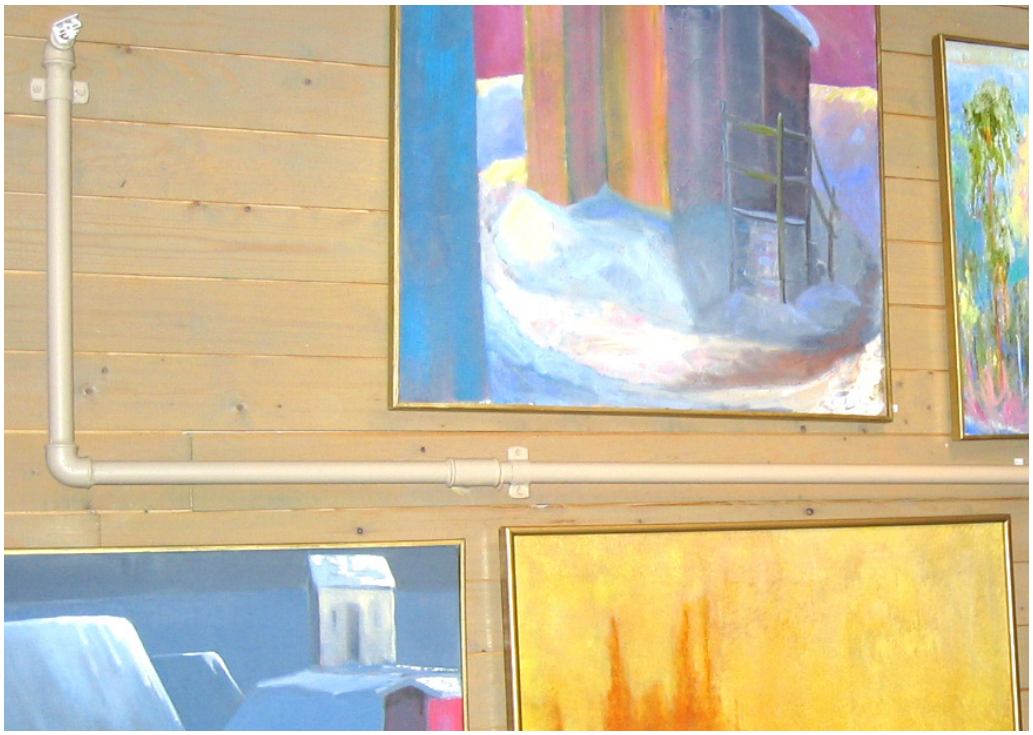
COWI FIRE RESEARCH REPORT 02/2010

Sprinkler Performance Knowledge Base



A Report in Support of the Nordic Project
"Fire Safety Design with Sprinklers"
Sponsored by Innovation Norway

March 2010

COWI

COWI AS
Nordic Project: Fire Safety Design with Sprinklers
Report: Sprinkler Performance Knowledge Base
Sponsored by: Innovation Norway

COWI

COWI AS
Otto Nielsens veg 12
Postboks 2564 Sentrum
NO-7414 Trondheim
Norway

Tel +47 02694
www.cowi.com

Fire Safety Design with Sprinklers

A Project by the Nordic Sprinkler Group
Working Group 2 Work Package 2

Sprinkler Performance Knowledge Base

March 2010

Version Preview
Date of issue 10th March 2010

Prepared Geir Jensen, Anne-Marit Haukø
Checked John Utstrand
Approved Geir Jensen

Table of Contents

Foreword

This sub-report by Working Group 2 for the Nordic Sprinkler Research Group is funded by Innovation Norway. World-wide accessible sources at date of writing of evidence on performance of sprinklers in fire have been compiled.

The report include sprinklers, residential sprinklers and water mist for protection of residential, care, hospital, office, education and retail type of buildings.

Research objectives are to:

1. Support Working Group 1 on development of a guide to assess trade-offs in fire design with sprinklers – for use in performance based design (PBD).

2. Provide a knowledge base for use by code or standard developers on prescriptive requirements and test criteria.

3. Provide a knowledge base for fire protection engineers or code officials in doing design verification of fire safety concepts.

4. Provide a knowledge base on evidence of sprinkler performances for researchers.

All sources are referenced and categorized for ease of use. Sources on Internet are linked to. This is a first edition, and limitations are:

- Most laboratory test evidence exist as non-disclosed proprietary reports - these can not be included in a publicly available knowledge base.

- Project resources prevent further data harvesting or elaborations to be made.

In recognizing global lack of a knowledge base for performance based design, however, we consider the present edition a useful status on evidence by 2010.

Updated editions may include new or missing material which can be submitted by research stakeholders world-wide.

Sprinkler Performance Knowledge Base

A fire safety design with sprinkler can neither be established nor verified without consensual and credible, real evidence.

The main table lists sources on *evidence of performance* by sprinkler and summarizes the content of each for easy search. The designations in left column contain links to entries which are accessible on the internet.

Listings of annexes 1 and 2 are the most extensive and include related research on trade-offs, codes, cost etc. Annex 1 categorizes the sources while 2 provide overview by topic.

Performance Categories

Performances

- Effectiveness to protect life from fire
- Effectiveness to extinguish, control or minimize property damage by fire
- Effectiveness as compensatory measure for prescriptive measures
- Reliability: Probability to perform as designed - on demand
- Cost

Entries are categorized

A. Sources on evidence of performance – life and property loss reduction
B. Sources on evidence of performance – reliability
C. Standards and codes specifying trade-offs or sprinkler performance criteria
D. Literature on sprinkler performances, cost/benefits or sprinkler trade-offs
E. Miscellaneous literature relevant to sprinkler performances

The main table of report summarizes content of sources in categories A and B. Annexes 1 and 2 each cover all categories.

Applications of the Sprinkler Performance Knowledge Base

The compilation is what we registered world-wide on sprinkler performance. It can be used by engineers, researches and authorities for tasks such as:

- Developing prescriptive code requirements
- Developing optimum performing sprinkler systems
- Develop, review or update sprinkler system standards
- Compare performances against alternative extinguishing systems (see below)
- Compare performances against alternative protection measures (see below)
- Setting of insurance rates and rebates
- Fire safety assessment of of existing buildings

Procedure for Application in Performance Based Design (PBD)

Typical Procedure

1. A sprinkler system is planned to comply with installation standard.
2. Task: Assess risk of a specific fire scenario. Probability and consequences of sprinkler operating?
3. Search most relevant entry in categories A (consequences) and B (reliability). To find faster, first search Appendix B by topic to find appropriate entries, make note of their designations and return to table.
4. Read description of the entries in table to decide which one(s) are the most relevant and click link(s) in left column to access the source. If no link, consider access by other means like purchasing it.
5. If successful, the source provide useful evidence for qualitative assessment of the specific scenario, or it provide a way of approach to assess it.

Examples

See sample sketches on separate page. These are made up to illustrate how a qualitative design may be communicated transparently for third party review.

Use of Result in PBD Reporting

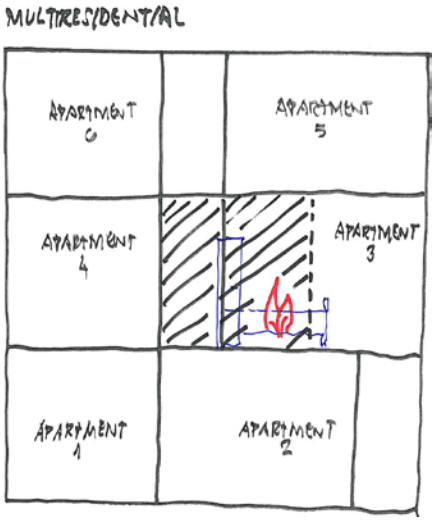
A PBD report should refer to the source(s) used for the qualitative assessment. The robustness or safety margin of results from the qualitative assessment will determine what additional analyses may be required.

Note that this way one can assess performance and reliability of sprinkler only.

Most often, the main design task is trade-off with sprinkler which require comparison against performance of alternative extinguishing systems or prescribed protection by code. For this purpose a method is being developed (WG 1 Draft): "*Methodology for Verifying Trade-offs in Buildings with Fire Sprinklers*".

Assessment of sprinkler performance in residential block scenario:

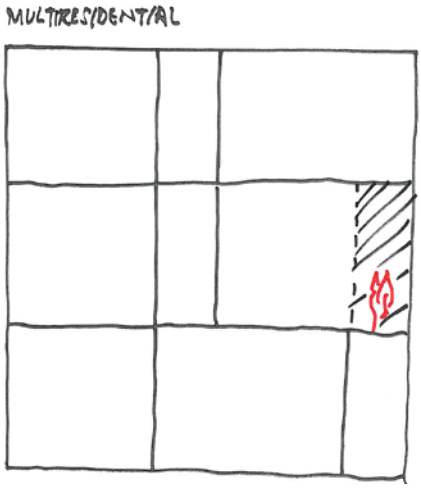
Bedroom fire
(sources A63, A,81, B04)



SCENARIO
Bedroom fire
Open door to corridor
SOURCES OF EVIDENCE
A63
A81
B04
LOSS OF LIFE
0
LOSS OF PROPERTY
6 000 EUR
LOSS AREA
8 m²
RELIABILITY
85

Assessment of sprinkler performance in residential block scenario:

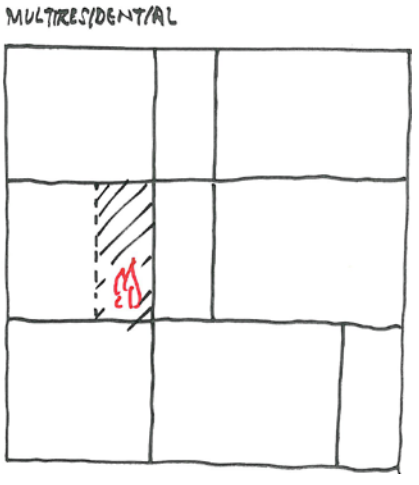
Television set fire
(source A06)



SCENARIO
Televison set fire
SOURCES OF EVIDENCE
A6
LOSS OF LIFE
0
LOSS OF PROPERTY
800 EUR
LOSS AREA
2 m²
RELIABILITY
90

Assessment of sprinkler performance in residential block scenario:

Table fire
(sources A06, A14, B06)



SCENARIO
Table (shielded) fire
SOURCES OF EVIDENCE
A6
A14
B6
LOSS OF LIFE
0
LOSS OF PROPERTY
1 000 EUR
LOSS AREA
2 m²
RELIABILITY
90

Quick Overview to find which Sources Apply to A Scenario

(search by topic)

Annex 1 can be searched by these topics in column headings:

I	Fire extinguishing performance for protection of life
II	Fire extinguishing performance for protection of property
III	Application, ad hoc or in situ type of tests
IV	Standard tests performed by laboratory
V	Reliability
VI	Cost
VII	Building regulation
VIII	Code requirements
IX	Trade-offs
X	Miscellaneous

Fire extinguished by water based system in standard laboratory test

Real fire extinguished by stand alone water mist system in a living room of a disabled person

(Sandefjord.Nettsted dsb.no)

SOURCE	SCENARIO	PERFORMANCE			CREDIBILITY	COMMENT
ID of literature compilation		**Loss of Life Reduction**	**Property Loss Reduction**	**Reliability**	Ranking 1-5 * 5=highest	

A Sources on evidence of performance – Life and property loss reduction

A1 Click IDs in this column to access (internet versions only)	Bedrooms in care homes. Does sprinkler protect persons intimate with fire – in the fire room? 6 tests: nightwear and bedclothes. Pork w/skin 'body target'. FED analyses.	Occupants of which nightwear or bedclothes initially are set on fire will not survive. Other occupants of the room do not experience untenable conditions Reference tests without sprinkler cause rapid death to persons intimate with fire and untenable conditions for others in the room	Not explored (sprinkler performance suggest fire limited to within 1 or few m^2) Report by Williams et al for ODPM: Bedroom sprinkler respond to bed fire within few minutes at heat release rate as low as 100 kW at ceiling temperatures 100-150 ^oC.	-	5	In the present tests sprinklers operated within 74-96 ^oC at heads – indicating the lower RTI values in comparison with study by Williams et al. The tests are reported in detail. This report conclude on residential sprinkler cost-effectiveness.
A2	Realistic kitchen fire in domestic two story maiso-nette dwelling. Chip pan fire.	Not a threat to able occupants Improved visibility in exits compared to non-sprinklered.	Effective control of pan fire.	-	4	Some impairment of visibility in close vicinity during early stage of the sprinkler activation. No spread to other items (likely fatal potential for sleeping if spread occur)
A2	Realistic bedroom fire in domestic two story maiso-nette dwelling. Bedding fire – sprinklered +non-sprinklered tests	Not a threat to able occupants Improved visibility in exits compared to non-sprinklered. Unsprinklered fire likely fatal as not sufficient time to move	Effective and rapid extinguishment.	-	4	Some impairment of visibility in close vicinity during early stage of the sprinkler activation.
A2	Realistic lounge fire in domestic two story maiso-nette dwelling. Armchair fire – sprinklered +non-sprinklered tests	Visibility as in non-sprinklered fire. No toxic threat to occupants able to exit. Unsprinklered fire likely fatal as not sufficient time to move	Effective and rapid extinguishment.	-	4	
A2	Realistic fire in shop in a shopping centre. 108 m2, h 4 m, enclosed room with no venting. Fire in 100 kg of mixed items: Clothing, toys, bo-oks, futons, wood shelves – sprinklered and non-sprinklered tests	Visibility as in non-sprinklered fire. No toxic threat to occupants able to exit. Unsprinklered fire likely fatal as not sufficient time to move	Effective and rapid extinguishment.	-	4	

A3	Prior, preliminary study of test results of A2 in regard to survivability at sprinkler-controlled fires.	See A2	See A2	-	3	This report include an overview of suvivability at sprinkler and water mist activations from several sources including commercial, residential, aircrafts.
A4	See A26, A28, A32, A33 and A34	See A26, A28, A32, A33 and A34	See A26, A28, A32, A33 and A34	Refer to FM Global 1995 analysis: Water mist system w/booster pump on public mains increase failure rate by 0.03 compared to residential sprinkler system without pump.	4	Meeting memo include brief discussion on reliability of water mist systems.
A5	Compiled experience with performance test methods for water based systems sprinkler, residential sprinkler, high/low mist	All systems tested: Good life safety performance Most challenging test: Corner test to UL 1626 (UL 2167)	All systems tested: Prevented fire spread room-corridor Most challenging test: Corner test to UL 1626 (UL 2167)		4 Results in this entry from a summary (review main report when available)	• UL 1626 • UL 2167 • FM 2030 • FM 5560 Appendix I (US LH Class) • IMO Res. A. 800 • DSB/SRSA guidelines No reference to VdS test methods. Authors suggest review of the DSB/ SRSA guide on acceptance criteria.
A6	Test series of residential sprinkler performance in 18 fire tests. Fuel burnt by area recorded,FEDanalysis Lounge, compartment and room of origin 30 min fires	Occupants in room of fire origin would not experience extreme pain from convected heat. In all of sprinklered fires death would not occur. Visibility: Sprinkler no significant effect, not worse and not improved Without sprinklers lounge fires would cause death to occupants of room of origin within 14-17 min. For open plan lounge fires or doors open fires without sprinklers would cause untenable conditons throughout the house. Test results for room of fire origin: Improved convected heat exposure, visibility insignficanty changed. Table fires become unsurvivable. Television set fires caused untenable conditions to room occupants by smoke prior to sprinkler activation. All nonsprinklered fires got lethal, visibility criteria exceeded first, then convected heat and toxicity criteria.	Property protection performance was not main objective. However, main report include data on extent of property damages by area.	-	4 Results in this entry from Summary Report Main report include data on extent of proerty damages.	A1 is a continuation of the A6 research. Project goal to determine cost-effectiveness criteria to justify installation: See A1 for updated findings and conclusions. A6 concluded residential sprinkler were not cost-effective for life safety. *However, additional benefits like reducing property loss etc could make residential sprinkler cost-effective overall.*
A7	Test series of sprinkler, low pressure water mist and high pressure water mist to determine secondary effects of spray on invaluable paintings	-	The secondary damage impact on paintings vary with type of system and painting location on wall. Impact varied with type of painting as well, authentic old or new.	-	4 (see also Swedish language main report)	The results are inconclusive. Comparison with Norwegian ad hoc test results suggest locations and spray directions of nozzles are governing factors rather than type of system or type of painting

A8	See A6	See A6	See A6	See A6	See A6	See A6
A9	Water mist system performance in large fires in road tunnels.	The improvement on life safety was obvious. Main factor: cooling effect by water mist on the smoke layer.	The property loss reduction was evdient. Main factor is cooling effect by water mist on the smoke layer.	-	3 (pre-liminary, not final report)	The paper discuss various sources and other tests. Overall, water mist is considered great potential for road tunnels if correclty applied.
A10	Reported findings from a questionnaire on 1000 installed water mist systems in UK in all categories of purpose of Approved Document B.	Performance is not reported.	Performance is not reported.	Few fire events are registered for the >1000 systems. For all of these events the water mist systems performed successfully.	3	The >1000 water mist systems are all proved fit for purpose by use of standards, fire demonstrations and performance tests. The systems are installed in dwellinghouses, flats and maisonettes in that order (most in dwellinghouses) according to officials. *Most of them are installed as compensatory measures to Building Regulation requirements (trade-offs).* This entry is less relevant for performance of water mist in fires - except for reliability to respond at real fires.
A11	See A1	See A1	See A1	See A1	See A1	See A1
A12	Test standard applying realistic set ups for fire in cabin, luxury cabin, corridor, public space etc on board ships.	See 'Comments'. Refer to document for details.	See 'Comments'. Refer to document for details.	-	4/5	This is a highly regarded test standard - and model for most water mist standards for on land applications as well. The furnitured 'cabins' are relevant to residential rooms on land. Approved systems pass acceptance criteria which are detailed in terms of loss of mass, ignited items, percentage of damage to items etc. Acceptance criteria is generally considered to exceed those of sprinklers, though equivalence is the aim.
A13	In this chapter trade-offs with residential sprinklers or conventional sprinklers are discussed.	Performance is not reported.	Performance is not reported.	-	4	This book and the actual chapter is on residential sprinkler history and general It is relevant for describing the early tests and the objectives for developing residential sprinkler systems in the US.
A14	US Benefit-cost analysis of residential sprinkler systems	The reduced loss of life is 100 % fewer civilian fatalities and 57 % fewer civilian injuries (background study of fires 2002-2005 with 13D sprinkler system and smoke alarms) Expected present value of net benefits (PVNB) (in 2005 $) is $2919 for colonial, $3099 for townhouse and $4166 for ranch style houses. Lives and property are both valued.	Reduced loss of property was 32 %. Expected present value of net benefits (PVNB) (in 2005 $) is $2919 for colonial, $3099 for townhouse and $4166 for ranch style houses. Lives and property are both valued.	Reliability was not part of study. However, the reported statistics (at left) is evidence that life safety reliability is very high. Loss of property is not addressed by '13D' systems. Still, a substantial loss reduction ia evident.	4/5	This report is currently the most ind-depth analysis of cost-effectiveness by residential sprikler systems. The most costeffective residential system is '13D' type on which the study is based. This report provide good performance quantification of a particular type of sprinkler system in terms of economc benefit for three types of bldgs. Such reports should be useful if provided for each of common sprinkler systems.

						The report stress that more complicated standard sprinkler systems may not exhibit net benefits, as the most simple kind of '13D' systems proved for the studied three categories of residences.
A15	See A2	See A2	See A2	See A2	See A2	See A2
A16	See A3	See A3	See A3	See A3	See A3	See A3
A17	See A1	See A1	See A1	See A1	See A1	See A1
A18	Reliability, cost and water quality of residential sprinkler systems (Aus.)	-	-	Reliability of most simple residential system (compare to 'D') is less than that of an ordinary sprinkler system. *By enhancements the simple system become more reliable and is suggested for multi-residential buildings and care facilities (typical use of 'R' systems). This would include health and mental hospitals (for which one normally apply conventional sprinkler) if supported by an extended study.* Reliability figures quoted from referenced work are 80-85 % (Rohr US 2001) and 94-100% (Rohr & Hall US 2005). The current research study deducts 95% as 'overall residential sprinkler reliability'.	4/5	*We find this report particularly relevant to the prime topics of the current Nordic Sprinkler Group, including trade-off concepts and cost-effectiveness*. The residential sprinkler systems of this cost-effective kind are referred to as "combination domestic fire sprinkler systems" in Aus. and compare to 'D' systems or "multi-purpose network sprinkler systems" in the US. The water quality and reliability research of this report is quite comprehensive. The water quality issue stems from stagnant water in pipe ends where water is never fully drained.
A19	See A10	See A10	See A10	See A10	See A10	See A10
A20	Recessed and concealed sprinklers tested to determine performance compared to pendent sprinkler in residential premises.	Based on 12 'stylised' tests (standard tests using realistic furniture in laboratory) and 10 realistic table and televison fires, recessed or concealed heads compare to pendant sprinkelrs in terms of life safety in the room of fire origion, although corrrect installation also proved crucial.	Slow growing and shielded fires proved a challenge to control by recessed or concealed sprinklers.	-	4/5	This extensive article provide an overview on UK research on sprinklers and residential sprinklers as of Nov 2007. Residential sprinklers cost-effective for care homes and all blocks of flats *when more than 11 storeys*. Not cost-effective for other dwellings unless one apply trade-offs to increase the effectiveness.
A21	The report on which A20 is based.	See A20	See A20	See A20	See A20	See A20
A22	A report on benefits and trade-offs using sprinkler. Extinguishing and control performances of sprinklers	Summarizes the results of some of the other entries in this compilation. *Guide and calculations on how to*	Summarizes the results of some of the other entries in this compilation. Discuss and list example trade-offs	Reliability is addressed by discussion based on statistical data of common fire protection measures.	3/4 (*As being referred to by UK ADB: May*	*This report is the single source that best addresses objectives of the Nordic Group WG 2 Project.*

	and residentail sprinklers and water mist. For use with performance based or prescriptive design. Cost, reliability and table listing trade-offs in UK ADB prescriptive code.	*determine sprinkler effectivenes in a given buildings – for use with performance based fire safety design and trade-offs.*	for sprinkler as well as for residential sprinkler systems. *Guide and calculations on how to determine sprinkler effectiveness in a given buildings – for use with performance based fire safety design and trade-offs*.	It compare sprinkler to other measures. All evidence support the statement sprinkler reliability by far outperforms reliability of for instance fire rated compartmentation.	*rank as 5*)	*In some respect this document provides method and guide like the WG 2 aims for.* The report is referred to by UK ADB prescriptive code.
A23	Extinguishing tests conducted by laboratory: A realistic kitchen fire and a bedroom fire. Several 'extinguishing' agents' tested. Sprinkler used for bedroom fire only.	-	The test results are interesting but less for general conclusions. It can be valuable to check this if one evaluates sprinkler suitability at kitchen and bedroom fire scenarios.	-	3	Interesting for these two residential fire scenarios.
A24	See A23	See A23	See A23	See A23	See A23	See A23
A25	Article explaining why minimum water density demand of NFPA 13D and 13R was increased 2002.	-	-	-	4	The discussion on performance of residential sprinkler of two different densities is relevant.
A26	A presentation on SINTEF criteria and test method for autonomous extinguishing systems for living room for disabled persons.	Sofa fire, upholstered chair fire, cooking stove fire scenarios. Door closed and open. Non-rated wall and ceiling surfaces. See complete report A28 for details. See Axx for tests of same scenarios.	Sofa fire, upholstered chair fire, cooking stove fire scenarios. Door closed and open. Non-rated wall and ceiling surfaces. See complete report A28 for details. See Axx for tests of same scenarios.	-	4/5	See complete report A28 for details.
A27	See A36	See A36	See A36	See A36	See A36	See A36
A28	See A26	The test method applies realistic furniture etc and a dedicated set of acceptance criteria. The tests assume disabled person in the room of fire origin. The 4 systems tested did not meet the criteria but for one exception.	-	-	4/5	This test method and criteria is adopted by authorities in Sweden and Norway. Finland did verifying tests and suggests review of parameters/criteria on details. Being considered in UK. Such systems are not known for being addressed by any other standard.
A29	Fire safety of two safety designs are compared using two different methods of analysis: Gretener (SIA DOC 81) method plus a method applying probability of severe fires that threaten construction integrity.	Life safety excluded from study.	A 60 min design with small compartments compared to a sprinklered design with larger compartments and 30 min rating. *The probabilistic method is reported to serve well. Author points at considerable savings for design of structures involving steel or timber.*		4/5	Swiss research. *The only source and method identified that analyse consequences of interaction of active and passive systems and sprinkler as a compensating measure for increased and fewer compartments - as opposed to work on sprinkler to reduce fire resistance only.*
A30	Presentation on the paper	See A29	See A29	See A29	See A29	See A29

	of A29. Provide details and sample calculations.					
A31	Article on successful real fire incident involving water mist in care home.	Fire in pillow/bed in a care home living room was automatically extinguished by the water mist system prior to manual intervention.	Fire in pillow/bed in a care home living room was automatically extinguished by the water mist system prior to manual intervention. Minimal secondary/water damage.	-	3	This sample success story of water mist is similar to numerous successful sprinkler activations. This is the way water mist works as expected. The article reminds of minor damage compared to room damage without sprinkler
A32	See A26 and A28	See A26 and A28	See A26 and A28	See A26 and A28	See A26 and A28	See A26 and A28
A33	Report discusses challenge of comparing performance of different water based suppression systems. It points at need for a guide.	-	-	-	4/5	Relevant when comparing different type of systems for extinguishing or suppression at specific applications.
A34	See A33	See A33	See A33	See A33	See A33	See A33
A35	A detailed report on tests made in laboratory to assess performance of a water mist system at fires in paper archive, compact shelves archive and fixed video cassette archive.	Proprietary report.	Proprietary report.	Proprietary report.	Proprietary report	This report is listed as *an example of numerous* laboratory tests made for manufacturers and not accessible for research. Such reports contain detailed and highly useful data for those assessing specific system performance at an application. The merit of such reports should be ranked high and favoured to general methods or tests to determine performance (comment by this author)
A36	Complete overview of tests to determine residential sprinkler performance in fire - made up to 2001.	Test methods are described. Since most use realistic furnitured test rooms they are relevant to assess performance of residential sprinklers as a compensatory measure.	Test methods are described. Since most use realistic furnitured test rooms they are relevant to assess performance of residential sprinklers as a compensatory measure.	-	4/5	The report complements the other listed sources on fire tests, since few of these cover historic development tests prior to 2001.
A37	Comprehensive cost-benefit analysis of residential sprinklers. Reliability, probabilities, statistics,damage reducing performance, cost etc.	A method of risk assessment included. Performance is based on tests reported in other entries of this list.	A method of risk assessment included. Performance is based on tests reported in other entries of this list.	Reliability is extensively handled. Much of content in A18 is discussed in this report as well.	4/5	Although more recent works in this list addresses the same, this report may be the most thorough one.
A38	Paper deals with challenge of comparing performances of different systems for different applications.	-	Laboratory tests are referenced on applications of aviation, sensitive artefacts and paintings.	Reliability is briefly discusssed	4	Performance based design with sprinklers require quantification in terms of loss of damage, loss of life etc. A new set of acceptance criteria is proposed.
A39	Full scale tests of multiroom configuration with corridor and sprinkler	Conditions in corridor and target room tenable in all sprinkler tests. 1 MW wood crib. Burn room 15m^3	-	-	4	Conclutions similar as A2 and A3 and is very clear. However, use of wood crib less realistic than A2 and A3 test fires.

B Sources on evidence of performance – Reliability

B1.1	Reliability study of sprinkler installations in DK by inspections	-	-	97.6 % of systems were considered operational at time of inspection.	3	The reliability study is unusual: Most other studies are based on fires. Entry B2 discusses this study. A similar study was performed earlier in NO: Results are very different – 74 and 80 % - despite similar systems and no pumps. The reason is obviously the way data is handled. See B8 on how to handle this.
B1.2	Comments to entry B1	-	-	-	3	The study cannot compare with any other and caution should be exerted when applying the results.
B2	An anonymised report distributed by an IAFSS forum member in 2005.	-	-	A controversial report presenting less good reliability data on sprinklers using statistical data and being critical of former statistics. This report is important since it changed statistical reports.	2	It is believed this report caused NFPA to change its way of presenting statistical data. They became more nuanced and reliability figures lowered. By now, the general opinion is NFPA reports are fair and correct – they also compare to figures published by NIST and BSI.
B3	NFPA article on the 2008 statistical report on sprinklers. See B7 for extensive report published 2009.	-	-	See B7 for updated figures 2009	4	Published annually.
B4	See B7	See B7	See B7	See B7	4	See B7
B5	See B7	See B7	See B7	See B7	4	See B7
B6	A summary of death statistics in Europe and arguments to prevent future loss by sprinkler	-	-	Pointing at sprinkler superior reliability and loss reduction, listing multiple-death fires.	2	-
B7	The NFPA annual report on sprinkler statistics 2009	Extensive loss of life reduction statistics	Extensive loss reduction statistics	- In reported structure fires large enough to activate them, sprinklers operated in 95% of fires in sprinklered properties. -Wet pipe sprinklers operated in 96% of these fires vs. 84% for dry pipe sprinklers. - In reported structure fires large enough to activate them, sprinklers operated and were effective in 91% of fires in sprinklered properties.	4	The most comprehensive statistics world-wide on sprinkler loss reduction and reliability performance

				-Wet pipe sprinklers operated and were effective in 92% of fires vs 77% for dry pipe sprinklers.		
B8	A compilation of 7 reports on sprinkler statistics from various countries of the world.	-	-	The reliability of sprinkler systems in Sweden is 92%.	3	A good report which handles diverse criteria of reports systematically. Note the results are in line with the most comprehensive reports (B7, B11, B15).
B9	See B7	See B7	See B7	See B7	4	See B7
B10	See B7	See B7	See B7	See B7	4	See B7
B11	A summary of statistics on sprinkler versus other protection systems. Made 9 years prior to B8.	-	-	Distinguishes on *operational* and *performance* reliability and discuss the implications of definitions and comparing statistics. Due to available sources most are *operational* data only and figures are high for sprinkler: 95-99%. Fire compartments w/doors: 69%(gypsum),81%(masonry)	4/5	This makes up the single US source attempting to compare reliability of fire protection systems. An equivalent study is B15 and figures compare well.
B12	See B12	See B12	See B12	See B12	4/5	See B12
B13	See A29 and A30	See A29 and A30	See A29 and A30	Three methods tested and compared in terms of suitability in performance based design and trade-offs between structural and active protection systems – the pro-babilistic method favorable.	4	See A29 and A30
B14	An article on sprinkler system reliability out of various statistical sources.	-	-	Conforms to terminology of B11 and results by sources varies 81.3% to 99.5%. A sound discussion on reliabi-lity estimates, probability calculations etc.	3/4	It is useful to consider B7, B11, B15 as well while applying this research article
B15	Standard on how to handle reliability of fire protection measures in performance based analyses. List of reliability data deducted from various statistics.	-	Overall reduction in loss due to provision of sprinklers: 50 %.	Probability of successful sprinkler operation: Maximum: 0.95 % General: Property protection: 0.9 % Life safety: 0.8 % Minimum: 0.75 %	4/5	This makes up the single UK source attempting to compare reliability of fire protection systems. An equivalent study is B18 and figures compare well.

* *Ranking of credibility: This table include Category A and B sources (test evidence) only. Ratings of knowledge base entries in Categories C-E are generally lower.*

ANNEX 1

Compiled Literature by Category

A Sources on Evidence of Performance – Loss Reduction (life and property)

1. Shipp, M; Clark, P: *Sprinkler Effectiveness in Care Homes*. BRE Ltd. ODPM Final Research Report BD2546. 2006. http://www.bre.co.uk/filelibrary/consultations/partB/Sprinkler_Effectiveness_in_Care_Homes.pdf
2. Purser, David: *Sprinklers and fire effluents. Methods for assessing life threat from sprinklered fires*. ISO TC92/SC3 WG2 N. 2001.
3. Purser, David: *Assessment of Time to Loss of Tenability Due to Smoke, Irritants, Asphyxiants and Heat in Full-Scale Building Fires – Effects of Suppression and Detection on Survivability*. BRE Ltd. Fire Research Station.
4. Arvidson, M: *Nordic Residential Sprinkler Guidelines*. Minutes from the first meeting of WG 3, Stockholm May 18, 2009.
5. Vaari, J: *Fire performance of automatic water based fire fighting systems for residential occupancies*. Slide presentation. VTT Technical Research Centre of Finland.2009.
6. Williams, C et al: *Effectiveness of sprinklers in residential premises*. Project report number 204505. February 2004. http://www.bretrust.org.uk/filelibrary/rpts/sprinkler/sprinkler_section2.pdf
7. Arvidson, M: *The influence of water from sprinkler sprays on invaluable wall- and ceiling paintings in heritage buildings*. SP Technical Research Institute of Sweden. 2007.
8. Williams, C et al: *Effectiveness of sprinklers in residential premises*. Project report number 204505. February 2004. http://www.bretrust.org.uk/filelibrary/rpts/sprinkler/sprinkler_section2.pdf
9. Mawhinney, J. R: *The case for Water Mist Systems in Road Tunnels*. Hughes Associates, Inc.
10. *Fire suppression in buildings using water mist, fog or similar systems - Final report*. Building Research Technical Report 4/2005. Office of the Deputy Prime Minister. December 2005. http://www.communities.gov.uk/documents/planningandbuilding/pdf/143273.pdf
11. Shipp, M; Clark, P: *Sprinkler Effectiveness in Care Homes*. BRE Ltd. ODPM Final Research Report BD2546. 2006. http://www.bre.co.uk/filelibrary/consultations/partB/Sprinkler_Effectiveness_in_Care_Homes.pdf
12. *Revised Guidelines for Approval of Sprinkler Systems Equivalent to that Referred to in Solas regulation II-2/12*. Resolution A.800(19). 1995. http://books.google.no/books?id=085DgvDYwTYC&pg=PA177&lpg=PA177&dq=%22Revised+Guidelines+for+Approval+of+Sprinkler+Systems+Equivalent+to+that+Referred+to%22&source=bl&ots=5UIoBQaHvQ&sig=QyfydwocG0WsLQEI6H6ivyaJ4U&hl=no&ei=LIu_Sq6sJ9PXQbE2pGgAQ&sa=X&oi=book_result&ct=result&resnum=1#v=onepage&q=%22Revised%20Guidelines%20for%20Approval%20of%20Sprinkler%20Systems%20Equivalent%20to%20that%20Referred%20to%22&f=false
13. Coleman, R. J: *Residential Sprinkler Systems*. Pages 24-25. National Fire Protection Association. 1991. http://www.amazon.com/gp/product/0877653461?tag=openlibr-20
14. Butry, D. T; Brown, M. H; Fuller, S. K: *Benefit-Cost Analysis of Residential Fire Sprinkler Systems*. NIST. September 2007. http://www.bfrl.nist.gov/oae/publications/nistirs/NISTIR_7451_Oct07.pdf
15. Purser, David: *Sprinklers and fire effluents. Methods for assessing life threat from sprinklered fires*. ISO TC92/SC3 WG2 N. 2001.

16. Purser, David: *Assessment of Time to Loss of Tenability Due to Smoke, Irritants, Asphyxiants and Heat in Full-Scale Building Fires – Effects of Suppression and Detection on Survivability*. BRE Ltd. Fire Research Station.
17. Shipp, M; Clark, P: *Sprinkler Effectiveness in Care Homes*. BRE Ltd. ODPM Final Research Report BD2546. 2006.
http://www.bre.co.uk/filelibrary/consultations/partB/Sprinkler_Effectiveness_in_Care_Homes.pdf
18. Soja, E: *Domestic Fire Sprinkler Systems - Report on Water Quality, Reliability and Application to Other Property*. Project Number FQ5011. BRANZ Limited. March 30, 2006.
http://www.branz.co.nz/cms_show_download.php?id=56
19. *Fire suppression in buildings using water mist, for or similar systems - Final report*. Building Research Technical Report 4/2005. Office of the Deputy Prime Minister. December 2005.
http://www.communities.gov.uk/documents/planningandbuilding/pdf/143273.pdf
20. *Hidden Potential*. Article, Fire safety Engineering, 20/06/2007.
http://www.fseonline.co.uk/articles.asp?article_id=6151
21. Williams, C; Annable, K: *Effectiveness of Sprinklers in residential premises - an evaluation of concealed and recessed pattern sprinkler products*. DCLG Final Research Report. Section 2: Description of the project. BRE Ltd. March 2006.
http://www.bre.co.uk/filelibrary/pdf/rpts/partb/218113_Final_report_Section_2_Description.pdf
22. *Use and Benefits of Incorporating Sprinklers in Buildings and Structures*. Arup Fire. Draft 2, January 2006.
http://products.ihs.com/cis/Doc.aspx?AuthCode=&DocNum=284320
23. Huczek, J. P: *Demonstartion Testing: Extinguishment of Kitchen Fires and the Effect of Sprinklers in a Residential Setting*. Southwest Research Institute (SwRI). 2007.
http://www.nfpa.org/assets/files//PDF/Proceedings/Demonstration_Testing.._-_J._Huczek.pdf
24. Huczek, J. P: *Demonstartion Testing: Extinguishment of Kitchen Fires and the Effect of Sprinklers in a Residential Setting*. Southwest Research Institute (SwRI). 2007.
http://www.nfpa.org/assets/files//PDF/Proceedings/Demonstration_Testing.._-_J._Huczek.pdf
25. Huggins, R: *Home Safe*. NFPA Journal May/June 2004.
http://findarticles.com/p/articles/mi_qa3737/is_200405/ai_n9360427/
26. Drangsholt, G; Rossebø, B. E: *Mobile vanntåkeanlegg - et alternativ til boligsprinkling*. Slide presentation. SINTEF NBL as.
27. Arvidson, M: *En sammanställning av väldokumenterade brandförsök med bostadssprinkler*. SP Sveriges Provnings- och Forskningsinstitut. SP Rapport 2001:03. ISBN 91-7848-844-3. 2001.
http://www.amazon.co.uk/sammanst%C3%A4llning-v%C3%A4ldokumenterade-brandf%C3%B6rs%C3%B6k-bostadssprinkler-rapport/dp/9178488443
28. Drangsholt, G; Rossebø, B. E: *Vanntåkeanlegg I omsorgsboliger. En kartlegging av hvilken effect mobile og let flyttbare vanntåkeanlegg harp å brannsikkerheten I omsorgsboliger*. Rapportnr. NBL A06108. SINTEF NBL as. 2006.
http://nbl.sintef.no/publication/lists/docs/NBL_A06108.pdf
29. Fontana, M: *Fire Sprinklers in Probabilistic Approaches to Protection*. ETH, Zurich, Switzerland.
30. Fontana, M: *Fire Sprinklers in Probabilistic Approaches to Protection*. Slide presentation. ETH, Zurich, Switzerland. March 2006.
31. *Vanntåkeanlegget fungerte perfekt*. DSB. December 9, 2008.
www.dsb.no/Article.asp?ArticleID=3038&oppslag=1
http://www.aktuellsikkerhet.no/id/33625.0
32. Drangsholt, G; Rossebø, B. E: *Vanntåkeanlegg I omsorgsboliger. En kartlegging av hvilken effect mobile og let flyttbare vanntåkeanlegg harp å brannsikkerheten I omsorgsboliger*. Rapportnr. NBL A06108. SINTEF NBL as. 2006.
http://nbl.sintef.no/publication/lists/docs/NBL_A06108.pdf
33. Wighus, R: *Ekvivalente systemer for brannbekjempelse i bygninger - en utredning*. Rapportnr. NBL A08107. SINTEF NBL as. Mai 2008.
http://nbl.sintef.no/publication/lists/docs/NBL_A08107.pdf
34. Wighus, R: *Ekvivalente systemer for brannbekjempelse i bygninger - en utredning*. Rapportnr. NBL A08107. SINTEF NBL as. Mai 2008.
http://nbl.sintef.no/publication/lists/docs/NBL_A08107.pdf

35. *Assessment of an automatic extinguishing process using water mist*. Centre des Archives Nationales de Pierrefitte Sur Seine (Pierrefitte Sur Seine Natinal Archive Center). Revision 1. Oct 30, 2007. (*proprietary – not for use*)
36. Arvidson, M: *En sammanställning av väldokumenterade brandförsök med bostadssprinkler*. SP Sveriges Provnings- och Forskningsinstitut. SP Rapport 2001:03. ISBN 91-7848-844-3. 2001. http://www.amazon.co.uk/sammanst%C3%A4llning-v%C3%A4ldokumenterade-brandf%C3%B6rs%C3%B6k-bostadssprinkler-rapport/dp/9178488443
37. Duncan, C. R. et al: *Cost-Effective Home Fire Sprinkler Systems*. BRANZ Report FCR 5-a. BRANZ. November 2003. http://www.buildingcommission.com.au/resources/documents/BRANZ_research_report.pdf
38. Wighus, R; Jensen, G: *Performance Criteria of Systems to Reduce Fire Damage by Prevention or Suppression.* SINTEF NBL AS/COWI AS. 2008. http://www.nfpa.org/assets/files//PDF/Foundation%20proceedings/Wighus.pdf
39. Madrzykowski, Daniel: *The Reduction of Fire Hazard in Corridors and Areas Adjoining Corridors Provided by Sprinklers*. NIST IR 46 31. http://fire.nist.gov/bfrlpubs/fire01/PDF/f01183.pdf

B Sources on Evidence of Performance - Reliability (life and property)

1. Knudsen, R; Bygbjerg, H: *Reliability of Automatic Sprinkler Systems* (AWS systems). DBI Report 2008:02. 2008. http://en.dbi-net.dk/media/AVS_Stat_UK_.pdf
   1.1. Jensen, G: Danish Sprinkler Statistics. E-mail. December 19, 2008.
2. Holt, I (??): *Reliability of Sprinkler systems*. Draft 5. 2004.
3. Hall, J. R. Jr: *The Latest NFPA Statistics on Sprinkler Performance*. NFPA Journal Mar/Apr 2008. http://afscc.org/Hall_Sprinkler_nfpa_90_percent_reliability.pdf
4. Hall, J. R. Jr: *An Analysis of Sprinkler Reliability Using Current Data*. Slide presentation. National Fire Protection Association. March 2006.
5. Hall, J. R. Jr: *An Analysis of Automatic Sprinkler System Reliability Using Current Data*. National Fire Protection Association. March 29, 2006. http://www.nfpa.org/assets/files/PDF/Proceedings/An_Analysis_of_Automatic_Sprinkler_Reliability...-J.Hall_pap.pdf
6. Brinson, A: *European Hotel Safety Issues*. Slide presentation. European Fire Sprinkler Network. March 28, 2006.
7. Hall, J. R. Jr: *U.S. Experience with Sprinklers and Other Automatic Fire Extinguishing Equipment.* National Fire Protection Association. January 2009. http://www.nfpa.org/assets/files/PDF/OSsprinklers.pdf
8. Malm, D; Pettersson, A-I: *Tillförlitlighet för automatiska sprinkleranläggningar - en analys av befintlig statistik*. Department of Fire safety Engineering and Systems Safety - Lund University, Sweden. Report 5270. 2008. http://130.235.7.155/publikationsdb/docs/5270-EN.pdf
9. *NFPA report finds reliability of fire sprinklers even higher than estimated.* NFPA Journal. November/December 2005. http://www.encyclopedia.com/doc/1P3-966412901.html
10. *U.S. Experience with Sprinklers.* One-Stop Data Shop, NFPA. http://trans-ennis.com/National%20Firer%20Protectio%20Association.pdf
11. Bukowski, R. W. et al: *Estimates of the Operational Reliability of Fire Protection Systems.* 1999. http://fire.nist.gov/bfrlpubs/fire99/PDF/f99079.pdf
12. Bukowski, R. W; Budnick, E. K: *Quantifying the Performance of Fire Detection, Sprinklers, and Fire Resistant Construction in the United States*. http://fire.nist.gov/bfrlpubs/fire97/PDF/f97199.pdf
13. Fontana, M; Fetz, C: *Interaction between active fire safety measures and required structural fire protection*. Institute for Structural Engineering, ETH Zurich. http://cibworld.xs4all.nl/dl/ib/0002/Pages/Forth/083rd.html
14. Budnick, E. K: *Automatic Sprinkler System Reliability*. Fire Protection Engineering, winter 2001.
15. PD 7974-7:2003 *Application of fire safety engineering principles to the design of buildings - Part 7: Probabilistic risk assessment.* BSI British Standards Institution. June 26, 2003.

C Test Standards and Codes on Trade-offs or Performance Criteria

1. *DD 252:2001 Components for residential sprinkler systems - Specification and test methods for residential sprinklers.* BSI British Standards Institution. March 2001.
2. Östman, B: *Fire safety desing with sprinklers - Agenda for meeting in Stockholm 16 June + Meeting minutes.* E-mail. June 18, 2009.
3. Madrzykowski, D; Fleming, R. P: *U.S. Review of Residential Sprinkler Systems: Research and Standards.* National Institute of Standards and Technology/ National Fire Sprinkler Association. January 2002.
4. *NFPA 13R Standard for the Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height.* National Fire Protection Association. 2007 Edition.
5. *NFPA 13D Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes.* National Fire Protection Association. 2007 Edition.
6. *DD 9999:2005 Code of practice for fire safety in the design, construction and use of buildings.* BSI British Standards Institution. ISBN 0 580 46039 8. July 8, 2005.
7. *prNS-INSTA 900-2 Residential sprinkler systems - Part 2: Requirements and test methods for sprinklers and their accompanying rosettes.* Standard Norge. November 14, 2008.
8. *Lett monterbare automatiske slokkesystemer.* Direktoratet for samfunnssikkerhet og beredskap (dsb). Juni 2007.
9. *NFPA 555 Guide on methods for Evaluating Potential for Room Flashover.* National Fire Protection Association. 2004 Edition.
10. *Tekniske retningslinjer for dimensjonering, prosjektering og installering av sprinkleranlegg I bygninger for boligbruk opp til og med 4 etasjer.* Direktoratet for samfunnssikkerhet og beredskap (dsb).Mars 1999.
11. *Byggdetaljblad 550.361 Sprinkleranlegg.* SINTEF Byggforsk. 2008.
12. Williams, C; Jackman, L: *An independent guide on water mist systems for residential buildings.* Building Research Establishment (BRE). 2006.
13. *DBI informerer om - Projektering, installation, drift og vedligeholdelse, inspection og godkendelse af vandtågeanlæg.* DBI Nyhedsbrev 01/06. Dansk Brand- og sikringsteknisk Institut. 2006.
14. *FG-veiledning for vanntåkesystemer.* Utgave 2. Forsikringsselskapenes Godkjennelsesnevnd. 2009.
15. *Approval Standard for Residential Automatic Sprinklers. Class Number 2030.* FM Approvals LLC. September 1983.
16. *FM 2-8N: NFPA 13 Standard for the Installation of Sprinkler Systems 1996 Edition.* Factory Mutual Insurance Company. September 2004.
17. *NS-EN 12845 Fixed firefighting systems. Automatic sprinkler systems. Design, installation and maintenance.* Norges Standardiseringsforbund. 1st edition, January 2004.
18. Fire protection Engineering. Issue No.9 winter 2001.
19. Nicholson, J: *Updating NFPA 13.* Pages 35-41. NFPA Journal. January/February 2006.
20. *NFPA 13 Standard for the Installation of Sprinkler Systems.* National Fire Protection Association. 2010 Edition.

D Sources on Trade-off Performance and Cost/Benefit Analyses

1. Wighus, R; Jensen, G: *Performance Criteria of Systems to Reduce Fire Damage by Prevention or Suppression.* SINTEF NBL AS/ COWI AS. 2008.
2. Wighus, R; Jensen, G: *Performance Criteria of Systems to Reduce Fire Damage by Prevention or Suppression.* Slide presentation. SINTEF NBL AS/ COWI AS. 2008.
3. *Sprinkler systems Planning and installation - Appendix T: Requirements for an automatic water mist fire protection system.* CEA Property Committee. 2008.
4. Williamson, J. W; Marshall, A. W; Trouvé, A: *Developing Extinction Criteria for Fires.* Department of Fire protection Engineering, University of Maryland.
5. Gann, R. G: *Technology for Fire Suppression in Aircraft: Findings on the Next Generation Fire Suppression Technology Program.* Building and Fire Research Laboratory.

6. *PD 7974-7:2003 Application of fire safety engineering principles to the design of buildings. Probabilistic risk assessment.* BSI British Standards Institution. June 26, 2003.
7. Coleman, R. J: *Residential Sprinkler Systems; Pages 24-27.* NFPA. 1991.
8. *The Economics of Sprinklers.* FSE. June 2008.
9. Greenman, R: *History Automatic Fire Sprinklers.* E-mail. March 9, 2003.
10. Coleman, R. J: *Residential Sprinkler Systems; Pages 104-113.* NFPA. 1991.
11. Nystedt, F: *Residential Sprinklers Providing Life Safety and Lowering Costs.* Department of Fire Safety Eng., Lund University.
12. Olsson, F; Frantzich, H: *An Approach towards a Simple Risk Based Design Method.* Department of Fire Safety Eng., Lund University.
13. Frantzich, H; Nystedt, F; Lundin, J: *Risk Concepts in Fire safety Design.* Lund University.
14. Duncan, C; Wade, C: *Cost-Effective Domestic Fire Sprinkler Systems.* Building Research Association of New Zealand (BRANZ). 2001.
15. Butry, D. T; Brown, M. H; Fuller, S. K: *Benefit-Cost Analysis of Residential Fire Sprinkler Systems.* NIST. September 2007.
16. Bengtson, S et al: *Brandskyddshandboken.* pp 148-157. ISSN: 1402-3504. Lunds Universitet. 2002.
17. Horwitz-Bennett, B: *Fire protection: The Right Balance.* Web-page: Consulting-Specifying Engineer. www.csemag.com/magazine/articles/cse0402round.asp 02/01/2004
18. Licht, R: *Balancing Active and Passive Fire protection Balance.* Alliance for Fire and Smoke Containment and Control.
19. *Home Sprinklers Score 'A' in NIST Cost-Benefit Study.* Web-page: NIST. www.nist.gov/public_affairs/tchbeat/tb2007_1011.htm October 12, 2007
20. Hall, J. R: *New Statistics on Sprinkler Reliability and Performance.* National Fire Protection Association.
21. *Boendesprinkler radar liv.* Pages 37-54. Trätek publication 0202007, 2002.
22. Annable, K: *Residential Sprinkler Systems - Hidden Potential.* FSE. June 2007.
23. *Home Fire Sprinkler Cost Assessment.* The Fire Protection Research Foundation. September 10, 2008.
24. The Fire Protection Research Foundation News: E-mail. January 19, 2009.
25. Robbins, A; Wade, C; Bengtsson, J: *Sprinklers and sustainability.* BUILD, pages 78-79, December 2008/January 2009.
26. *U.S. Experience with Sprinklers.* One-Stop Data Shop, NFPA.
27. Coleman, R. J: *Residential Sprinkler Systems*. Pages 24-27. National Fire Protection Association. 1991.
28. Siarnicki, Ronald Jon: *Residential sprinklers: One community's experience twelve years after mandatory implementation.* Fire Chief. Prince George's County, Maryland. 2001. http://www.fireteamusa.com/Documents/PrinceGeorgeStudy.pdf
29. *The Nations Fire Problem*. America Burning. The National Commission. USA. 1973.
30. *America at Risk. America Burning Revisited*. FEMA 2002. http://www.usfa.dhs.gov/downloads/pdf/publications/fa-223-508.pdf
31. *Home Fire Sprinkler Cost Assessment.* The Fire Protection Research Foundation. NFPA. USA. 2008. http://www.nfpa.org/assets/files//PDF/Research/FireSprinklerCostAssessment.pdf
32. Weatherby, Steve: *Benefits of Residential Fire Sprinklers*. Home fire Sprinkler Coalition. USA. 2009. http://www.homefiresprinkler.org/images/Prince-Georges-County-Report.pdf
33. *Comparative Analysis of Housing Cost and Supply Impacts of Sprinkler Ordinances at the Community Level.* Final Report. USA. National fire Protecton Association. 2009. http://www.firesprinklerinitiative.org/assets/files/FSI_Comparison_Analysis_Final_Report.pdf
34. *Integration of Residential Sprinklers with Water Supply Systems*. National Fire Protection Association. USA. 2009. http://www.firesprinklerinitiative.org/assets/files/FSIWaterSupplyIntegration.pdf

E Additional Sources

1. Baretto, M; Fedøy, A: *Sammenligning av vanntåke og sprinkling*. Høgskolen Stord/Haugesund. 2005.
2. -
3. Mirkhah, A: *Plan now or pay later*. NFPA Journal. March/April 2006.
4. Nicholson, J: *Welcoming sprinklers into the home*. NFPA Journal. July/August 2005.
5. Suhrke, T: *Automatisk brannslokking i boliger kan spare liv*. Brannmannen nr. 6 - 2005.
6. Johansen, D; Lennavik, T: *Effekt av sprinkleranlegg i Scottsdale. Vurderinger rundt bruk av sprinkleranlegg som brannsikringstiltak i Norge*. NBFL. 2006.
7. Purser, David: *Sprinklers and fire effluents. Methods for assessing life threat from sprinklered fires*. ISO TC92/SC3 WG2 N. 2001.
8. Purser, David: *Assessment of Time to Loss of Tenability Due to Smoke, Irritants, Asphyxiants and Heat in Full-Scale Building Fires – Effects of Suppression and Detection on Survivability*. BRE Ltd. Fire Research Station.
9. Hartzell, G. E: *Combustion products and their effects on life safety*. NFPA. 1997.
10. *Life threat from fires - Guidance on the estimation of time available for escape using fire data*. ISO/DTS 13571. 2001.
11. Yu, X: *Investigation of Recessed and Concealed Sprinklers Activation in Wind Tunnel Plunge Test and in BRANZFIRE Computer Model*. University of Canterbury, New Zealand. March 2007.
12. *Cost of installing residential fire sprinklers averages $1.61 per square foot*. NFPA News Release. 2008. http://www.nfpa.org/newsReleaseDetails.asp?categoryid=488&itemId=40496
13. Jensen, G: *Building Design with Sprinkler - Verification Approach*. Slide presentation. COWI. November 20, 2008.
14. Bygbjerg, H: *DBI informerer om - Projektering, installation, drift og vedligeholdelse, inspection og godkendelse af vandtågeanlæg*. Dansk Brand- og sikringsteknisk Institut. DBI Nyhedsbrev 01/06. http://dbi-net.dk/files/pdf/inspektion_nyhed/nyhedsbrev_01-06.pdf
15. *Quick comparison of NFPA 13, 13R, and 13D standards*. Slide presentation. San Fransisco Fire Department. October 12, 2007. http://www.sfgov.org/site/uploadedfiles/dbi/DBIProsSummit/NFPA%2013%20Installation%20of%20Sprinkler%20Systems.ppt
16. Golinveaux, J: *Changing Standards for Residential Sprinklers*. BrandPosten nr 31, 2004.
17. Huggins, R: *Home Safe*. NFPA Journal May/June 2004.
18. Bek, Peter: *Sprinkleranlægs Brandeffektdæmpende Egenskap*. Master degree project report at DTU, Denmark. 2009. http://www.brand.dtu.dk/upload/institutter/byg/master_brand/brandtekniske%20projektopgaver/sprinkleranl%C3%A6gs%20brandeffektd%C3%A6mpende%20egenskab%20af%20peter%20bek.pdf
19. Heskestad and Hill: *Experimental fires in Multiroom/Corridor Enclosures*. NBS GCR 86 502. CIB W14/85/10. USA. http://fire.nist.gov/bfrlpubs/fire86/PDF/f86001.pdf

ANNEX 2

Compiled Literature – Overview to Search by Topic

ID	TITLE OF DOCUMENT	I Extinguishing performance - life	II Extinguishing performance -property	III Application tests	IV Standard laboratory tests	V Reliability	VI Cost	VII Building regulation	VIII Requirements in codes	IX Trade-offs	X Misc.
A Sources on Evidence of Performance – Loss Reduction (Life and Property)											
A1	Shipp, M; Clark, P: *Sprinkler Effectiveness in Care Homes*. BRE Ltd. ODPM Final Research Report BD2546. 2006. http://www.bre.co.uk/filelibrary/consultations/partB/Sprinkler_Effectiveness_in_Care_Homes.pdf	●		●	●		●				
A2	Purser, David: *Sprinklers and fire effluents. Methods for assessing life threat from sprinklered fires*. ISO TC92/SC3 WG2 N. 2001.	●		●							
A3	Purser, David: *Assessment of Time to Loss of Tenability Due to Smoke, Irritants, Asphyxiants and Heat in Full-Scale Building Fires – Effects of Suppression and Detection on Survivability*. BRE Ltd. Fire Research Station.	●		●							
A4	Arvidson, M: *Nordic Residential Sprinkler Guidelines*. Minutes from the first meeting of WG 3, Stockholm May 18, 2009.	●				●	●				●
A5	Vaari, J: *Fire performance of automatic water based fire fighting systems for residential occupancies*. Slide presentation. VTT Technical Research Centre of Finland.2009.	●		●	●		●	●	●		
A6	Williams, C et al: *Effectiveness of sprinklers in residential premises*. Project report number 204505. February 2004. http://www.bretrust.org.uk/filelibrary/rpts/sprinkler/sprinkler_section2.pdf	●		●	●		●	●			
A7	Arvidson, M: *The influence of water from sprinkler sprays on invaluable wall- and ceiling paintings in heritage buildings*. SP Technical Research Institute of Sweden. 2007.		●	●	●						
A8	Williams, C et al: *Effectiveness of sprinklers in residential premises*. Project report number 204505. February 2004. http://www.bretrust.org.uk/filelibrary/rpts/sprinkler/sprinkler_section2.pdf	●		●	●		●	●			
A9	Mawhinney, J. R: *The case for Water Mist Systems in Road Tunnels*. Hughes Associates, Inc.		●								●
A10	*Fire suppression in buildings using water mist, fog or similar systems - Final report*. Building Research Technical Report 4/2005. Office of the Deputy Prime Minister. December 2005. http://www.communities.gov.uk/documents/planningandbuilding/pdf/143273.pdf					●		●	●		
A11	Shipp, M; Clark, P: *Sprinkler Effectiveness in Care Homes*. BRE Ltd. ODPM Final Research Report BD2546. 2006. http://www.bre.co.uk/filelibrary/consultations/partB/Sprinkler_Effectiveness_in_Care_Homes.pdf	●		●	●		●				

		I Extinguishing performance - life	II Extinguishing performance -property	III Application tests	IV Standard laboratory tests	V Reliability	VI Cost	VII Building regulation	VIII Requirements in codes	IX Trade-offs	X Misc.
A12	*Revised Guidelines for Approval of Sprinkler Systems Equivalent to that Referred to in Solas regulation II-2/12*. Resolution A.800(19). 1995. http://books.google.no/books?id=085DgvDYwTYC&pg=PA177&lpg=PA177&dq=%22Revised+Guidelines+for+Approval+of+Sprinkler+Systems+Equivalent+to+that+Referred+to%22&source=bl&ots=5UIoBQaHvQ&sig=Qyfyd-wocG0WsLQEI6H6ivyaJ4U&hl=no&ei=LIu_Sq6sJ9PX-QbE2pGgAQ&sa=X&oi=book_result&ct=result&resnum=1#v=onepage&q=%22Revised%20Guidelines%20for%20Approval%20of%20Sprinkler%20Systems%20Equivalent%20to%20that%20Referred%20to%22&f=false		●		●			●	●		●
A13	Coleman, R. J: *Residential Sprinkler Systems*. Pages 24-25. National Fire Protection Association. 1991. http://www.amazon.com/gp/product/0877653461?tag=openlibr-20	●						●		●	●
A14	Butry, D. T; Brown, M. H; Fuller, S. K: *Benefit-Cost Analysis of Residential Fire Sprinkler Systems.* NIST. September 2007. http://www.bfrl.nist.gov/oae/publications/nistirs/NISTIR_7451_Oct07.pdf	●				●	●	●	●		
A15	Purser, David: *Sprinklers and fire effluents. Methods for assessing life threat from sprinklered fires*. ISO TC92/SC3 WG2 N. 2001.	●		●							
A16	Purser, David: *Assessment of Time to Loss of Tenability Due to Smoke, Irritants, Asphyxiants and Heat in Full-Scale Building Fires – Effects of Suppression and Detection on Survivability*. BRE Ltd. Fire Research Station.	●		●							
A17	Shipp, M; Clark, P: *Sprinkler Effectiveness in Care Homes*. BRE Ltd. ODPM Final Research Report BD2546. 2006. http://www.bre.co.uk/filelibrary/consultations/partB/Sprinkler_Effectiveness_in_Care_Homes.pdf	●		●	●		●				
A18	Soja, E: *Domestic Fire Sprinkler Systems - Report on Water Quality, Reliability and Application to Other Property*. Project Number FQ5011. BRANZ Limited. March 30, 2006. http://www.branz.co.nz/cms_show_download.php?id=56	●				●	●		●		●
A19	*Fire suppression in buildings using water mist, for or similar systems - Final report*. Building Research Technical Report 4/2005. Office of the Deputy Prime Minister. December 2005. http://www.communities.gov.uk/documents/planningandbuilding/pdf/143273.pdf					●		●	●		
A20	*Hidden Potential*. Article, Fire safety Engineering, 20/06/2007. http://www.fseonline.co.uk/articles.asp?article_id=6151	●		●		●			●		
A21	Williams, C; Annable, K: *Effectiveness of Sprinklers in residential premises - an evaluation of concealed and recessed pattern sprinkler products*. DCLG Final Research Report. Section 2: Description of the project. BRE Ltd. March 2006. http://www.bre.co.uk/filelibrary/pdf/rpts/partb/218113_Final_report_Section_2_Description.pdf	●		●		●			●		
A22	*Use and Benefits of Incorporating Sprinklers in Buildings and Structures*. Arup Fire. Draft 2, January 2006. http://products.ihs.com/cis/Doc.aspx?AuthCode=&DocNum=284320	●	●	●	●	●	●	●	●	●	
A23	Huczek, J. P: *Demonstration Testing: Extinguishment of Kitchen Fires and the Effect of Sprinklers in a Residential Setting*. Southwest Research Institute (SwRI). 2007. http://www.nfpa.org/assets/files//PDF/Proceedings/Demonstration_Testing.. - J. Huczek.pdf	●		●							
A24	Huczek, J. P: *Demonstartion Testing: Extinguishment of Kitchen Fires and the Effect of Sprinklers in a Residential Setting*. Southwest Research Institute (SwRI). 2007. http://www.nfpa.org/assets/files//PDF/Proceedings/Demonstration_Testing.. - J. Huczek.pdf	●		●							
A25	Huggins, R: *Home Safe*. NFPA Journal May/June 2004. http://findarticles.com/p/articles/mi_qa3737/is_200405/ai_n9360427				●				●		

		I Extinguishing performance - life	II Extinguishing performance -property	III Application tests	IV Standard laboratory tests	V Reliability	VI Cost	VII Building regulation	VIII Requirements in codes	IX Trade-offs	X Misc.
	/										
A26	Drangsholt, G; Rossebø, B. E: *Mobile vanntåkeanlegg - et alternativ til boligsprinkling*. Slide presentation. SINTEF NBL as.	●		●	●						
A27	Arvidson, M: *En sammanställning av väldokumenterade brandförsök med bostadssprinkler*. SP Sveriges Provnings- och Forskningsinstitut. SP Rapport 2001:03. ISBN 91-7848-844-3. 2001. http://www.amazon.co.uk/sammanst%C3%A4llning-v%C3%A4ldokumenterade-brandf%C3%B6rs%C3%B6k-bostadssprinkler-rapport/dp/9178488443	●		●	●				●		
A28	Drangsholt, G; Rossebø, B. E: *Vanntåkeanlegg I omsorgsboliger. En kartlegging av hvilken effect mobile og let flyttbare vanntåkeanlegg harp å brannsikkerheten I omsorgsboliger*. Rapportnr. NBL A06108. SINTEF NBL as. 2006. http://nbl.sintef.no/publication/lists/docs/NBL_A06108.pdf	●		●	●						
A29	Fontana, M: *Fire Sprinklers in Probabilistic Approaches to Protection*. ETH, Zurich, Switzerland.		●			●				●	
A30	Fontana, M: *Fire Sprinklers in Probabilistic Approaches to Protection*. Slide presentation. ETH, Zurich, Switzerland. March 2006.		●			●				●	
A31	*Vanntåkeanlegget fungerte perfekt*. DSB. December 9, 2008. www.dsb.no/Article.asp?ArticleID=3038&oppslag=1 http://www.aktuellsikkerhet.no/id/33625.0	●									●
A32	Drangsholt, G; Rossebø, B. E: *Vanntåkeanlegg I omsorgsboliger. En kartlegging av hvilken effect mobile og let flyttbare vanntåkeanlegg harp å brannsikkerheten I omsorgsboliger*. Rapportnr. NBL A06108. SINTEF NBL as. 2006. http://nbl.sintef.no/publication/lists/docs/NBL_A06108.pdf	●		●	●						
A33	Wighus, R: *Ekvivalente systemer for brannbekjempelse i bygninger - en utredning*. Rapportnr. NBL A08107. SINTEF NBL as. Mai 2008. http://nbl.sintef.no/publication/lists/docs/NBL_A08107.pdf	●			●			●		●	
A34	Wighus, R: *Ekvivalente systemer for brannbekjempelse i bygninger - en utredning*. Rapportnr. NBL A08107. SINTEF NBL as. Mai 2008. http://nbl.sintef.no/publication/lists/docs/NBL_A08107.pdf	●			●			●		●	
A35	*Assessment of an automatic extinguishing process using water mist*. Centre des Archives Nationales de Pierrefitte Sur Seine (Pierrefitte Sur Seine Natinal Archive Center). Revision 1. October 30, 2007. (*proprietary*)										
A36	Arvidson, M: *En sammanställning av väldokumenterade brandförsök med bostadssprinkler*. SP Sveriges Provnings- och Forskningsinstitut. SP Rapport 2001:03. ISBN 91-7848-844-3. 2001. http://www.amazon.co.uk/sammanst%C3%A4llning-v%C3%A4ldokumenterade-brandf%C3%B6rs%C3%B6k-bostadssprinkler-rapport/dp/9178488443	●		●	●				●		
A37	Duncan, C. R. et al: *Cost-Effective Home Fire Sprinkler Systems*. BRANZ Report FCR 5-a. BRANZ. November 2003. http://www.buildingcommission.com.au/resources/documents/BRANZ_research_report.pdf	●	●			●	●	●			
A38	Wighus, R; Jensen, G: *Performance Criteria of Systems to Reduce Fire Damage by Prevention or Suppression.* SINTEF NBL AS/ COWI AS. 2008. http://www.nfpa.org/assets/files//PDF/Foundation%20proceedings/Wighus.pdf	●	●	●	●	●		●		●	
A39	Madrzykowski, Daniel: *The Reduction of Fire Hazard in Corridors and Areas Adjoining Corridors Provided by Sprinklers*. NISTIR 4631 http://fire.nist.gov/bfrlpubs/fire01/PDF/f01183.pdf	●		●							

B Sources on Evidence of Performance – Reliability

		I Extinguishing performance - life	II Extinguishing performance -property	III Application tests	IV Standard laboratory tests	V Reliability	VI Cost	VII Building regulation	VIII Requirements in codes	IX Trade-offs	X Misc.
B1-1	Knudsen, R; Bygbjerg, H: *Reliability of Automatic Sprinkler systems (AWS systems)*. DBI Report 2008:02. 2008. http://en.dbi-net.dk/media/AVS_Stat_UK_.pdf					●					
B1-2	Jensen, G: *Danish Sprinkler Statistics*. E-mail. December 19, 2008.					●					
B2	Holt, I (??): *Reliability of Sprinkler systems*. Draft 5. 2004.					●					
B3	Hall, J. R. Jr: *The Latest NFPA Statistics on Sprinkler Performance*. NFPA Journal March/April 2008. http://afscc.org/Hall_Sprinkler_nfpa_90_percent_reliability.pdf					●					
B4	Hall, J. R. Jr: *An Analysis of Sprinkler Reliability Using Current Data*. Slide presentation. National Fire Protection Association. March 2006.					●					
B5	Hall, J. R. Jr: *An Analysis of Automatic Sprinkler System Reliability Using Current Data*. National Fire Protection Association. March 29, 2006. http://www.nfpa.org/assets/files/PDF/Proceedings/An_Analysis_of_Automatic_Sprinkler_Reliability...-J.Hall_pap.pdf					●					
B6	Brinson, A: *European Hotel Safety Issues*. Slide presentation. European Fire Sprinkler Network. March 28, 2006.					●					
B7	Hall, J. R. Jr: *U.S. Experience with Sprinklers and Other Automatic Fire Extinguishing Equipment.* National Fire Protection Association. January 2009. http://www.nfpa.org/assets/files/PDF/OSsprinklers.pdf					●					
B8	Malm, D; Pettersson, A-I: *Tillförlitlighet för automatiska sprinkleranläggningar - en analys av befintlig statistik*. Department of Fire safety Engineering and Systems Safety - Lund University, Sweden. Report 5270. 2008. http://130.235.7.155/publikationsdb/docs/5270-EN.pdf					●					
B9	*NFPA report finds reliability of fire sprinklers even higher than estimated.* NFPA Journal. November/December 2005. http://www.encyclopedia.com/doc/1P3-966412901.html					●					
B10	*U.S. Experience with Sprinklers.* One-Stop Data Shop, NFPA. http://trans-ennis.com/National%20Firer%20Protectio%20Association.pdf					●					
B11	Bukowski, R. W. et al: *Estimates of the Operational Reliability of Fire Protection Systems.* 1999. http://fire.nist.gov/bfrlpubs/fire99/PDF/f99079.pdf					●				●	
B12	Bukowski, R. W; Budnick, E. K: *Quantifying the Performance of Fire Detection, Sprinklers, and Fire Resistant Construction in the United States*. http://fire.nist.gov/bfrlpubs/fire97/PDF/f97199.pdf					●					
B13	Fontana, M; Fetz, C: *Interaction between active fire safety measures and required structural fire protection*. Institute for Structural Engineering, ETH Zurich. http://cibworld.xs4all.nl/dl/jb/0002/Pages/Forth/083rd.html					●				●	
B14	Budnick, E. K: *Automatic Sprinkler System Reliability*. Fire Protection Engineering, winter 2001.					●					
B15	*PD 7974-7:2003 Application of fire safety engineering principles to the design of buildings - Part 7: Probabilistic risk assessment.* BSI British Standards Institution. June 26, 2003.					●					

C Standards and Codes specifying Trade-offs or Sprinkler Performance Criteria

		I Extinguishing performance - life	II Extinguishing performance -property	III Application tests	IV Standard laboratory tests	V Reliability	VI Cost	VII Building regulation	VIII Requirements in codes	IX Trade-offs	X Misc.
C1	*DD 252:2001 Components for residential sprinkler systems - Specification and test methods for residential sprinklers.* BSI British Standards Institution. March 2001.	●			●						
C2	Östman, B: *Fire safety desing with sprinklers - Agenda for meeting in Stockholm 16 June + Meeting minutes.* E-mail. June 18, 2009.										●
C3	Madrzykowski, D; Fleming, R. P: *U.S. Review of Residential Sprinkler Systems: Research and Standards.* National Institute of Standards and Technology/ National Fire Sprinkler Association. January 2002.	●			●						
C4	*NFPA 13R Standard for the Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height.* National Fire Protection Association. 2007 Edition.	●			●						
C5	*NFPA 13D Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes.* National Fire Protection Association. 2007 Edition.	●			●						
C6	*BS 9999:2008 Code of practice for fire safety in the design, construction and use of buildings.* BSI British Standards Institution. ISBN 978 0 580 57920 2. October 2008.										●
C7	*prNS-INSTA 900-2 Residential sprinkler systems - Part 2: Requirements and test methods for sprinklers and their accompanying rosettes.* Standard Norge. November 14, 2008.	●			●						
C8	*Lett monterbare automatiske slokkesystemer.* Direktoratet for samfunnssikkerhet og beredskap (dsb). Juni 2007.	●			●			●	●		
C9	*NFPA 555 Guide on methods for Evaluating Potential for Room Flashover.* National Fire Protection Association. 2004 Edition.										●
C10	*Teknsike retningslinjer for dimensjonering, prosjektering og installering av sprinkleranlegg I bygninger for boligbruk opp til og med 4 etasjer.* Direktoratet for samfunnssikkerhet og beredskap (dsb).Mars 1999.	●			●			●	●		
C11	*Byggdetaljblad 550.361 Sprinkleranlegg.* SINTEF Byggforsk. 2008.										●
C12	Williams, C; Jackman, L: *An independent guide on water mist systems for residential buildings.* Building Research Establishment (BRE). 2006.										●
C13	*DBI informerer om - Projektering, installation, drift og vedligeholdelse, inspection og godkendelse af vandtågeanlæg.* DBI Nyhedsbrev 01/06. Dansk Brand- og sikringsteknisk Institut. 2006.								●		
C14	*FG-veiledning for vanntåkesystemer.* Utgave 2. Forsikringsselskapenes Godkjennelsesnevnd (FG). 2009.								●		
C15	*Approval Standard for Residential Automatic Sprinklers. Class Number 2030.* FM Approvals LLC. September 1983.				●						
C16	*FM 2-8N: NFPA 13 Standard for the Installation of Sprinkler Systems 1996 Edition.* Factory Mutual Insurance Company. September 2004.				●						
C17	*NS-EN 12845 Fixed firefighting systems. Automatic sprinkler systems. Design, installation and maintenance.* Norges Standardiseringsforbund. 1st edition, January 2004.				●						
C18	Fire protection Engineering. Issue No.9 winter 2001.										●
C19	Nicholson, J: *Updating NFPA 13.* Pages 35-41. NFPA Journal. January/February 2006.								●		●
C20	*NFPA 13 Standard for the Installation of Sprinkler Systems.* National Fire Protection Association. 2010 Edition.				●						

		I Extinguishing performance - life	II Extinguishing performance -property	III Application tests	IV Standard laboratory tests	V Reliability	VI Cost	VII Building regulation	VIII Requirements in codes	IX Trade-offs	X Misc.
D Sprinkler Performances, Cost/Benefit or Sprinkler Trade-offs											
D1	Wighus, R; Jensen, G: *Performance Criteria of Systems to Reduce Fire Damage by Prevention or Suppression.* SINTEF NBL AS/ COWI AS. 2008.			●						●	●
D2	Wighus, R; Jensen, G: *Performance Criteria of Systems to Reduce Fire Damage by Prevention or Suppression.* Slide presentation. SINTEF NBL AS/ COWI AS. 2008.			●						●	●
D3	*Sprinkler systems Planning and installation - Appendix T: Requirements for an automatic water mist fire protection system.* CEA Property Committee. 2008.				●						●
D4	Williamson, J. W; Marshall, A. W; Trouvé, A: *Developing Extinction Criteria for Fires.* Department of Fire protection Engineering, University of Maryland.										●
D5	Gann, R. G: *Technology for Fire Suppression in Aircraft: Findings on the Next Generation Fire Suppression Technology Program.* Building and Fire Research Laboratory.	●									●
D6	*PD 7974:2003 Application of fire safety engineering principles to the design of buildings.* Part 4 and Part 7. BSI British Standards Institution. 2003.	●	●			●	●	●	●	●	●
D7	Coleman, R. J: *Residential Sprinkler Systems; Pages 24-27.* NFPA. 1991.	●									●
D8	*The Economics of Sprinklers.* FSE. June 2008.						●				
D9	Greenman, R: *History Automatic Fire Sprinklers.* E-mail. March 9, 2003.										●
D10	Coleman, R. J: *Residential Sprinkler Systems; Pages 104-113.* NFPA. 1991.									●	●
D11	Nystedt, F: *Residential Sprinklers Providing Life Safety and Lowering Costs.* Department of Fire Safety Eng., Lund University.						●				
D12	Olsson, F; Frantzich, H: *An Approach towards a Simple Risk Based Design Method.* Department of Fire Safety Eng., Lund University.										●
D13	Frantzich, H; Nystedt, F; Lundin, J: *Risk Concepts in Fire safety Design.* Lund University.										●
D14	Duncan, C; Wade, C: *Cost-Effective Domestic Fire Sprinkler Systems.* Building Research Association of New Zealand (BRANZ). 2001.	●					●				
D15	Butry, D. T; Brown, M. H; Fuller, S. K: *Benefit-Cost Analysis of Residential Fire Sprinkler Systems.* NIST. September 2007.	●					●				
D16	Bengtson, S et al: *Brandskyddshandboken.* Pages 148-157. ISSN: 1402-3504. Lunds Universitet. 2002.										●
D17	Horwitz-Bennett, B: *Fire protection: The Right Balance.* Web-page: Consulting-Specifying Engineer. www.csemag.com/magazine/articles/cse0402round.asp 02/01/2004									●	
D18	Licht, R: *Balancing Active and Passive Fire protection Balance.* Alliance for Fire and Smoke Containment and Control.									●	
D19	*Home Sprinklers Score 'A' in NIST Cost-Benefit Study.* Web-page: NIST. October 12, 2007 www.nist.gov/public_affairs/tchbeat/tb2007_1011.htm										●
D20	Hall, J. R: *New Statistics on Sprinkler Reliability and Performance.* National Fire Protection Association.	●	●			●					
D21	*Boendesprinkler radar liv.* Pages 37-54. Trätek publication 0202007, 2002.										●
D22	Annable, K: *Residential Sprinkler Systems - Hidden Potential.* FSE. June 2007.								●		●
D23	*Home Fire Sprinkler Cost Assessment.* The Fire Protection Research Foundation. September 10, 2008.						●				

		I Extinguishing performance - life	II Extinguishing performance -property	III Application tests	IV Standard laboratory tests	V Reliability	VI Cost	VII Building regulation	VIII Requirements in codes	IX Trade-offs	X Misc.
D24	The Fire Protection Research Foundation News: E-mail. January 19, 2009.										●
D25	Robbins, A; Wade, C; Bengtsson, J: *Sprinklers and sustainability.* BUILD, pages 78-79, December 2008/January 2009.										●
D26	*U.S. Experience with Sprinklers.* One-Stop Data Shop, NFPA.					●					
D27	Coleman, R. J: *Residential Sprinkler Systems*. Pages 24-27. National Fire Protection Association. 1991.			●	●						●
D28	Siarnicki, Ronald Jon: *Residential sprinklers: One community's experience twelve years after mandatory implementation.* Fire Chief. Prince George's County, Maryland. 2001. http://www.fireteamusa.com/Documents/PrinceGeorgeStudy.pdf							●		●	
D29	*The Nations Fire Problem*. America Burning. The National Commission. USA. 1973.										●
D30	*America at Risk. America Burning Revisited*. FEMA 2002. http://www.usfa.dhs.gov/downloads/pdf/publications/fa-223-508.pdf							●			●
D31	*Home Fire Sprinkler Cost Assessment*. The Fire Protection Research Foundation. NFPA. USA. 2008. http://www.nfpa.org/assets/files//PDF/Research/FireSprinklerCostAssessment.pdf						●	●	●		
D32	Weatherby, Steve: *Benefits of Residential Fire Sprinklers*. Home Fire Sprinkler Coalition. USA. 2009. http://www.homefiresprinkler.org/images/Prince-Georges-County-Report.pdf						●	●	●	●	●
D33	*Comparative Analysis of Housing Cost and Supply Impacts of Sprinkler Ordinances at the Community Level.* Final Report. USA. National fire Protecton Association. 2009. http://www.firesprinklerinitiative.org/assets/files/FSI_Comparison_Analysis_Final_Report.pdf						●	●			●
D34	*Integration of Residential Sprinklers with Water Supply Systems*. National Fire Protection Association. USA. 2009. http://www.firesprinklerinitiative.org/assets/files/FSIWaterSupplyIntegration.pdf							●			●

		I Extinguishing performance - life	II Extinguishing performance -property	III Application tests	IV Standard laboratory tests	V Reliability	VI Cost	VII Building regulation	VIII Requirements in codes	IX Trade-offs	X Misc.
E Miscellanous Sources Relevant to Sprinkler Performances											
E1	Baretto, M; Fedøy, A: *Sammenligning av vanntåke og sprinkling.* Høgskolen Stord/Haugesund. 2005.										●
E2	-										
E3	Mirkhah, A: *Plan now or pay later.* NFPA Journal. March/April 2006.										●
E4	Nicholson, J: *Welcoming sprinklers into the home.* NFPA Journal. July/August 2005.										●
E5	Suhrke, T: *Automatisk brannslokking I boliger kan spare liv.* Brannmannen nr. 6 - 2005.								●		●
E6	Johansen, D; Lennavik, T: *Effekt av sprinkleranlegg i Scottsdale. Vurderinger rundt bruk av sprinkleranlegg som brannsikringstiltak i Norge.* NBFL. 2006.								●		●
E7	Purser, David: *Sprinklers and fire effluents. Methods for assessing life threat from sprinklered fires*. ISO TC92/SC3 WG2 N. 2001.	●		●							
E8	Purser, David: *Assessment of Time to Loss of Tenability Due to Smoke, Irritants, Asphyxiants and Heat in Full-Scale Building Fires – Effects of Suppression and Detection on Survivability*. BRE Ltd. Fire Research Station.	●		●							
E9	Hartzell, G. E: *Combustion products and their effects on life safety*. NFPA. 1997.	●		●							
E10	*Life threat from fires - Guidance on the estimation of time available for escape using fire data*. ISO/DTS 13571. 2001.										●
E11	Yu, X: *Investigation of Recessed and Concealed Sprinklers Activation in Wind Tunnel Plunge Test and in BRANZFIRE Computer Model*. University of Canterbury, New Zealand. March 2007.								●		●
E12	*Cost of installing residential fire sprinklers averages $1.61 per square foot*. NFPA News Release. 2008. http://www.nfpa.org/newsReleaseDetails.asp?categoryid=488&itemId=40496						●				
E13	Jensen, G: *Building Design with Sprinkler - Verification Approach*. Slide presentation. COWI. November 20, 2008.										●
E14	Bygbjerg, H: *DBI informerer om - Projektering, installation, drift og vedligeholdelse, inspection og godkendelse af vandtågeanlæg*. Dansk Brand- og sikringsteknisk Institut. DBI Nyhedsbrev 01/06. http://dbi-net.dk/files/pdf/inspektion_nyhed/nyhedsbrev_01-06.pdf							●			
E15	*Quick comparison of NFPA 13, 13R, and 13D standards*. Slide presentation. San Fransisco Fire Department. October 12, 2007. http://www.sfgov.org/site/uploadedfiles/dbi/DBIProsSummit/NFPA%2013%20Installation%20of%20Sprinkler%20Systems.ppt				●						
E16	Golinveaux, J: *Changing Standards for Residential Sprinklers*. BrandPosten nr 31, 2004.	●			●						
E17	Huggins, R: *Home Safe*. NFPA Journal May/June 2004.										●
E18	Bek, Peter: *Sprinkleranlægs Brandeffektdæmpende Egenskap*. Master degree project report at DTU, Denmark. 2009. http://www.brand.dtu.dk/upload/institutter/byg/master_brand/brandtekniske%20projektopgaver/sprinkleranl%C3%A6gs%20brandeffektd%C3%A6mpende%20egenskab%20af%20peter%20bek.pdf									●	●
E19	Heskestad and Hill: *Experimental fires in Multiroom/Corridor Enclosures*. NBS GCR 86 502. CIB W14/85/10. USA. http://fire.nist.gov/bfrlpubs/fire86/PDF/f86001.pdf									●	●

COWI