detector
TRD	Aspirating smoke detector, high sensitivity
VD	Point heat detector
VDL Pair	Line heat detector, short-circuiting type
VDL Tube	Line heat detector, pneumatic type
VDL Wire	Line heat detector, melting wire type
VDL	Line heat detector
VIFD	Visual imaging fire detector
VK	Thermal imaging fire detector

1 EXECUTIVE SUMMARY

Fire detection systems in general are effective fire safety measures for heritage buildings and museums. Still, we are faced with these challenges of detectors and inherent cable installations:

- Irreversibly impair fabric or décor
- Renovation and maintenance incur irreversible damage to fabric or décor
- Aesthetically invasive measures in sensitive environments
- Detectors do not respond to fires as quickly as anticipated
- Excessive nuisance alarms: detectors disconnected, or downgraded response
- Cable installations increase risk of fire from lightning
- Application may be inappropriate in terms of cost, efficiency, obtrusiveness

A summary of technologies used for minimizing invasive detector installations has been made. Results are evaluated and recommendations given. The solutions and recommendations generally apply world-wide. Some tests were made to find optimum solutions for the highly valued stave churches of Norway. Other projects and tests were made to investigate outdoor area fire surveillance of historic town centres and multiple building heritage sites.

For indoor applications in historical buildings and museums aspirating smoke detectors are found to be the best option overall to minimize invasion, reversibility, early detection, reliability and on several other factors evaluated. Where heat detection is sufficient, line heat detectors are by far most suited to heritage. Line heat detectors may hardly be visible, are sensitive along their lengths, very reliable, cost-effective and some may be repaired locally with no special parts.

Wireless point detectors are a valued solution to avoid unnecessary invasion. These have improved from the need to exchange batteries frequently, except for non-heated areas in cold climates. The expensive products offer high reliability and are unobtrusive, although most wireless units are quite bulky.

Both visual and thermal image fire detectors (camera software fire detection) may be used in large indoor spaces from well hidden locations. The visual category is prone to deception by moving objects and shadows. The thermal ones are very reliable: They discriminate any movements or shade and detect fire by temperatures exceeding set limits only, but are quite expensive for indoor use.

For surveillance of historic town centres, multiple building heritage sites or all wooden structures externally, thermal imaging fire detectors (cameras) are the most efficient, also because they transmit video to manned alarm stations. Staff will then discriminate harmless incidents from real fires, and avoid unnecessary intervention. Cameras make invasive installations in the buildings unnecessary.

Aspirating smoke detectors are efficient in detecting outdoor or neighbourhood fires even when all sampling tubing and holes are inside a building, and with a low probability of false alarms. This is due to an integrating effect: Small samples of low density smoke in several sampling points will raise an alarm, while quite dense

smoke in one sampling point only will not. Aspirating smoke detectors must be located so that their fans do not cause noise problems in churches. Installation must be done carefully to avoid condensation problems in non- or partly heated buildings. In harsher environments dust filter renewal may be frequent. Aspirating smoke detectors are known for unobtrusive installations and considered to be the least invasive detectors for heritage buildings in general. They offer several other benefits, such as the robustness against false alarms while still being very sensitive to real smoke from fire.

Line heat detectors are also reliable and inexpensive. They are valued for their superior reliability in order to activate extinguishing systems. Smoke detectors are required for early detection of incipient fires, but are less reliable to activate systems that may cause secondary damage. Line heat detectors respond earlier than point heat detectors, and typically as fire heat release exceeds 200 kW - integrating types respond as quickly as point smoke detectors to flaming fires.

Evaluations of minimum invasiveness relate to wired point heat or point smoke detectors as references. Point smoke detectors respond to flaming fire as the smoke layer reaches temperatures within 10-15°C above that of normal air which are common values applied in engineering models. Point optical smoke detectors respond to smouldering fires without substantial room air temperature increase, while ionization smoke detectors may not respond at all. Point heat detectors typically respond as the smoke layer reaches 80-300°C depending on the temperature growth gradient. Sprinklers activate typically from 500 kW rate of heat release at normal room heights.

Although the prime consideration of this report is minimum invasive solutions, other suitability issues like early detection, reliability, cost and other factors are evaluated. Engineering principles for optimum application designs, and measures to reduce false alarms, are also included.