Department for Communities and Local Government

2012 updates to the Fire Service Emergency Cover toolkit

Special service and fire fatality rate functions

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Chapter 1

Special service fatality rates

Categories to include in the Fire Service Emergency Cover toolkit

1.1 Six types of special service categories, each with a combination of sub-categories, are proposed for retention in the Fire Service Emergency Cover toolkit, namely:

- Road traffic collisions with extrications and road traffic collision other;
- Other transport rescues extrication and other transport other;
- Other rescues – Other rescue other, collapsed structure, confined space noxious, rescue from mud, rescue from under machinery;
- Water rescue – from river, fallen in ice and in lake;
- Suicide – threatened and fatal suicides;
- First and co-responder – unconscious and chest pain.

1.2 There are currently nine special service categories in the Fire Service Emergency Cover toolkit. The alignment of the new proposed categories to the current Fire Service Emergency Cover toolkit categories is indicated in Table 1. Export functions, such as using bulkcalcs, for the Incident Reporting System (IRS) would be required to export all incidents and associated with one or more fatality or casualty (of any type) or rescue are required to export data from the Incident Recording System to the Fire Service Emergency Cover toolkit.

Table 1: Alignment of new to current Fire Service Emergency Cover Toolkit special service categories

Current Fire Service Emergency Cover Toolkit category	Proposal	Special service sub type ID's to include
Road Traffic Collision	Retain	1 and 6
Extrications	Redefine as Other Rescue	60, 61, 62, 63, 67
Other Special Services	Redefine as Other Transport rescues	10 and 15
Lift release	Delete	-
Lock in /lock out	Delete	-
Rescue from height	Replace with Suicide	270 and 271

Line rescue	Replace with co and first responder	282 and 283
HAZCHEM	Delete	-
Rescue from water	Retain	30, 31 and 32

Fatality rate functions

Definition of fatality rate

1.3 The analysis produced fatality rates per fatality, casualty and rescue, expressed as a fraction (probability) per fatality, casualty or rescue. This is a change from the current Fire Service Emergency Cover toolkit which uses fatalities per life risk incident (i.e. incidents involving one or more fatality, casualty or rescue (FCR)).

Response time definition

1.4 The response time is measured in minutes from time of call to time on scene. A maximum response time of (say) 120 minutes could be applied to limit computation time.

Road traffic collisions

1.5 The current fatality rate response time relationship and partial benefit formula in the Fire Service Emergency Cover toolkit would be deleted and replaced with the function below. The function models the first two appliances.

1.6 The fatality rate function models the arrival time of the first and second appliance. The function is:

y = ((((0.0024*Rt1) + 0.0202))*0.93)))*(((Rt2/Rt1)*0.026)) + 0.93))))

Where:
Rt1 is the response time of the first appliance
Rt2 is the response time of the second appliance
0.93 is a correction factor
y is the rate of death per fatality, casualty or rescue, expressed as a fraction.

1.7 The function applies as follows:

Step	Explanation
a	Multiply Rt1 by 0.0024

b	Add 0.0202 to product of a
c	Multiply product of b by 0.93
d	Divide Rt2 by Rt1
e	Multiple product of d by 0.026 and add 0.93 to this
f	Multiple c by e

1.8 In the case of serious injury, a linear regression function can be applied of y = 0.0043x + 0.2087, where y is the rate of serious injury and x is the first appliance response time. This applies to the time of the first appliance only.

1.9 In case of slight injury the following formula may be used, y = -0.0015x + 0.5268, where x is the first response time and y is the proportion of fatality, casualty or rescues that are slight.

Other rescue

1.10 The fatality rate function models the arrival of the first two appliances. The function is:

((((0.0017*Rt1) + 0.052))*0.89)))*(((0.0131*(Rt2/Rt1)) + 0.9642))))

Where:
Rt1 is the response time of the first appliance
Rt2 is the response time of the second appliance
0.89 is a correction factor

1.11 The function applies as follows:

Step	Explanation
a	Multiply Rt1 by 0.0017
b	Add 0.052 to a
c	Multiply b by 0.89
d	Divide Rt2 by Rt1
e	Multiply d by 0.0131
f	Add 0.9642 to e
g	Multiply c by e

1.12 The formula for serious and slight injuries were:

Serious y = 0.0015*x + 0.1901
Slight y = -0.0049*x + 0.327
Where
x is the first response time
y is the rate of injury per fatality, casualty or rescue.

Other transport rescues

1.13 The function is based on the response time of the first appliance only. The function is:

$y = 0.0805e^{0.0661x}$
Where:
y is the fatality rate
x is the response time of the first appliance
e is the exponential function

Suicide

1.14 The function for suicides is based on the response time of the first appliance only. The function is:

$y = 0.28e^{0.027x}$
Where:
y is the fatality rate
x is the response time of the first appliance
e is the exponential function

Co and first responder incidents

1.15 The function for co and first responder incidents is based on the response time of the first appliance only. The function is:

$y = 0.0828e^{0.0195x}$
Where:
y is the fatality rate
x is the response time of the first appliance
e is the exponential function

1.16 The relationship for serious injury was

$y = 0.036*\ln(x) + 0.2452$

Where

y = serious injury rate as a per cent of fatality, casualty or rescues
x = first response time
ln is the natural logarithm of x
0.2452 is a constant

1.17 A formula for slight injuries is:

$y = 0.5677e^{-0.01x}$

Where
x is the first response time
y is the proportion of fatality, casualty or rescues that are slight injuries
e is the exponential function

Rescue from water

1.18 The function for water rescue incidents is based on the response time of the first appliance only. The function is:

$y = 0.1029e^{0.0567x}$
Where:
y is the fatality rate
x is the response time of the first appliance
e is the exponential function

Ratio of serious injury to fatal per type of special service

1.19 In order to enable the inclusion of serious and slight injuries for the other categories of special services in the valuation of special service incidents, the following ratios could be applied.

Table 2: Ratio of injury to all FCRs

	Serious to all FCR	Slight
Other transport	0.28	0.32
Water	0.09	0.23
Suicide	0.125	0.12

1.20 There would be a constant casualty rate across all response times, i.e.

$y = S*FCR*1$

Where
S is the proportion of fatality, casualty or rescues that are slight.
y is the number of slight casualties
FCR is the number of fatalities, casualties or rescues
1 is the constant for the impact of response times.

Values per injury

1.21 The Department for Transport provide updated values of life and injury that can be applied to the valuation of special service injuries. For example, the Department for Transport[1] cited the following values.

Table 3: Average value of prevention per reported road accident casualty and per reported road accident: GB 2009 (Department for Transport, 2010)

Casualty type	Cost per Casualty (£)	Cost per Accident (£)
Fatal	1,585,510	1,790,200
Serious	178,160	205,060
Slight	13,740	21,370

1.22 The values for cost per casualty can be applied to the rescue element of the Fire Service Emergency Cover Toolkit for fatal, serious and slight/first aid injuries respectively. It is suggested a zero value is assigned to precautionary checks until further research is completed.

Cost benefit analysis

1.23 The cost benefit analysis spreadsheet needs to add in predicted serious and slight injuries and provide values for these.

[1] http://assets.dft.gov.uk/statistics/releases/road-accidents-and-safety-annual-report-2010/rrcgb2010-02.pdf

Chapter 2

Special service risk definitions

2.1 The revised fatality rates require amendment of the risk definitions. The current risk assessment definitions use rates of fatalities, casualties or rescues incidents per kilometre square rather than rate of fatalities, casualties or rescues per kilometre square or linear kilometres in the case of roads. The proposed new risk definitions are given in Table 44 and Table 5 by time slot. All rates are fatalities, casualties and rescues per kilometre square or linear kilometre.

Table 4: Proposed risk assessment definitions for special services per km^2					
Road traffic collisions	>2.34	1.17 to 2.33	0.58 to 1.16	0.29 to 1.15	<0.29
Other rescues	>3.07	1.5 to 3.07	0.8 to 1.49	0.4 to 0.79	<0.4
Other transport	>0.73	0.37 to 0.72	0.18 to 0.36	0.09 to 0.18	<0.09
Co and first responder	>3.29	1.65 to 3.28	0.82 to 1.64	0.41 to 1.81	<0.41
Suicides	>0.66	0.33 to 0.65	0.16 to 0.32	0.08 to 0.15	<0.08
Water rescues	>0.80	0.4 to 0.79	0.2 to 0.39	0.1 to 0.19	<0.1

Mid points and user overrides

2.2 Fire Service Emergency Cover Toolkit users may wish to override the risk category given by the historic data and instead apply an assumed risk category. Table 6 provides mid points for application if users select risk categories.

Table 5: Proposed risk assessment definitions for special services per km^2 by time period							
Time period		Rates of Road Traffic Collisionss per km^2	Other rescues per km^2	Rates of water rescue per km^2	Other transport per km^2	Co and first responder per km^2	Suicides per km^2
Weekday, each 4 hour time slot	Very high	>0.279	>0.365	>0.095	>0.087	>0.392	>0.079
	High	0.139 to 0.279	0.179 to 0.365	0.048 to 0.095	0.044 to 0.087	0.196 to 0.392	0.039 to 0.079
	Medium	0.069 to 0.139	0.095 to 0.179	0.024 to 0.048	0.021 to 0.044	0.098 to 0.196	0.019 to 0.039
	Low	0.035 to 0.069	0.048 to 0.095	0.012 to 0.024	0.011 to 0.021	0.049 to 0.098	0.010 to 0.019
	Very low	<0.035	<0.048	<0.012	<0.011	<0.049	<0.010
Weekend, each 4 hour time slot	Very high	>0.111	>0.146	>0.038	>0.035	>0.157	>0.031
	High	0.056 to 0.111	0.071 to 0.146	0.019 to 0.038	0.018 to 0.035	0.079 to 0.157	0.016 to 0.031
	Medium	0.028 to 0.056	0.038 to 0.071	0.010 to 0.019	0.009 to 0.018	0.039 to 0.079	0.008 to 0.016
	Low	0.014 to 0.028	0.019 to 0.038	0.005 to 0.010	0.0043 to 0.009	0.020 to 0.039	0.004 to 0.008
	Very low	<0.014	<0.019	<0.005	<0.0043	<0.020	<0.004

Table 6: Proposed mid points for selected risk categories of special services per km^2 by time period							
Time period		Rates of Road Traffic Collisions per km^2	Other rescues per km^2	Rates of water rescue per km^2	Other transport per km^2	Co and first responder per km^2	Suicides per km^2
Weekday, each 4 hour time slot	Very high	0.42	0.55	0.14	0.13	0.59	0.12
	High	0.209	0.272	0.071	0.065	0.294	0.059
	Medium	0.104	0.137	0.036	0.033	0.147	0.029
	Low	0.052	0.071	0.018	0.016	0.073	0.014
	Very low	0.023	0.031	0.008	0.007	0.032	0.006
Weekend, each 4 hour time slot	Very high	0.17	0.22	0.06	0.05	0.24	0.05
	High	0.084	0.109	0.029	0.026	0.118	0.024
	Medium	0.042	0.055	0.014	0.013	0.059	0.012
	Low	0.021	0.029	0.007	0.006	0.029	0.006
	Very low	0.009	0.013	0.003	0.003	0.013	0.003

Chapter 3

Dwelling fire functions

Fatalities

3.1 A function is provided below for predicting fire deaths in dwellings based on the first and second appliance response time and the proportion of incidents requiring one appliance or two or more appliances. The function only models the first two appliances and would replace the current partial benefits models in the Fire Service Emergency Cover toolkit.

(((((P1*(0.0129e(0.0668*Rt1)))+(0.85*(((P2*(0.0229e(0.06Rt2))*((Rt2/Rt1)*0.0435)+ 0.994)))))

Where
P1 is the proportion of incidents requiring one appliance
P2 is the proportion of incidents requiring two appliances
Rt1 is the first appliance response time
Rt2 is the second appliance response time
e is the exponential function

The function entails:

Step	Explanation
a	Multiply Rt1 by 0.0668
b	Derive the exponential of a
c	Multiply result of b by 0.0129
d	Multiply result of c by P1
e	Multiply Rt2 by 0.06
f	Derive exponential of e
g	Multiply product of f by 0.0229
h	Multiply g by P2
i	Divide RT2 by RT1
j	Multiply result of i by 0.0435
k	Add 0.994 to j
l	Multiply k by 0.85
m	Add k and d together

3.2 The default for P1 is 0.31 and 0.69 for P2 as per Table 7. The values for different types of dwellings are also given in Table 77. This provides the option of Fire Service Emergency Cover toolkit users varying the values for P1 and P2 according to the predominant type of dwelling in each risk area. This could be set on the risk area dialog box.

Table 7: Proportion of incidents with one versus two or more appliances		
	One appliance	**Two or more appliances**
All flats	57%	43%
Houses	8%	92%
Sheltered flats	32%	68%
Caravan	17%	83%
Bungalows	21%	79%
All (default)	31%	69%

3.3 As an option, users can determine the predominant type of property in a risk area and have the Fire Service Emergency Cover toolkit apply the following multipliers (Table 8) to the predicted fatality rate per fatality, casualty or rescue and predicted serious injury rate per fatality, casualty or rescue.

Table 8: Casualties by type of dwelling (compressed categories)			
	Multipliers of predicted rate of fatality per fatality, casualty or rescue	**Multipliers of predicted rate of serious injury per fatality, casualty or rescue**	**Multipliers of slight as a % of all fatalities, casualties or rescues**
Caravan	4.5	6.4	1.05
Bungalow	2.3	0.98	1.00
Houses	1.1	1.10	1.06
All flats, Houses of Multiple Occupation and tenements	0.75	0.90	0.93
Sheltered Houses	0.67	0.55	1.09

Serious and slight injuries

3.4 A formula for serious injury is given below:

$y = 0.037e^{0.0234x}$
Where
y is the proportion of fatality, casualty or rescues that are serious
x is the first appliance response time
e is the exponential function.

3.5 There was a very weak apparent relationship between response time and the rate of slight injuries. However, to complete the modelling the following formula can be applied:

$y = -0.007x + 0.678$
Where
x is the first response time

y is the proportion of fatalities, casualties or rescues that are slight.

3.6 The rate of slight injuries can be modified per type of dwelling as per Table 8 if this option is applied by users.

3.7 The total fatal, serious and slight injuries do not add to 100% of all fatalities, casualties or rescues. The remainder are precautionary checks and rescues which are treated as unharmed and so have no notional cost attached to them.

3.8 The analysis did not indicate a need to amend dwelling risk assessment definitions.

Cost benefit analysis

3.9 The cost benefit analysis spreadsheet needs to add in predicted serious and slight injuries and provide values for these.

Chapter 4

Other building fire functions

Fatality rate response time relationship

4.1 It is proposed to model fires in Other Buildings with less than 5 fatalities, casualties or rescues and then model fires in Other Buildings with 5 or more fatalities, casualties or rescues, and then add the results together.

Individual risk fires in Other Buildings

4.2 The function for fires with less than 5 fatalities, casualties or rescues would be:

$y = (0.0157e^{0.0236x})*1.1*\text{Multiplier}$
Where
y is the fatality rate, fatalities as a number per Individual risk fire
x is the first appliance response time in minutes.
1.1 is the assumed number of fatalities, casualties or rescues per Individual risk fire
Multiplier is the modification factor per type of Other Building given in Table 9.
e is the exponential function

The calculation steps are:

Step	Explanation
a	Multiply the first appliance response time by 0.0236
b	Calculate the exponential of a
c	Multiply result of b by 0.0157.
d	Multiply c by 1.1
e	Multiply d by respective multiplier

4.3 A worked example for hospitals with a 5 minute first response time is:

Step	Explanation
a	5 x 0.0236 = 0.118
b	Exponential of 0.118 = 1.125
c	0.0157 x 1.125 = 0.018
d	1.1 x 0.018 = 0.019
e	2.1 x 0.019 = 0.041

4.4 Each individual risk fire in an Other Building would have an assumed 1.1 fatalities, casualties or rescues, based on the actual average number of fatalities, casualties or rescues per Other Building fire with less than 5 fatalities, casualties or rescues.

4.5 The rates of individual fires are shown in Table 10. These would be multiplied by the site assessment (societal risk) ratings.

Table 9: Modifiers for response time fatality rate deaths per type of Other Building

Type of Other Building	Multiplier		
	Fatalities	**Serious**	**Slight**
Vulnerable (hospitals and care homes)*	2.41	1.00	0.97
Education (schools and further education)	0.1*	1.74	0.94
Work (factories & warehouses, offices, other workplaces)	1.53	1.93	0.90
Shops	0.25	0.66	1.05
Premises open to public and Other premises open to the public	1.52	1.02	0.99
Sleeping (hotel, hostel, other sleeping accommodation)	0.92	0.62	1.04
Licensed premises	0.31	1.33	0.98
Prisons (if included as separate category)	0.13**	0.26	1.08

*Based on 1996-2006 data as no deaths in 2009-11 data but small sample of fatalities, casualties or rescues for 2009-12.

**Based on no deaths in 310 fatalities, casualties or rescues in 2009-11and 3 deaths from 1336 fatalities, casualties or rescues in 1996-2006.

4.6 Houses in Multiple Occupation, purpose built flats and houses converted to flats are excluded from this part of the Other Building calculation.

The individual risk rates of fires in Other Building types are shown in Table 10.

Table 10: Individual risk rates of fire in Other Buildings (excluding HMOs, purpose built flats and houses converted to flats)		
Code	**Property**	**Rate per 10,000 buildings**
A	Hospital	378
B	Care Home	31.4
F	Hotel	25.5
H	Other Sleeping Accommodation	29.7
J	Further Education	15.8
K	Public Building	0.3
L	Licensed Premises	13.3
M	School	7.3
N	Shop	1.7
P	Other premises open to the public	4.3
R	Factory or warehouse	3.9
S	Office	0.5
T	Other work place	1.7
E	Hostel	20.2

*Prisons rate is 6,095 per 10,000 buildings

4.7 The single versus multiple compartment factors are not to be applied to the outcomes of Individual Risk fires.

Serious and slight injury

4.8 The following formula may be applied to predicting serious injuries in Other Buildings.

$$y = (0.0366\ln(x) + 0.0324) * 1.1 * \text{Multiplier}$$

Where
x is the first response time in minutes
y is the proportion of fatalities, casualties or rescues that are serious injury
ln is the natural logarithm
Multiplier is the serious injury multiplier for that type of other building

4.9 A formula for slight injuries is given below:

$$y = (-0.043\ln(x) + 0.5989) * 1.1 * \text{Multiplier}$$

Where
x is the first response time in minutes
ln is the natural logarithm
y is the proportion of fatalities, casualties or rescues that are slight injury.

Multiplier is the slight injury multiplier for that type of other building

4.10 These formulas would be applied to the rate of Individual risk fires to give the number of serious and slight fatalities, casualties or rescues.

Societal risk fires in other buildings

4.11 The same function is applied to fires involving 5 or more fatalities, casualties or rescues, but assuming each of the first four appliances handle 25% of fatalities, casualties or rescues as follows:

$$y = ((0.25*(0.0157e^{0.0236Rt1})*MPL)+(0.25*(0.0157e^{0.0236Rt2})*MPL) + (0.25*(0.0157e^{0.0236Rt3}) * MPL)+ ((0.25*(0.0157e^{0.0236Rt4}) * MPL)$$

Where
y is the fatality rate, fatalities as a number per Societal risk fire
Rt1 to Rt4 are the response times of the first four appliances respectively.
MPL is the maximum number of people at risk.

4.12 The rate of societal risk fires per building would be as per the current values in the Fire Service Emergency Cover Toolkit[2]. House of Multiple Occupation, purpose built flats and houses converted to flats would be included in this calculation for societal risk fires.

Total deaths

4.13 The result for Individual risk and societal risk would be summed to give a total predicted number of deaths per output area. The same risk definitions would apply for fatality rates as in the current the Fire Service Emergency Cover toolkit model.

Cost benefit analysis

4.14 The cost benefit analysis spreadsheet needs to add in predicted serious and slight injuries and provide values for these.

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[2] A rate of 15,152 Societal Risk fires per 1,000,000 prisons was indicated by 1996-2006 data for GB prisons based on 2.64 (default MPL of 8) societal risk fires per year amongst 186 prisons. If prisons are added as a category the rate for Other sleeping accommodation would be reduced to 12.6 per million buildings.

If prisons are included separately a rate of financial loss per minute and rate of property risk fire is required by the Fire Service Emergency Cover Toolkit. The rate of financial loss has not been calculated before. An option is to apply the highest value of £4,211 per minute developed for Other Buildings, for hospitals, until an actual value is developed, although most prison fires are stopped and controlled by fire safety systems and actions of staff which may give a lower value. There were approximately 3 fires per year per prison in 2009-2011 in GB, based on 1,534 fires in a 2.56 year period and assuming 186 prisons/youth offending units, i.e. 3,000 per 1,000 prisons per year.