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Joint Industry Programme on carbon monoxide issues

A review of carbon monoxide incident information for 1997/8 produced from the full investigation of incidents which had resulted from the use of piped natural gas and LPG within Great Britain

Prepared by
Advantica Technologies Limited
(*formerly* BG Technology)
for the Health and Safety Executive

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A review of carbon monoxide incident information for 1997/8 produced from the full investigation of incidents which had resulted from the use of piped natural gas and LPG within Great Britain

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This report has been written by BG Technology as part of the Joint Industry Programme (JIP) Addressing Carbon Monoxide (CO) Issues, within the Incident Data project area. The aim of this project is to identify common causes of CO incidents related to appliance and system design, installation and maintenance. This information can then be used to further improve customer safety, to target expenditure on CO incident prevention and to identify further research work.

As part of this project a national data collection scheme for piped natural gas and L.P.G. CO incidents, which occur within Great Britain, has been established by BG Technology. This has been with the support of the HSE and the gas industry. Information for incidents since 1996/97, which was prior to the setting up of the JIP, has been obtained from industry reports and has already been reported as part of the JIP

This is the second report of a series that are to be published. It covers the financial reporting period 1997/98. The incidents are only described by postcode to ensure anonymity. During this period the majority of the incidents reported were domestic incidents. There were four non-domestic incidents reported and one LPG incident.

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SUMMARY

This report has been prepared as part of the Joint Industry Programme (JIP) Addressing Carbon Monoxide (CO) Issues and within the Incident Data project area. The aim of this project is to identify common causes of CO incidents related to appliance and system design, installation and maintenance. This information can be used to improve customer safety, target expenditure on CO incident prevention and further research work. As part of this project a national data collection scheme for piped natural gas and LPG CO incidents, which occur within Great Britain, has been established. This has been with the support of the HSE and the gas industry. This information has been collected together by BG Technology for analysis. Information for incidents since 1996/97, which was prior to the setting up of the JIP, has been obtained from industry reports and has already been reported as part of the JIP. This is the second report of a series that are to be issued and covers the period 1997/98. Historical data has also been used within the report from previously unpublished internal company reports. This information has been used to show incident trends. The results of this report are summarised below: -

The number of domestic related CO poisoning deaths reported, at 22 during 1997/98, was in line with previous trends.

The majority of all CO poisoning deaths involved domestic open flued appliances.

Space heating appliances were responsible for the majority of deaths.

The total FPPY figure of 0.48×10^{-6} is within, what would normally be considered as, the "broadly accepted region" of HSE's criteria for the tolerability of risk. However, societal concerns over gas safety override averaged numerical considerations.

The appliance types that were above the HSE's criteria for the tolerability of risk are single-point water heaters (8.78×10^{-6}).

Central heating appliances were responsible for the majority of casualties.

The majority of casualties are located in the bedroom and living room.

There was an above average risk of a CO incident in domestic properties built before 1946 and also in tenanted accommodation that was privately owned.

Flueing and ventilation faults were common in many domestic incidents.

Whilst it has often been suggested that annual appliance servicing could help prevent the majority of domestic incidents it has not been possible to support or refute that conclusion from the data presented in this report.

There was one LPG incident reported during 1997/98.

Reports on four non-domestic incidents were submitted and analysed during 1997/98.

1 INTRODUCTION

This report on accidental CO incidents resulting from the use of piped natural gas gives details of CO poisoning incidents for the period April 1st 1997 to March 31st 1998. The data for all sources of incidents comes from BG Technology's own incident recording system up to 1995. From 1996 the information is obtained from incident reports and investigation forms completed on behalf of gas suppliers. If any additional reports should be received after publication of this report they will be included within updated annual statistical tables in future reports.

The body of the main report deals solely with domestic incidents. Business incidents and LPG incidents are to be found in Appendix C and D. When it was indicated on the DIDR form that it was or was a strongly suspected intentional incident then the form was excluded from the analysis.

This report gives tables and plots of actual fatalities and incidents reportable via the Downstream Incident Data Report (DIDR) - Form 551/7. It also gives plots relating to the risk associated when using gas appliances expressed in terms of fatalities per person per year (FPPY), as incidents per person per year (IPPY) and as casualties per person per year (CPPY). The definitions and use of IPPY and CPPY values are described in Appendix A. Fatality, casualty and incident trend data are presented for incidents that occurred between 1990/91 and 1997/8.

Note: Some inconsistencies may appear in some parts of the report because all the required information may not have been completed on the DIDR forms e.g. in Table 7 the numbers of casualties, as represented by their location, differs from the total number reported in Table 1. Some information was completed as "unknown" or "other" and in some instances the tick box was not completed (field empty).

Appendix B gives details of each of the CO poisoning incidents for 1997/8.

The order used in this report follows the layout used in the DIDR - Form 551/7.

Note: Included on the DIDR form are 3 sections to complete related to the installation - to current standards, to standards current at time of installation, not to any appropriate standards or unsure/don't know, of the following:-

- the appliance
- the flue
- the permanent ventilation

For "the appliance" items that are standards related, include the correct room/location, proximity to walls, fire resistance and electrical safety. Each of the three items are dealt with separately on the DIDR form and within this report.

2 ANALYSIS OF REPORTED DATA

2.1 TOTAL INCIDENT DETAILS - ANALYSIS OF SECTION 1 OF DIDR

BG Transco issued 346 Incident Notification Forms during the reporting period. These gave details of CO Poisoning Reports under their companies internal reporting procedures.

During the year there were 97 domestic reports that met the requirements for reporting on the DIDR form. The majority of these had been notified directly to Transco, via the operation of the national gas emergency service, and reported by Transco's internal reporting procedures. In addition there were some incidents reported directly to gas suppliers by, for example, coroners or the police that do not get entered onto Transco's reporting system. These 97 forms were fully analysed for this report. Every effort was made to obtain as many completed DIDR forms for this report as possible, but due to the voluntary nature of the reporting scheme it is likely that a very few reports were not supplied. Each form is treated as a separate DIDR incident and will be referred to as an "incident" throughout the rest of this report. The incident risk data and trend data has been combined with the casualty details described in section 2.2.

The date of occurrence of each domestic incident has been plotted by month in Figure 1, for the 12 month period April 1997 to March 1998.

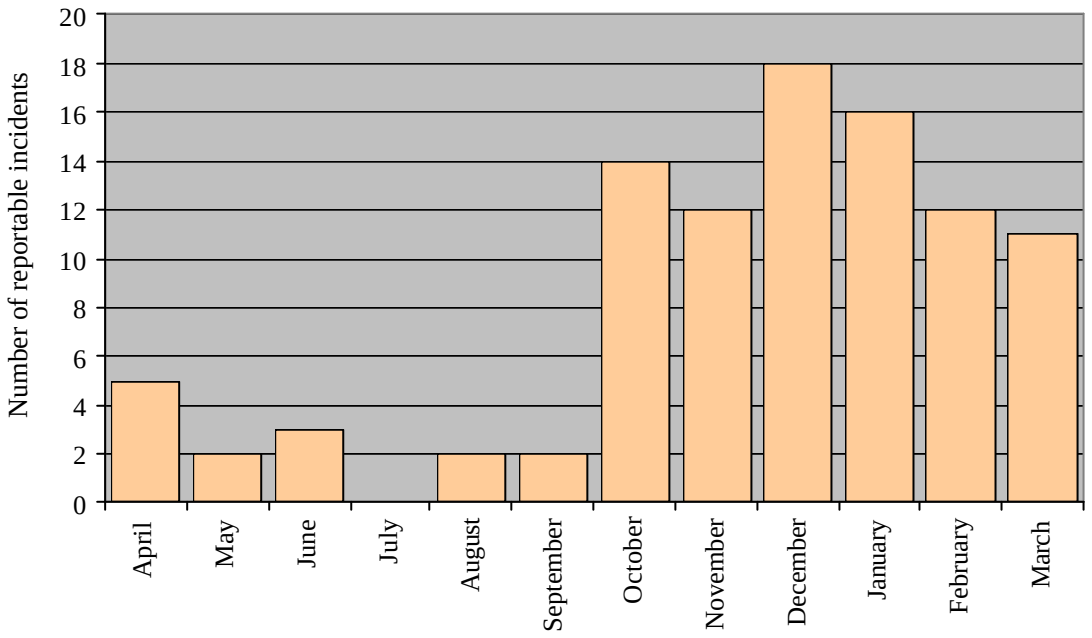

Figure 1 - Profile of incident occurrences over the year

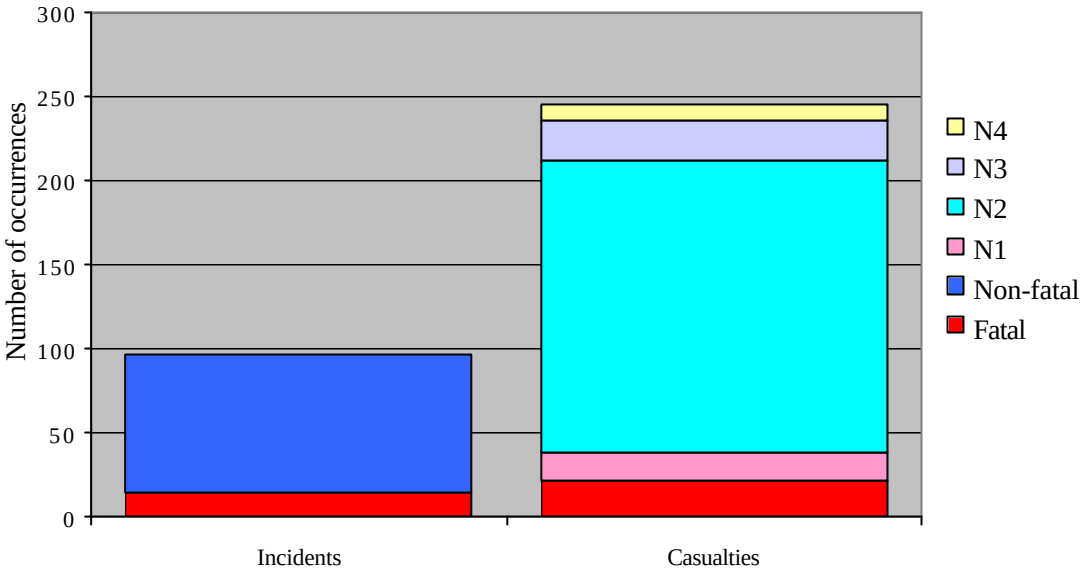

Figure 2 - Incident analysis

Figure 2 gives the number of reported domestic occurrences of CO incidents and CO casualties that took place during the year 1997/98. Further information on casualty groups are given in section 2.2 of this report.

Details of LPG incidents are given in Appendix C.

Note: There was one LPG incident reported during this reporting period.

Details of business incidents are to be found in Appendix D.

2.2 TOTAL CASUALTY DETAILS - ANALYSIS OF SECTION 2 OF DIDR

The total number of people, reported by the DIDR form, to have been injured by piped natural gas for the period 1997/98, by CO poisoning, is presented below in Table 1.

Table 1 - Classification of non-fatal casualties

Classification	N1	N2	N3	N4	Total
Number of casualties	16	174	24	10	224

Table 1 indicates the breakdown of the non-fatal casualties by casualty classification N1 to N4 used on the DIDR form. The four classifications are:-

N1 - requiring immediate hospitalisation for more than 24 hours
N2 - requiring immediate hospitalisation for less than 24 hours
N3 - requiring other medical treatment
N4 - receiving no medical treatment

Note: There were no non-fatal casualties that were unclassified.

Figure 2, in section 2.1, gives the number of occurrences of incidents and casualties that took place during the year.

Using this data a corresponding risk data analysis has been carried out. The results from this are given in Table 2. The table also includes details of the number of fatalities and the number of incidents reported on the DIDR form.

Table 2 - The number of CO incidents and casualties, used for the risk analysis, with the corresponding risk values

Total number of incidents	Total number of fatal casualties	Total number of nonfatal casualties	Over-all IPPY ($x10^{-6}$)	Over-all FPPY ($x10^{-6}$)	Over-all CPPY ($x10^{-6}$)
97	22	224	2.13	0.48	4.92

In the calculation of FPPY, CPPY and IPPY the following statistics were used for this report.

a) The number of domestic customers i.e. the number of households using piped natural gas for 1997/98 - 19.06 million - see report section 7, reference 7.1.3.

b) The average number of people per household in Great Britain for 1997/98 = 2.39 - see report section 7, reference 7.1.4 .

Note: In the calculation of FPPY, CPPY and IPPY [a x b] replaces [Number of people at risk x Appliance Population]. Definitions are given in Appendix A.

Overall trends are given in Table 3 and plotted in Figures 3 and 4.

Table 3 - Trend data

Year	90/91	91/92	92/93	93/94
"A"	28	29	38	29
"B"	0.67	0.68	0.9	0.65
"C"	124	139	174	167
"D"	3	3.3	4.1	4.4
"E"	75	77	87	86
"F"	1.8	1.8	2	1.9

Year	94/95	95/96	96/97	97/98
"A"	31	-	25	22
"B"	0.69	-	0.54	0.48
"C"	189	-	121	224
"D"	4.2	-	2.63	4.92
"E"	102	-	67	97
"F"	2.3	-	1.46	2.13

Notes to Table 3:
A = Total number of deaths due to CO poisoning in each financial year
B = FPPY (Average fatalities per person per year are $x10^{-6}$). The FPPY was calculated by the same method as that used for Table 2.
C = Total number of non-fatal casualties due to CO poisoning in each financial year.
D = CPPY (Average non-fatal casualties per person per year are $x10^{-6}$). The CPPY was calculated by the same method as that used for Table 2.
E = Total number of incidents due to CO poisoning in each financial year.
F = IPPY (Average incidents per person per year are $x10^{-6}$). The IPPY was calculated by the same method as that used for Table 2.
Following the restructuring of British Gas insufficient information was collected to enable the statistics for 1995/96 to be calculated.

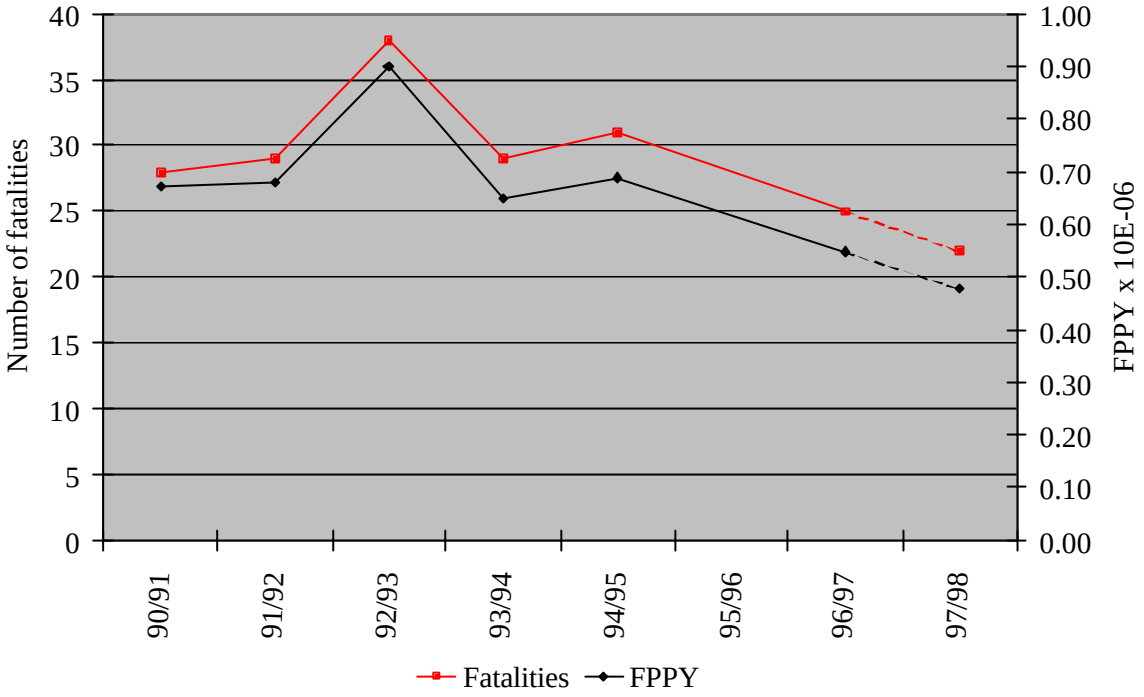

Figure 3 - Graph of fatality trends

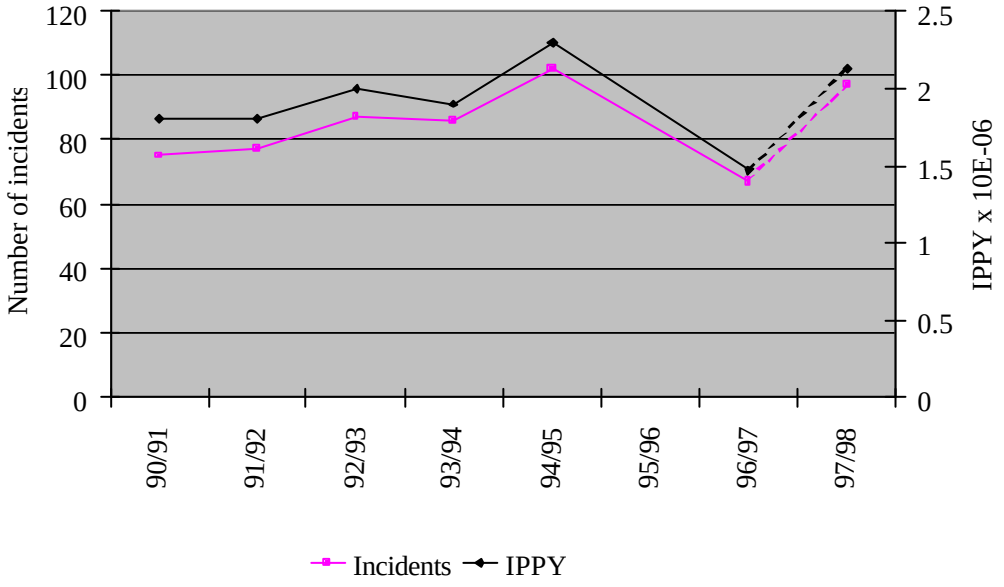

Figure 4 - Graph of incident trends

The age and numbers of the combined totals of the fatal and all non-fatal casualties are given in Figure 5.

Note: this was for all incidents where the casualty age details had been completed.

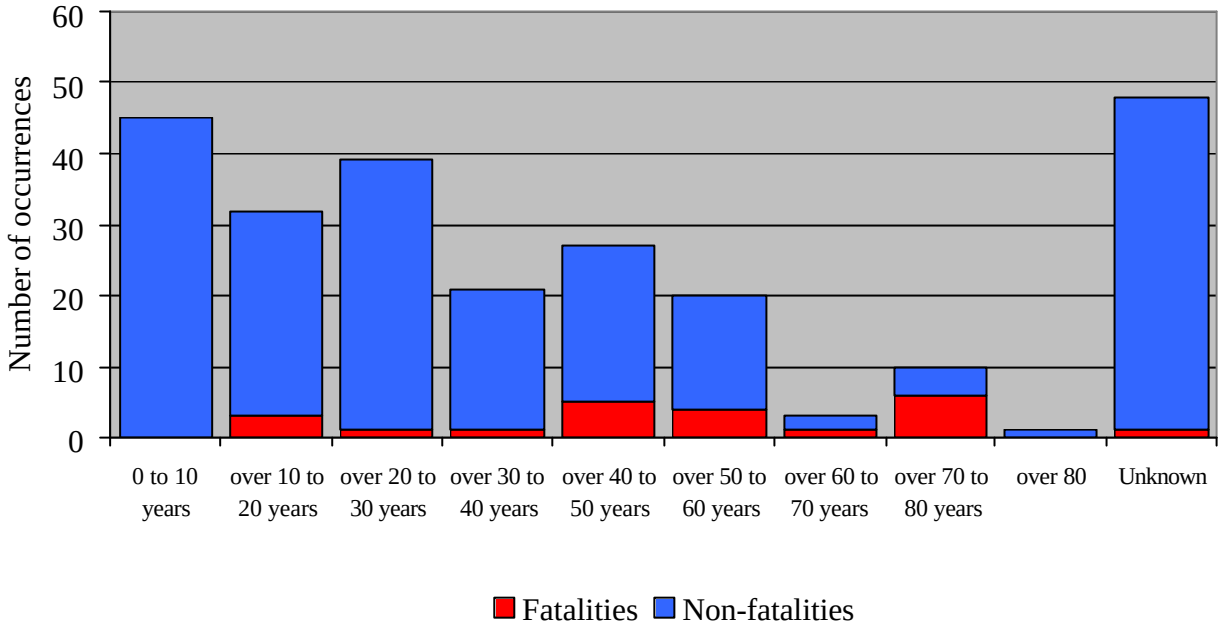

Figure 5 - Casualty age profile

2.3 PROPERTY DETAILS - ANALYSIS OF SECTION 3 OF DIDR

Figure 6 indicates that the highest proportion of incidents occurred in terraced houses (35%) followed by semi-detached houses (23%).

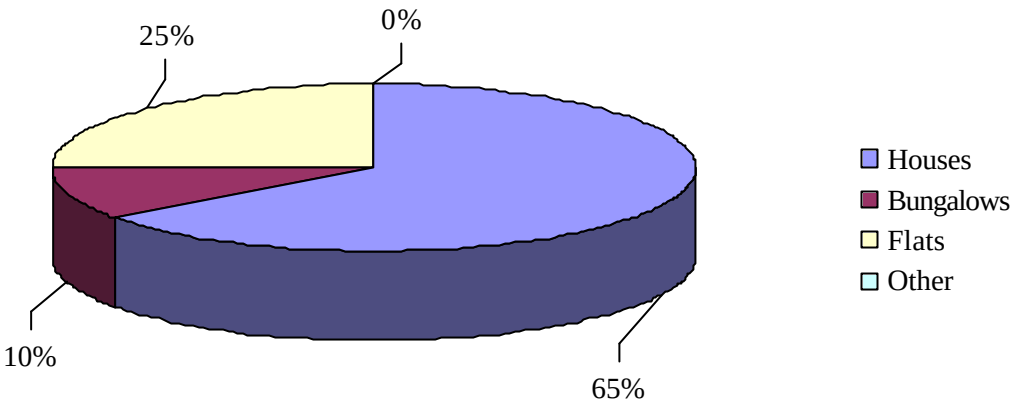

Figure 6 - Property types

Table 4 shows the number of and percentage of each style of property, within each property type, in which incidents took place during the year. There were no incident properties categorised as "other".

Table 4 - Breakdown of incident sites by property style

Bungalow	Nos (%)	Flat	Nos (%)	House	Nos (%)
Detached	6 (6)	Bed sit	2 (2)	Detached	7 (7)
Semi-detached	4 (4)	Conversion	3 (3)	Semi-detached	22 (23)
Terraced	0 (0)	Maisonette	1 (1)	Terraced	34 (35)
		PBB (4 storeys or less)	16 (16)	Townhouse	0 (0)
		PBB (5 storeys or more)	2 (2)		

The Living in Britain, 1998 General Household Survey from the ONS gives a breakdown of types of accommodation in Britain. The analysis is given below where it is compared to the incident statistics.

Table 5 - Comparison of DIDR incident stats with accommodation stats

Property style	Accommodation Stats for GB (%)	Incident Stats (%)
Detached house/bungalow	23	13
Semi-det house/bungalow	33	27
Terraced house	26	35
Purpose built flat or maisonette	15	18
Converted flat or maisonette/rooms	4	6

The age bands of the properties in which incidents took place are shown on Figure 7.

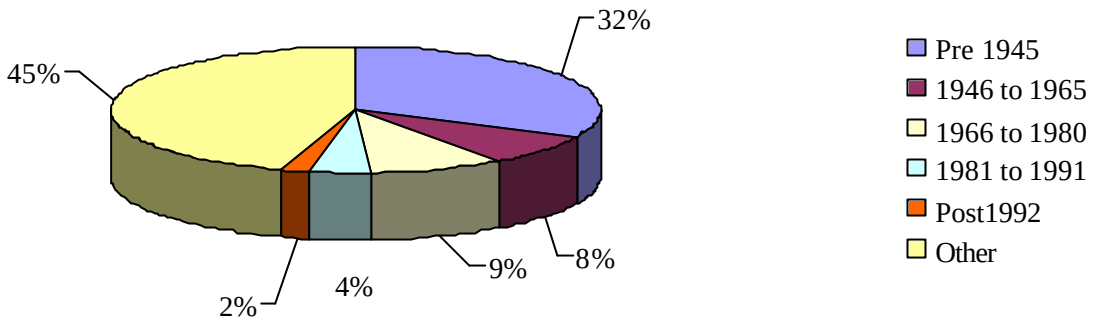

Figure 7 - Property construction period

The two largest sectors are properties built before 1946 at 32% and unclassified at 44%. Where the age was specified (54 properties) the pre 1946 group is the majority at 57%. The next largest group was 28% for those built after 1965. Those built after 1945 and before 1966 were 15% of the total. The Living in Britain publication, 1998 edition, from the Office for National Statistics (ONS) states that for Britain 40% of all dwellings were built before 1945, 23% were built in the period 1945 to 1964 and 37% were built during or after 1965.

Figure 8 gives the occupancy types of the properties shown on the DIDR forms. The percentage owner occupied was 51% and 43% were tenanted. Empty fields or unrecognised values made up the remainder. Of the tenanted properties all 43% were single occupancy, with no multiple occupancy. The percentage of the tenanted sector that were council owned is 11%, privately owned was 23% and 6% were owned by a housing association, the remainder were classified as other.

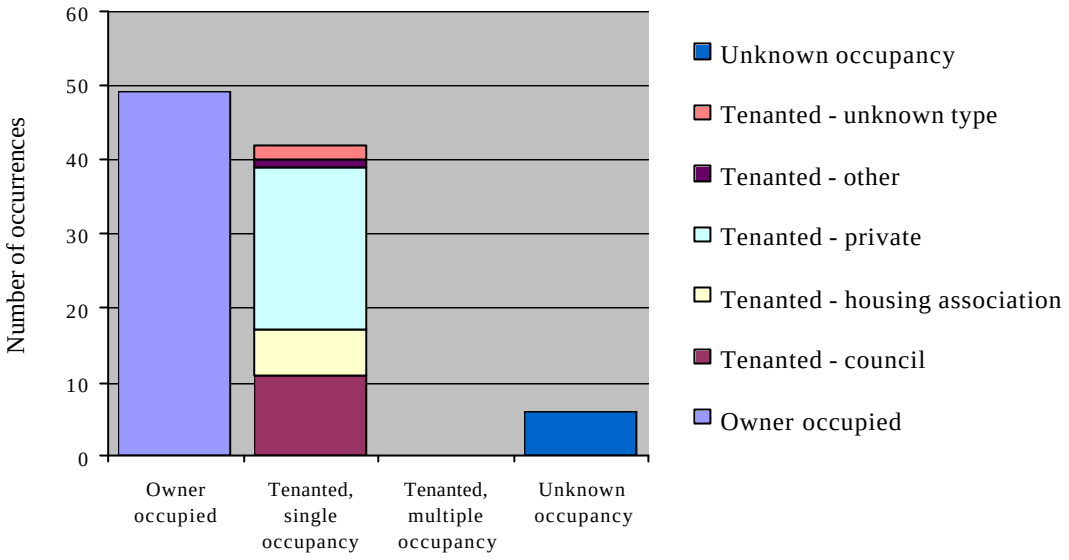

Figure 8 - Occupancy type

The Living in Britain 1998 General Household Survey from the ONS gives the owner occupied tenure group as 69% and the tenanted sector as 30%. This covers renting from the local authority at 16%, privately at 9% and from a housing association at 5%.

Table 6 shows the analysis of the glazing and ground floor details for the incident sites. These are also described graphically in figures 9 and 10.

Table 6 - Construction details of the incident property

Glazing details	%	Ground floor details	%
Single	15	Solid	13
Double	22	Suspended	5
Partial double	4	Partial solid	0
Undefined	59	Undefined	82

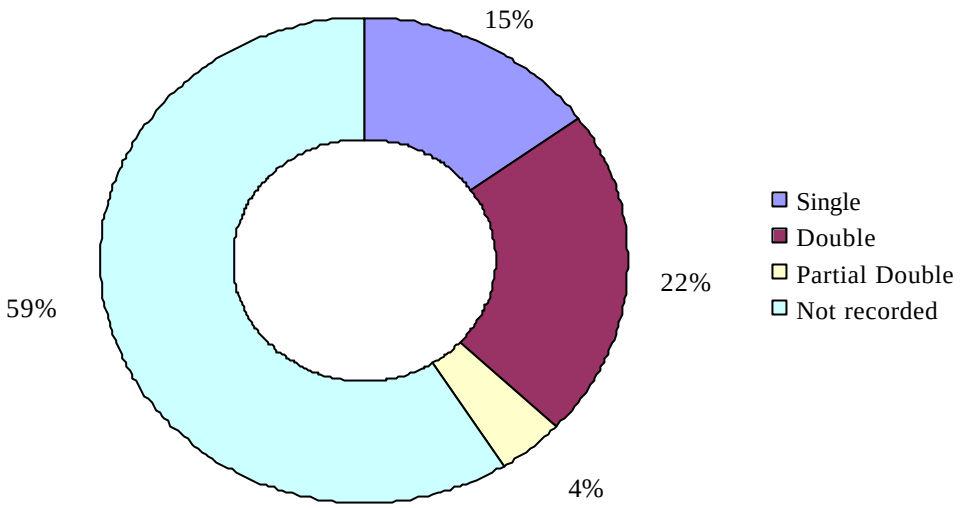

Figure 9 - Glazing details

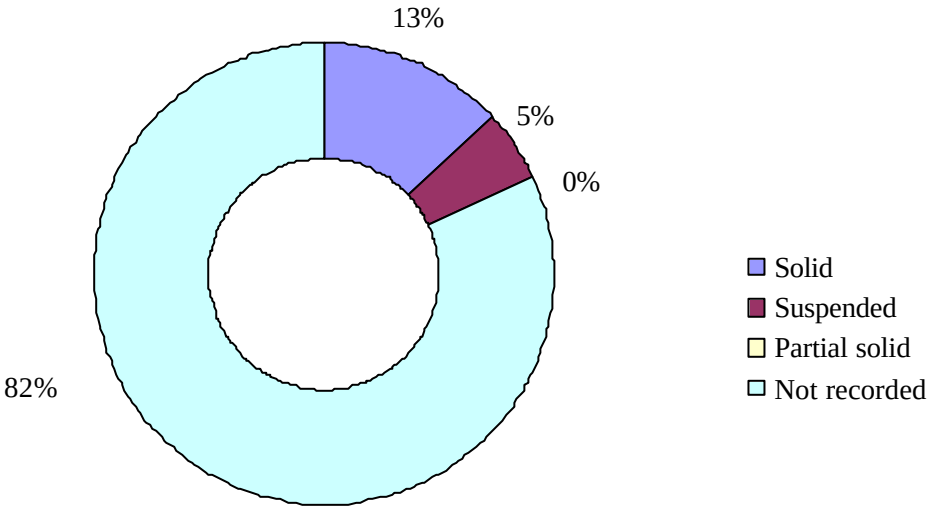

Figure 10 - Ground floor construction

2.4 CASUALTY & APPLIANCE LOCATION - ANALYSIS OF SECTION 4 OF DIDR

The location of the incident appliance and the casualties are given below in Table 7.

Table 7 - Appliance and casualty locations

Location	Number of appliances at each location	Number of casualties at each location	Number of casualties reported in the same room as the appliance
Attic	0	0	0
Bathroom	0	7	0
Bedroom	3	53	4
Bedsit	0	6	0
Cellar	3	0	0
Dining Room	2	3	1
Utility	4	0	0
Garage	0	0	0
Hall	13	4	1
Kitchen	49	18	12
Landing	1	4	0
Living room	21	53	19
Shower-room	0	0	0
Other	1	0	0
Empty Field	0	25	25

Of the 97 incident sites the majority of incident appliances were located in rooms (72%), 22% were described as being located in compartments and the remainder were not coded. This is shown on Figure 11.

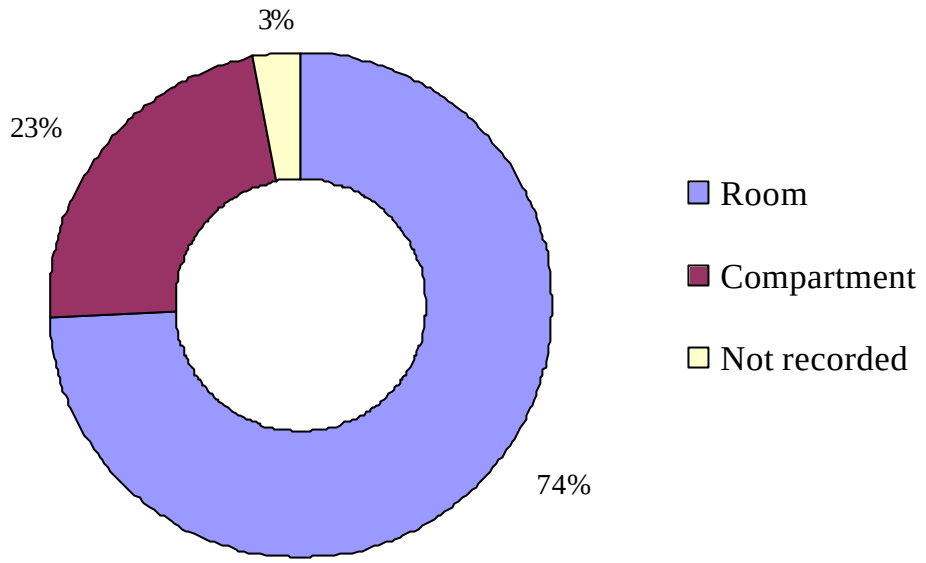

Figure 11 - Appliance location

There were 4 appliances located in a room below ground level. At 93 incidents the casualties were in the same property as the incident appliance. The remainder were not coded. This is shown on Figure 12.

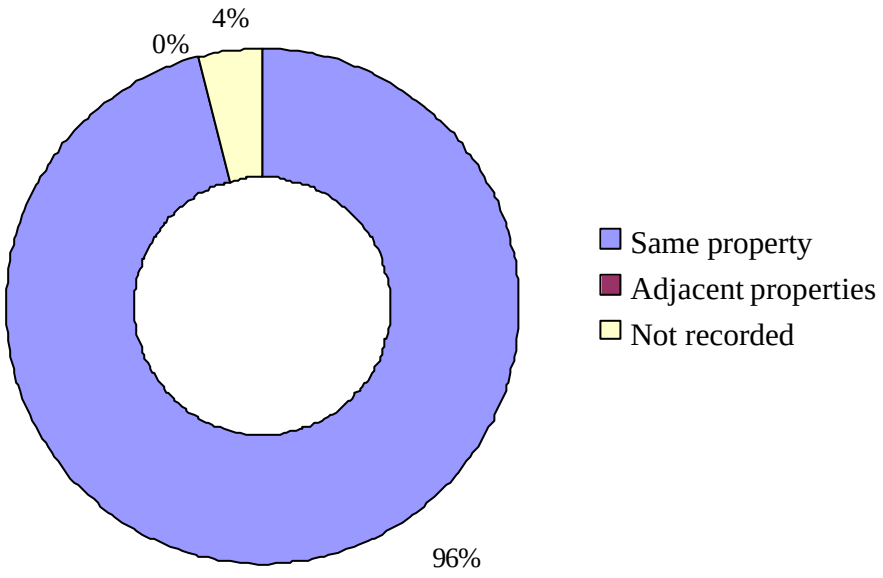

Figure 12 - Casualty/Appliance location

2.5 INCIDENT APPLIANCES - ANALYSIS OF SECTION 5 OF DIDR

2.5.1 Incidents during 1997/98

Details of the CO poisoning incidents for 1997/98, by appliance type, are given in Table 8 and in Figure 13.

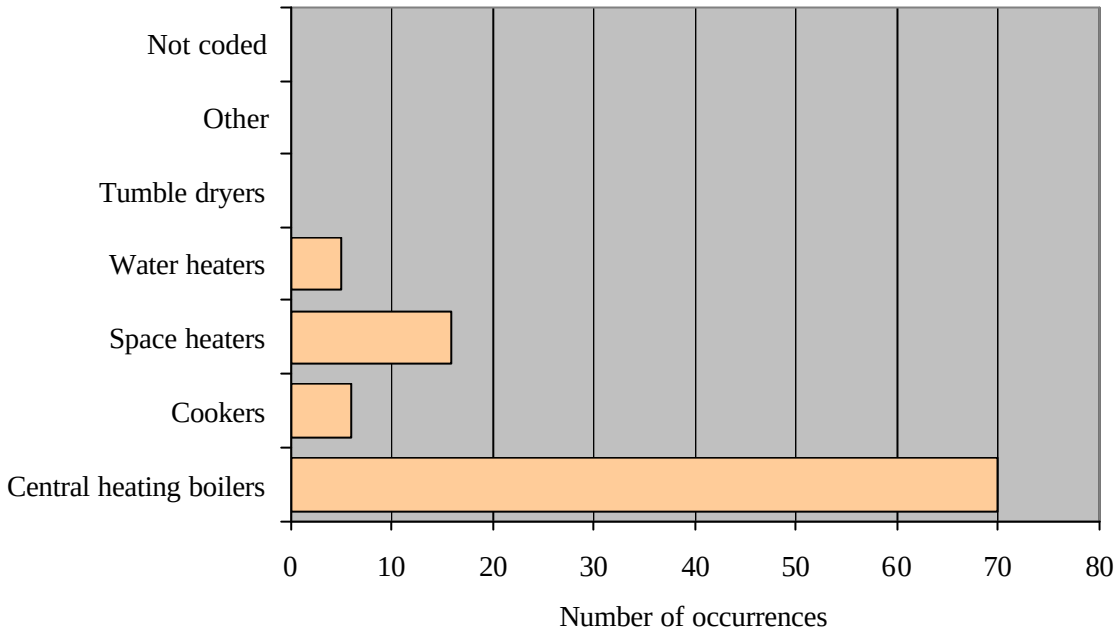

Figure 13 - Incidents by appliance type

TABLE 8 - Incidents by appliance types

Appliance	Incidents (All) - Total	Incidents - Fatal	Casualties (All) - Total	Casualties - Fatal
Central Heating Boilers				
Back unit	6	0	26	0
Floor standing	14	1	37	2
Floor standing combi	0	0	0	0
Thermal storage unit	0	0	0	0
Wall mounted	33	2	84	2
Wall mounted combi	15	1	42	1
Warm air unit	2	0	8	0
Total	**70**	**4**	**197**	**5**
Cookers				
Free standing	6	3	9	4
Built-in oven	0	0	0	0
Built-in hob	0	0	0	0
Total	**6**	**3**	**9**	**4**
Space Heaters				
Balanced flue g .f.	0	0	0	0
Cabinet heater	0	0	0	0
Decorative g .f.	0	0	0	0
Flueless heater	0	0	0	0
Inset live fuel effect g	1	0	1	0
Rad. & rad. con. g .f.	15	7	26	10
Wall heater	0	0	0	0
Total	**16**	**7**	**27**	**10**
Dryers				
Tumble Dryers (total)	**0**	**0**	**0**	**0**
Water Heaters				
Bulk storage	0	0	0	0
Circulator	1	0	1	0
Multi-point	0	0	0	0
Single-point	4	1	12	3
Total	5	1	13	3
OTHER	**97**	**15**	**246**	**22**
Table total	**107**	**19**	**231**	**23**

Notes: The CASUALTIES (ALL) - TOTAL includes fatal casualties.
Appendix B gives details, by appliance type, for each incident. ***In the above table and following tables g .f. has been used as an abbreviation for gas fire***

There were no reports of any condensing appliances having been involved in any incidents during this reporting period.

The breakdown of the types of central heating units involved in incidents is given in Figure 14.

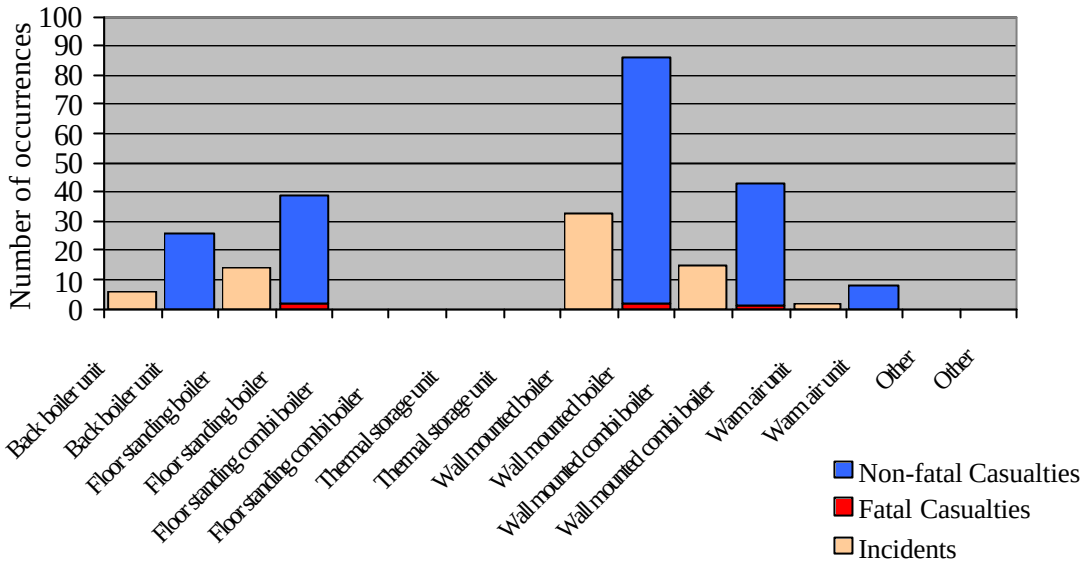

Figure 14 - Central heating boilers

Figure 15 shows the fatality trends associated with appliance type since 1990/91. It should be noted that it is likely that there have been changes to the profile of gas appliances in use within Britain between 1990/91 and 1997/98. The FPPY risk values shown in Table 12 take account of these changes.

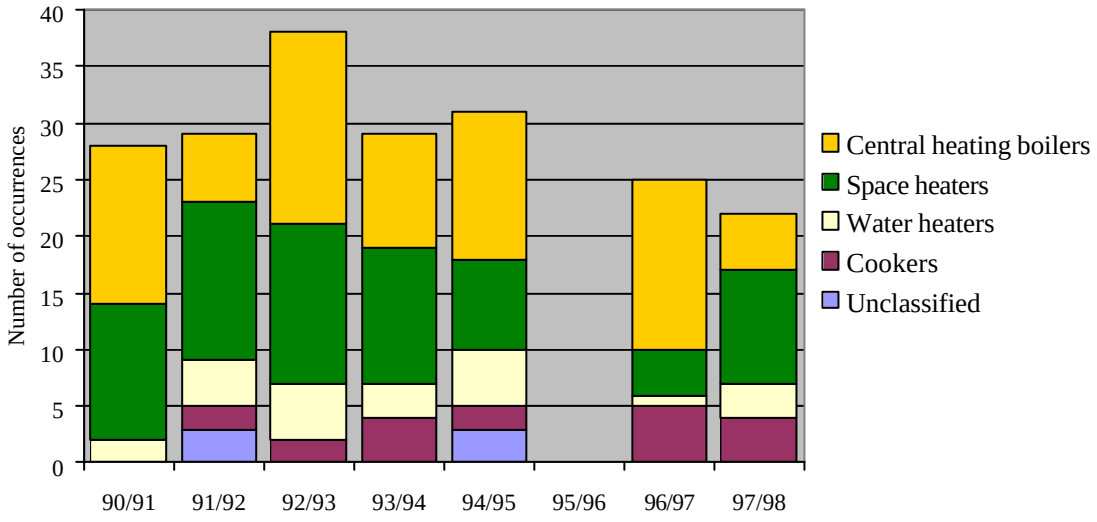

Figure 15 - Fatalities by appliance type

The age of the appliances involved in incidents during the reporting period has been given under the main appliance groups in Table 9. It is also described in Figure 16.

Table 9 - Age of incident appliances

Appliance Type	Age (years)					
	0 –5	6 - 10	11 - 15	16 - 20	Over 20	Unknown
Central heating boilers	4	16	6	1	5	38
Cookers	0	0	0	1	0	5
Space heaters	3	1	1	1	0	10
Dryers	0	0	0	0	0	0
Water heaters	0	0	0	0	0	5
TOTAL	7	17	7	3	5	58

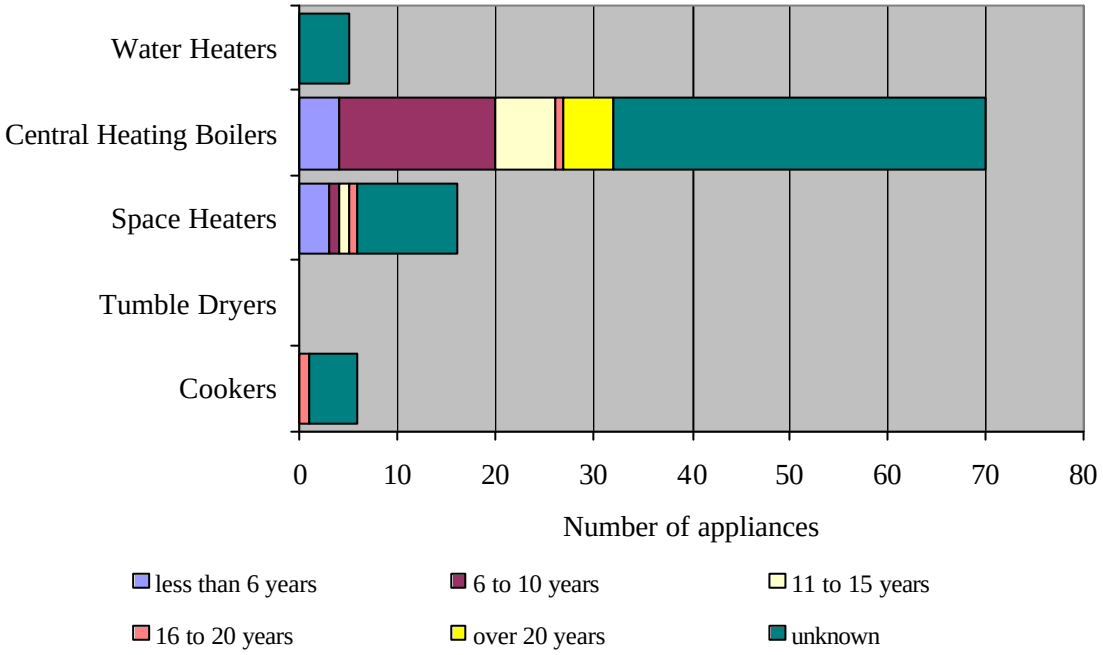

Figure 16 - Appliance age distribution

2.5.2 Notes relating to individual appliance types and models

The following information is extracted from the incident details given in Table 8 and Appendix B:

2.5.2.1 Central Heating

Overall the number of incidents resulting from all types of central heating appliances was 70. This was 72% of all incidents reported and also accounted for 23% of all the fatalities recorded. There were no incidents where the model of the boiler was not given. The majority of incidents involved wall hung boilers. Central heating boiler incidents accounted for 80% of all casualties.

Back boiler units

There were 6 incidents involving back boilers. There were no fatal incidents. Non-fatal casualties totalled 26. Four incidents involved Baxi Bermuda appliances. Restricted heat exchangers, mainly by soot were the cause of high levels of CO. In 4 cases the ventilation was not fully effective.

Floor standing boilers

Fourteen incidents involved open flued models (all open, individual, natural draught flues). There were 2 fatalities and 35 non-fatal casualties. Four incidents involved Potterton Kingfisher models, with one appliance having a room sealed flue. Flueing faults were evident in 56% of cases.

> Note: Some appliance models may appear under several different manufacturers' names within Appendix B. For example Apollo boilers have been entered under Thorn, Myson and Potterton Myson.

Floor standing combi boilers

There were no incidents involving floor standing combi boilers.

Thermal storage units

There were no recorded incidents involving these appliances.

Wall mounted boilers

There were 33 incidents involving wall mounted open flued boilers, with 2 fatalities and 82 non-fatal casualties. This amounts to approximately 33% of all casualties. Thirteen incidents involved Glow Worm Fuelsaver boilers (39% of all wall hung boiler incidents).

There were 4 incidents involving wall mounted, room sealed, fan flued boilers and 2 room sealed natural draught.

In 19 incidents the appliance was linted and in 18 incidents the heat exchanger was blocked. In 17 incidents the flue was not to standards and in 15 incidents the ventilation was substandard.

Wall mounted combi boilers

There were 15 incidents, including 1 fatality and 41 non-fatal casualties, involving wall mounted combi boilers. Models involved were Vaillant boilers (9 VCW models), 1 Ferroli boiler, 2 Vokera boilers, 1 Saunier Duval boiler, 1 Worcester boiler and 1 Ocean boiler.

A lack of servicing was reported at most of these incidents. Ten incidents had a substandard flue.

Warm air units

There were 2 incidents involving warm air units with 8 casualties. The models responsible were a Halstead and a McClary. One appliance was connected to a blocked flue and in the other instance the flue had become separated from the appliance. Both needed servicing, had substandard flues and had inadequate ventilation.

2.5.2.2 Cookers

From the 6 incidents reported from free standing cookers there were 4 fatalities and 5 casualties. In three of the incidents the grill burner was the cause of the CO. In another case the cooker was being used to heat the kitchen.

2.5.2.3 Space Heaters

Space heaters were involved in 16 incidents, with 10 fatalities and 17 non-fatal casualties.

The space heating incidents all involved open, individual, natural draught flued fires. One incident involved an inset live fuel effect fire and the remaining 15 were all radiant convector gas fires. In all but two instances the appliance models were different. Flue blockage was a major factor in 8 cases and in 7 cases the flue was not to standard. In most cases the appliance required servicing.

2.5.2.4 Tumble Dryers

There were no appliances reported during the year in association with CO incidents.

2.5.2.5 Water Heaters

There were 4 incidents involving a flueless, single-point water heater, which led to 3 fatalities and 9 non-fatal casualties. In 2 cases the appliances were operated for extended periods and this was considered to be the main cause of the incident.

Only 1 incident involved a circulator, with 1 non-fatal casualty. The appliance was in need of servicing and had substandard flueing and ventilation.

2.5.3 Appliance risk values

Details relating to the risk values by appliance type are shown below in Table 10. In terms of the risk of a fatal incident (FPPY) only the single point water heater has a FPPY value greater than the recommended level of 1×10^{-6}.

The appliances in descending order of risk are as follows: Single-point water heaters (8.78×10^{-6}) and radiant and radiant convector gas fires. (0.54×10^{-6}).

Table 10 - Risk values by appliance type

Appliance	Population ($x10^6$)	FPPY ($x10^{-6}$)	CPPY ($x10^{-6}$)	IPPY ($x10^{-6}$)
Central Heating Boilers				
Back boiler unit	3.13	0	3.48	0.8
Floor standing	3.17	0.26	4.62	1.85
Floor standing combi	-	-	-	-
Thermal storage unit	-	-	-	-
Wall mounted	7.4	0.11	4.64	1.87
Wall mounted combi	2.44	0.17	7.02	2.57
Warm air unit	0.39	-	8.58	2.14
Cookers				
Free standing	8.81	0.19	0.24	0.285
Built-in oven	-	-	-	-
Built-in hob	-	-	-	-
Space Heaters				
Balanced flue g .f.	-	-	-	-
Cabinet heater	-	-	-	-
Decorative g .f.	-	-		
Flueless heater	-	-	-	-
Inset live fuel effect g .f.	-	-	-	-
Rad. & rad. Con. g .f.	7.73	0.54	0.87	0.81
Wall heater	-	-	-	-
Dryers				
Tumble dryers (total)	-	-	-	-
Water Heaters				
Bulk storage	-	-	-	-
Circulator	-	-	-	-
Multi-point	-	-	-	-
Single-point	0.14	8.78	26.33	11.7

Note: Population figures provided by GfK Marketing Services Ltd. (Reference 7.1.1). No population figures were available for Inset live fuel effect gas fires and therefore no risk values could be calculated.

2.5.4 Trends (1989/90 -1997/98)

Trends regarding CO Poisoning incident fatalities by appliance type are given below in Table11 and are also shown in Figure 15, which is in section 2.5.1 of the report. This table has been completed as fully as possible using information that was available from the 97/98 DIDR forms and from historical records held by BG Technology (Reference 7.1.2). As future years are added to the table then the level of detail shown will improve.

Table 11 - Trend data of the number of fatalities due to CO incidents, by appliance type

Appliance	Year							
	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98
C/H Boilers -Total	**14**	**6**	**17**	**10**	**13**	**-**	**15**	**5**
Back unit	-	-	-	-	1	-	3	-
Floor standing	-	-	-	-	6	-	2	2
Floor standing combi	-	-	-	-	-	-	-	-
Thermal storage unit	-	-	-	-	-	-	-	-
Wall mounted	2	-	-	2	1	-	5	2
Wall mounted combi	1	2	4	2	2	-	3	1
Warm air unit	-	-	1	1	2	-	1	-
Cookers -Total	**-**	**2**	**2**	**4**	**2**	**-**	**5**	**4**
Free standing	-	-	-	-	-	-	5	4
Built-in oven	-	-	-	-	-	-	-	-
Built-in hob	-	-	-	-	-	-	-	-
Space Heaters -Total	**12**	**14**	**14**	**12**	**8**	**-**	**4**	**10**
Balanced flue g .f.	-	-	-	-	-	-	-	-
Cabinet heater	-	-	-	-	-	-	-	-
Decorative g .f.	-	-	-	-	-	-	-	-
Flueless heater	-	-	-	-	-	-	-	-
Inset live fuel effect g .f.	-	-	-	-	-	-	-	-
Rad. & rad. con. g .f.	-	-	-	-	-	-	3	10
Wall heater	-	-	-	-	-	-	-	-
Dryers	-	-	-	-	-	-	-	-
Water Heaters -Total	**2**	**4**	**5**	**3**	**5**	**-**	**1**	**3**
Bulk storage	-	-	-	-	-	-	-	-
Circulator	-	-	-	-	-	-	-	-
Multi-point	-	-	-	-	-	-	-	-
Single-point	-	-	-	-	-	-	1	3
Other	**-**	**3**	**-**	**-**	**3**	**-**	**-**	**-**
TOTAL -All Appliances	**28**	**29**	**38**	**29**	**31**	**-**	**25**	**22**

Trends in terms of the risk of a fatality by appliance type, expressed as FPPY values are shown below in Table 12. This table has also been completed as fully as possible using information that was available from the 97/98 DIDR forms and from historical records held by BG Technology. As future years are added to the table then the level of detail shown will also improve.

Table 12 - Trend data of fatalities per person per year (FPPY)

Appliance	Year							
	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98
C/H Boilers -Total	**0.47**	**0.14**	**0.38**	**0.17**	**0.27**	**-**	**0.38**	**0.12**
Back unit	-	-	-	-	-	-	0.39	-
Floor standing	-	-	-	-	-	-	0.23	0.26
Floor standing combi	-	-	-	-	-	-	-	-
Thermal storage unit	-	-	-	-	-	-	-	-
Wall mounted	41.1	-	18.3	37.5	0.65	-	0.27	0.11
Wall mounted combi	0.35	0.64	1.1	0.54	0.54	-	1.1	0.17
Warm air unit	-	-	0.67	0.7	1.38	-	0.76	-
Cookers -Total	**-**	**0.1**	**0.06**	**0.01**	**0.07**	**-**	**0.16**	**0.13**
Free standing	-	-	-	-	-	-	0.24	0.19
Built-in oven	-	-	-	-	-	-	-	-
Built-in hob	-	-	-	-	-	-	-	-
Space Heaters -Total	**0.4**	**0.43**	**0.42**	**0.36**	**0.24**	**-**	**-**	**-**
Balanced flue g .f.	-	-	-	-	-	-	-	-
Cabinet heater	-	-	-	-	-	-	-	-
Decorative g .f.	-	-	-	-	-	-	-	-
Flueless heater	-	-	-	-	-	-	-	-
Inset live fuel effect g .f.	-	-	-	-	-	-	-	-
Rad. & rad. con. g .f.	-	-	-	-	-	-	0.16	0.54
Wall heater	-	-	-	-	-	-	-	-
Dryers	-	-	-	-	-	-	-	-
Water Heaters -Total	**0.33**	**0.5**	**1.3**	**0.9**	**1.47**	**-**	**-**	**-**
Bulk storage	-	-	-	-	-	-	-	-
Circulator	-	-	-	-	-	-	-	-
Multi-point	-	-	-	-	-	-	-	-
Single-point	-	-	-	-	-	-	3.81	8.78
Other	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
TOTAL -All Appliances	**0.28**	**0.29**	**0.34**	**0.28**	**0.29**	**-**	**-**	**-**

Note: In Table 12 all the FPPY values are x10^{-6}

2.6 SAFETY DEVICES - ANALYSIS OF SECTION 6 OF DIDR

One CO safety device was noted as being fitted in the kitchen of one incident. The incident was caused by a faulty cooker grill which was located at the opposite end of the kitchen. It was a mains powered type of CO alarm which was found to be operational. At an incident involving a dripping, single point water heater the vitiation device was found to be faulty.

2.7 FLUE DETAILS - ANALYSIS OF SECTION 7 OF DIDR

The majority of appliances were open flued, natural draft (78 incidents - 80%). Flueless appliances featured in 10 incidents and there were 7 room sealed flues, 4 of which were fanned. Of the 2 remaining cases one was an integral open flue the other a shared open flue. Flueing details are given in Figure 17.

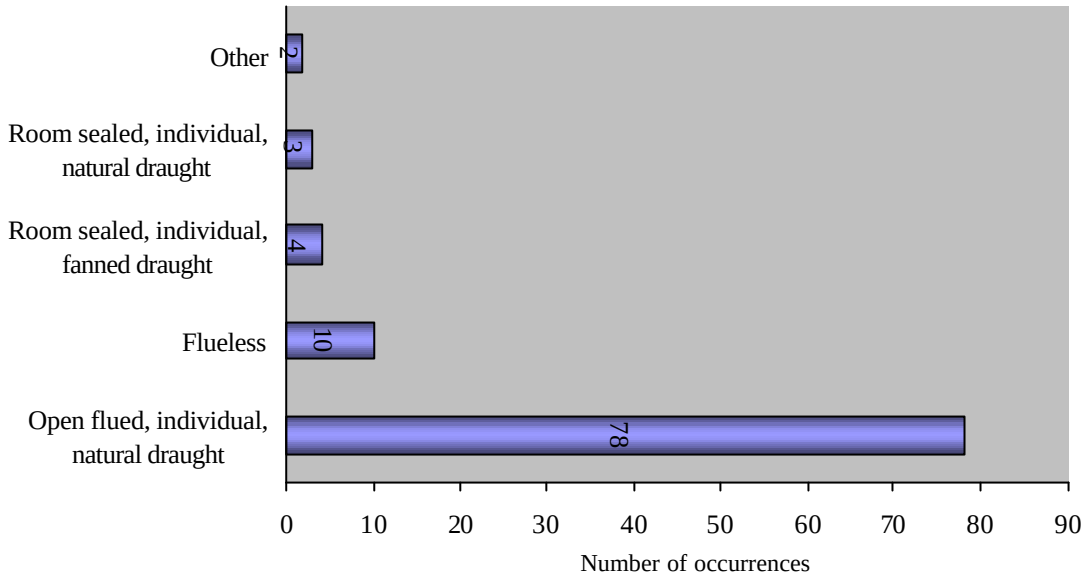

Figure 17 - Incidents by flue type

The analysis of flues to standard is given in Figure 18. There were 36% of flues to current standards, 5% to standards applicable at the time of installation, 11% were not known and 47% were not to any appropriate standards.

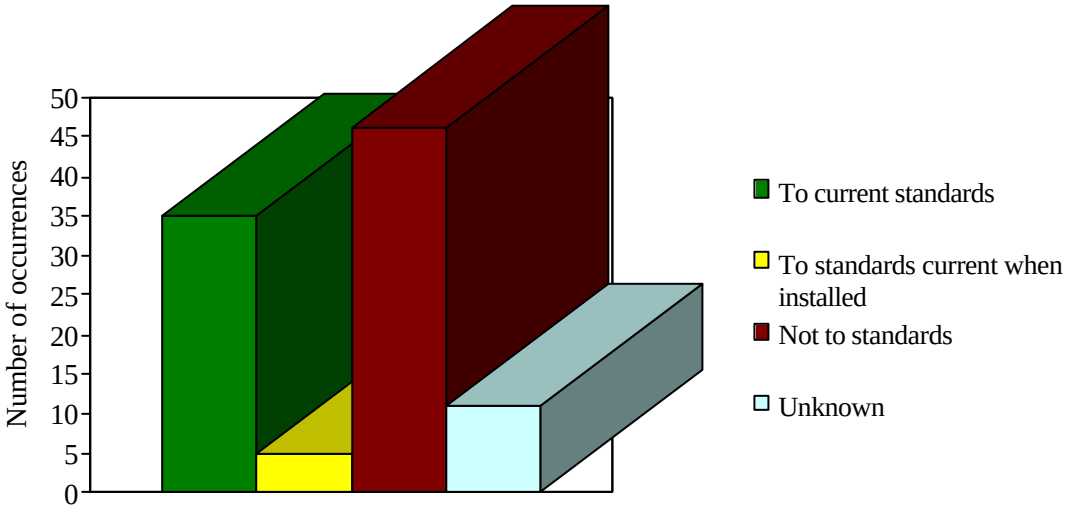

Figure 18 - Flues to standard

The number of flueing faults found are given in Table 13 (report section 2.9). A breakdown of the flueing faults, by appliance type, is given in Appendix B. Details of the flue compliance to standards, for each incident appliance, are also given in Appendix B.

Flue liners were fitted in 14 cases. In 2 cases the liner was fitted with the appliance and in 12 cases it was not known.

2.8 PERMANENT VENTILATION - ANALYSIS OF SECTION 8 OF DIDR

Permanent ventilation was required in 69 (73%) of the incidents and was not required in 26 cases. Ventilation was provided in 54 cases (78%) but was only to current standards in 19 installations (36%).

Where air vents were fitted they were still effective in 35 (68%) of incidents and partially effective in 10 (19%) of the incidents. In 7 incidents the ventilation was totally ineffective. Of those with totally or partially ineffective ventilation, 11 were blocked intentionally and 3 unintentionally.

Where the appliance was fitted in what was reported as a compartment/cupboard it was to standards applicable at the time of installation in 4 (18%) instances. It was not to standards in 18 (82%) instances.

Extract fans, recirculating fans and cooker hoods were reported to have been in use during 2 incidents.

The number of overall ventilation faults found are given in Table 13 (report section 2.9). A breakdown of the ventilation faults, by appliance type, is given in Appendix B.

2.9 ON-SITE CHECKS - ANALYSIS OF SECTION 9 OF DIDR

The following details in Table 13 are for all incident appliances. They give the total numbers of faults found upon incident appliances. In Appendix B a breakdown of the information from the DIDR is given by appliance type. The number of faults, by the main fault groups listed below, are given in Figure 19 and in Figure 20 each individual fault is shown, for comparison purposes.

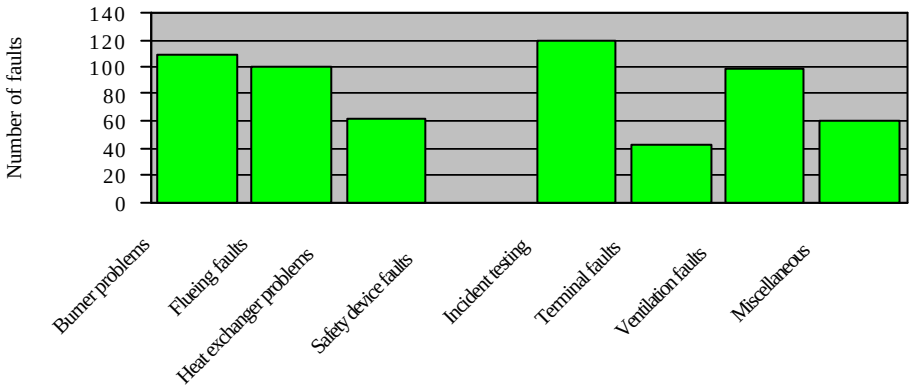

Figure 19 - Main fault groups

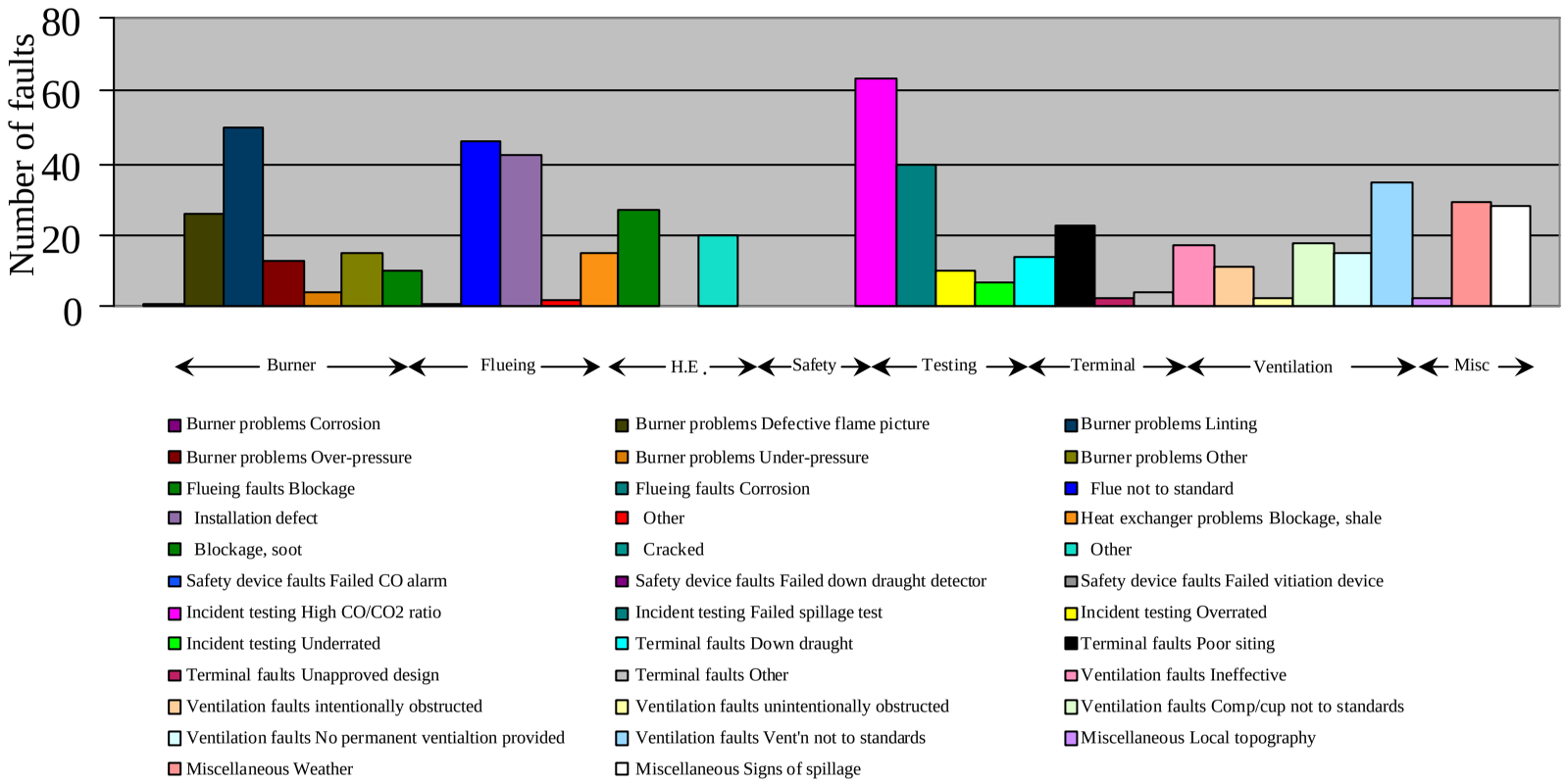

Figure 20 - Individual faults

Table 13 - Incident appliance faults

Fault group	Number of faults	Fault group	Number of faults
Burner		**Incident testing**	
Corrosion	1	High CO/CO2 ratio	63
Defective flame picture	26	Failed spillage test	40
Linting	50	Overrated	10
Over-pressure	13	Underrated	7
Under-pressure	4	**Terminal**	
Other	15	Down draught	14
Flue		Bad siting	22
Blockage	10	Unapproved design	3
Corrosion	1	Other	4
Flue not to any standard	46	**Ventilation**	
Installation defect	42	Air vent/vents ineffective	17
Other	2	Air vents obstructed - intentionally	11
Heat exchanger		Air vents obstructed - unintentionally	3
Blockage - shale	15	Compartment/cupboard not to any standards	18
Blockage - soot	27	No permanent ventilation provided	15
Cracked	0	Ventilation provided was not to any standard	34
Other	20	**Miscellaneous**	
Safety device		Local topography	3
Failed CO alarm	0	Weather	29
Failed down draught detector	0	Signs of spillage	28
Failed vitiation device	0		

Note: In Table 13 the numbers quoted are the number of appliances found with the fault listed.

In the majority (73%) of cases CO was proven to be able to enter the incident property when tested in the as-found condition and to be the likely cause of the incident.

In the majority of cases (69%) a sufficient concentration of CO was produced by the incident appliance which would have resulted in the level of COHb found in the victims.

In the majority of cases (67%) it was indicated that the concentration of CO could be achieved in the available time.

A safety warning notice had been attached to the incident appliance or at the gas meter prior to the incident on 2 occasions.

2.10 INSTALLATION DETAILS - ANALYSIS OF SECTION 10 OF DIDR

Incident appliances were installed new at 26 sites (27%). They were second hand at 6 sites (6%) of sites and it was unknown if the appliance was fitted as new or second hand for the remaining 65 (67%) incident locations. The time period when the incident appliance was fitted, before the incident, is given in Table 14 along with the number of appliances in each age group.

Table 14 - Installation period for incident appliances

Appliance type	Age (years)						Total
	0 - 5	6 - 10	11 - 15	16 - 20	Over 20	Unknown	
New	6	13	3	0	3	1	26
Second-hand	4	1	0	0	0	1	6
Unknown	0	0	3	0	2	60	65
Total	**10**	**14**	**6**	**0**	**5**	**62**	**97**

The incident appliance was known to have been installed by a CORGI registered fitter (or equivalent) in 6 instances (6%) and by DIY persons in 4 incidents (4%). Unknown persons fitted the remainder.

In the majority of incidents (75) the appliance was fitted to standards (77%). The appliance was not installed correctly and to the standards applicable at the time of installation in 14 of the 97 incidents recorded (14%). It was unknown in a further 8 incidents (8%).

2.11 INCIDENT APPLIANCE HISTORY - ANALYSIS OF SECTION 11 OF DIDR

2.11.1 Servicing information

The DIDR returns show that there were 15 incident appliances covered by a regular service contract at the time of the incident. In 30 cases there was no regular service contract and for the remaining incidents the situation was unknown.

2.11.2 Last working visit information

Analysis of the number of tick boxes completed for the "last working visit" is given in Table 15.

Table 15 - Details of the last working visit

Last working visit by:	Number of tick-boxes completed
CORGI fitter	39 (40%)
Non-CORGI fitter	0 (0%)
Other	4 (4%)
Unknown	54 (56%)

2.11.3 Reason for the visit

Analysis of the number of tick boxes completed for the "reason for the visit" is given in Table 16.

Table 16 - Reason for the last working visit

Reason for visit:	Number of tick-boxes completed
Breakdown	3 (3%)
Report of fumes	2 (2%)
Safety check/inspection	9 (9%)
Service	30 (31%)
To install the incident appliance	3 (3%)
Other	3 (3%)
Unknown	47 (48%)

2.11.4 Time period from the last working visit

Analysis of the number of tick boxes completed for the time period involved between the last working visit and the incident are given in Table 17.

Table 17 - Interval between the last working visit and the incident

Time between the last working visit and the incident	Number of tick-boxes completed
Less than 6 months	18 (19%)
6 months to 1 year	17 (18%)
1 year to 2 years	12 (12%)
More than 2 years	6 (6%)
Unknown	44 (45%)
Not applicable	0 (0%)

2.11.5 Fumes history

Prior to the incident, the incident "appliance" had been inspected following reports of fume spillage in 2 incidents. There were no reports of incident installations being inspected following reports of fume spillage. The occupants reported experiencing symptoms typically associated with CO poisoning at 12 incident sites.

3 GENERAL DISCUSSION

The final CO analysis report compiled within British Gas, before its reorganisation, was for the year 1994/95. This is the second of a new analysis of CO incident information brought about by the introduction of the DIDR form. The DIDR form was only introduced in June 1998 and therefore wherever possible information has had to be collected on DIDR forms from CO incident investigations that had been carried out before the introduction of the DIDR form.

The year 1995/96 has provided minimal information. This has therefore left a gap in the historical data, which is indicated as a zero return, during the historical trend analysis. With the new incident reporting form and associated classifications there is no "history", which would allow comparison with historical data, for many of the items recorded on the DIDR form.

Generally the types of incidents featured in 1997/98 were the same as previous years. As in previous years the majority of incidents involved open flue appliances with only 7% involving room sealed appliances. Central heating appliance incidents led to the majority of casualties, (80%), the next highest group were space heaters at 10%. However the majority of fatalities occurred with gas fires (45%), with central heating fatalities at 22%.

In addition to the domestic incidents there was one LPG reported incident reported in Appendix C and a further 3 business incidents reported in Appendix D.

3.1 TOTAL INCIDENT DETAILS

The number of domestic CO incidents fully investigated, reported and analysed for use in this report was 97.

In the previous annual report for 1996/97 there were 67 CO incidents that were analysed. In other years it has varied between 64 and 102.

As in previous years the majority of the incidents took place during the heating season.

The incident locations were analysed by postcodes. The number of incidents is however small, compared to the number of homes in Great Britain and only two postcode areas featured more than once. These were W14 and B17 at two counts each. The area of W14 covers the area of West Kensington, London and B17 is the Harborne area of Birmingham.

3.2 TOTAL CASUALTY DETAILS

The total number of fatalities was slightly down on the previous year, 22 versus 25, however non-fatal casualties recorded were approximately double. The reports of serious casualties in group N1 has reduced from 47 last year to only 10 this year. The increase has been mainly in those who attended hospital for less than 24 hours.

The total FPPY figure of 0.48×10^{-6} is within, what would normally be considered as, the "broadly accepted region" of HSE's criteria for the tolerability of risk. However, societal concerns over gas safety override averaged numerical considerations. This value is the lowest in the period since 1990/91. The values of Overall IPPY and CPPY values show an increase over last years values, but inspection of Table 3 confirms that the values are in line with previous years when similar numbers of incident reports were entered onto the database.

3.3 PROPERTY DETAILS

Incidents took place more often in terraced and semi-detached properties during 1996/97 and in 1997/98. Unlike last year though the incidents that took place across all property types is not in broad agreement to the proportions of each type of property within Britain (Table 5). The largest variation was in detached houses/bungalows which had 10% less incidents than might be expected if the results were independent of property type. Terraced houses also featured with a 9% greater number of incidents than would be expected.

Where the age was specified for the incident it was older properties (pre 1946) which are seen to feature more often in incidents. The proportion of incidents in older properties is also 17% higher than would be expected if incidents were just dependent on the age profile of properties in Great Britain. The high number of incidents where this information was not provided makes a complete analysis of age related incidents difficult.

From the figures on occupancy quoted in section 2.3 it can be seen that there were more incidents within owner occupied properties than in tenanted properties. But when a relative risk analysis is carried out it indicates that tenanted/privately owned accommodation is the area of greatest relative risk and that owner occupied and tenanted/council properties show the lowest relative risk.

Comparison of the relative risk factors (based on a division of the percentage split of DIDR reported incidents for that group by the national percentage of occurrences of that group - 100 being the overall average factor, and using the figures quoted in section 2.3) shows that the tenanted/council group has the safest relative risk factor of 69. This was calculated as follows ((11/16) x 100) = 69. Owner occupied properties have a relative risk factor of 74, tenanted/housing association group have a relative risk factor of 120 and tenanted/privately owned accommodation is the area of greatest relative risk with a factor of 256. This is a significant increase in the relative risk factor over other types of accommodation. Last years report also indicated that tenanted/privately owned accommodation was the highest risk area.

3.4 CASUALTY & APPLIANCE LOCATION

The majority of appliances that led to incidents were located in the kitchen of the incident sites. The next most common area was in the living room. These are as expected for the typical majority of domestic gas appliances.

The greatest numbers of casualties were located in the bedroom and living room. Almost all those in the bedroom were affected by appliances located in other rooms, as were 64% of those in the living room.

As would be expected the great majority of incidents took place with the casualties and incident appliance in the same property.

3.5 INCIDENT APPLIANCES

The total number of incidents was made up of 70 incidents involving central heating boilers, 16 incidents involving space heaters, 6 involving cookers and 5 involving water heaters. Central heating boilers therefore account for the majority of CO incidents and also the casualties. However, the cause of the incident is normally related to the installation rather than the appliance itself.

The fatality trend tables indicate that natural gas appliances are responsible for a broadly similar number of fatalities over the eight year period. The two most recent years do show a trend of a small reduction in the number of fatalities but it is to early to know if this will continue. This year the radiant & radiant convector gas fire group of appliances were responsible for the most

fatalities with the highest number over the period 1997/98. Flue blockage featured in half of all the incidents recorded.

The risk of a fatality, related to a CO incident, though appears to be far greater with single-point water heaters than any other appliance type. These appliances have risk values well above what would normally be considered as, the "broadly accepted region" of HSE's criteria for the tolerability of risk (1×10^{-6}). Historically water heaters have been recognised as a major problem in the past and this led to changes in safety requirements and initiatives to replace potentially unsafe appliances. Problems were particularly due to their unflued use, their use in bathrooms and from a lack of servicing. Numbers of these appliances in use has decreased in recent years, as has the number of people at risk, however the FPPY is expected to remain high.

The majority of non-fatal casualties involved central heating boilers. The number of non-fatal casualties associated with all central heating appliances is nearly forty times the number of fatalities. This is not dissimilar to results shown in BG historical data. But for space heaters and cookers the ratio is nearer 3 to 1. This is in line with last years results.

Many appliances featuring in the incidents this year, as in other years, feature incorrect ventilation, poor flueing and a lack of servicing.

The information given on the central heating boilers shows that flueing and ventilation faults were common and that flue and heat exchanger blockage was also a cause of incidents.

In most instances featuring cookers it was the grill burner that was the cause of incidents.

3.6 SAFETY DEVICES

There was one incident where a CO alarm had been noted. It was operational and when tested it alarmed 15 minutes after the faulty grill was turned on. The casualties were in the kitchen and had low levels of COHb. This was probably due to the use of the grill before the alarm activated. The faulty vitiation device on the dripping water heater permitted vitiation to take place. The heater was kept in operation due to a constant drip from the tap.

3.7 FLUE DETAILS

As in previous years the most significant point to be noted is that the majority of incidents involved open flue appliances (80%). There were found to be 46% of all flues that were not installed to appropriate standards and 43% of all incidents where the flue had an installation defect. Flue blockage had also taken place in 10 (10%) of the incidents.

The second most common flue type involved with CO incidents were room sealed, individual fanned draught flues. There were 4 incidents involving this type of configuration. Three were Potterton Netaheat boilers and the other was a Thorn Apollo Fanfare. There were 2 incidents involving natural draught room sealed boilers. One was a Chaffoteaux and the other was a Glow Worm Spacesaver. Further details are given in Appendix B under "Wall mounted boilers".

3.8 PERMANENT VENTILATION

During the period for most incidents the permanent ventilation required had not been provided, or if it was provided it had not been to current standards or had become restricted. Such factors can affect flue performance and in combination with other faults are generally acknowledged to contribute towards the causes of CO incidents.

As a common fault at incident sites this is an item that can be improved by continued customer awareness campaigns and during routine servicing.

3.9 ON-SITE CHECKS

When investigated it was found that often there were similar faults on the appliance i.e. the appliance was spilling products and had a high CO/CO2 ratio, the heat exchanger was partially or fully blocked, there was a defective flame picture and linting had also taken place, were the most common. To a lesser extent almost all of the faults listed on the DIDR form have taken place somewhere and have been discovered during an investigation.

3.10 INSTALLATION DETAILS

There were only a few appliances that had not been installed correctly and to the relevant standards. Only a very few incident appliances had been installed second-hand. But in the majority of incidents information was not forthcoming on where the appliance was bought and who fitted the appliance.

3.11 INCIDENT APPLIANCE HISTORY

Where information was given it appears that 13 of the incident appliances had been regularly serviced by CORGI registered fitters and in total 15 incident appliances were regularly serviced. A combination of factors was present at most incident sites with several separate occurrences probably leading to the production of CO. In 2 incidents the appliance had been inspected following reports of fumes spillage and at 12 incidents it is reported that the occupants had experienced symptoms typically associated with CO poisoning.

4 SUMMARY

4.1 The number of domestic related CO poisoning deaths reported, at 22 during 1997/98, was in line with previous trends.

4.2 The majority of all CO poisoning deaths involved domestic open flued appliances.

4.3 Space heating appliances were responsible for the majority of deaths.

4.4 The total FPPY figure of 0.48×10^{-6} is within, what would normally be considered as, the "broadly accepted region" of HSE's criteria for the tolerability of risk. However, societal concerns over gas safety override averaged numerical considerations.

4.5 The appliance types that were above the HSE's criteria for the tolerability of risk are single-point water heaters (8.78×10^{-6}).

4.6 Central heating appliances were responsible for the majority of casualties.

4.7 The majority of casualties are located in the bedroom and living room.

4.8 There was an above average risk of a CO incident in domestic properties built before 1946 and also in tenanted accommodation that was privately owned.

4.9 Flueing and ventilation faults were common in many domestic incidents.

4.10 Whilst it has often been suggested that annual appliance servicing could help prevent the majority of domestic incidents it has not possible to support or refute that conclusion from the data presented in this report.

4.11 There was one LPG incident reported during 1997/98.

4.12 Reports on four non-domestic incidents were submitted and analysed during 1997/98.

5 CONCLUSIONS

Analysis of the CO incident statistics, collected from the Downstream Incident Data Report form, have produced results in line with previous years results. The analysis identifies the most common faults found at incidents. This information can be used to improve customer safety, target expenditure on CO incident prevention and further research work.

6 RECOMMENDATIONS

6.1 The continuing importance of collecting and analysing incident statistics needs to be stressed. Without this data the risks associated with appliances, installations etc, cannot be accurately assessed and acted upon.

6.2 The data should be made available to all interested parties, i.e. those concerned with the safety, transportation and supply of gas and also those involved in the installation and maintenance of gas appliances.

7 DATA USED AND REFERENCES

7.1 DATA USED

7.1.1 Appliance Population Statistics - Statistics for Great Britain provided by GfK Marketing Services Ltd., Sheer House, Station Approach, West Byfleet, Surrey KT14 6NL.

7.1.2 Historical Incident Data - BG Technology database.

7.1.3 Number of Natural Gas Customers - Best estimates, for Great Britain, obtained from BG Group plc company records.

7.1.4 Population & Housing Statistics for Great Britain - The size of the average household has been calculated from figures produced by the Office for National Statistics and published in the Annual Abstract of Statistics.

7.2 REFERENCES

7.2.1 Definitions of FPPY, CPPY and IPPY - BG Technology Reports.

APPENDIX A DEFINITIONS AND THE USE OF FPPY, IPPY AND CPPY VALUES

a) Fatalities Per Person Per Year (FPPY)

FPPY is a measure of the risk of death from owning a specific appliance type.

FPPY is defined as:-

$$FPPY = \frac{\text{Number of Fatalities}}{\text{Number of people at risk x Appliance Population}}$$

Notes:

1) In the report the number of people at risk is taken as the average number of people per household (2.43 in 1996/7). - provided from Government Statistics - see report section 7.

2) The "Overall FPPY" is calculated, as above, except that "Appliance Population" is replaced by the number of customers - see report section 7.

3) The appliance population figures used have been taken from information provided by GfK Marketing Services - see report section 7.

b) Incidents Per Person Per Year (IPPY)

IPPY is a measure of the risk of having an accident with a specific appliance type.

IPPY is defined as:-

$$IPPY = \frac{\text{Number of Incidents}}{\text{Number of people at risk x Appliance Population}}$$

c) Casualties Per Person Per Year (CPPY)

CPPY is a measure of the risk of being injured by owning a specific appliance type.

CPPY is defined as:-

$$CPPY = \frac{\text{Number of Casualties}}{\text{Number of people at risk x Appliance Population}}$$

APPENDIX B TABLES, BY APPLIANCE TYPE, SHOWING THE NUMBER OF FAULTS AND INDIVIDUAL INCIDENT DETAILS

Table B1 shows the tables included in this appendix. They have been completed for the appliance groups only where there were relevant incident appliances to describe.

The nomenclature adopted allows data to be presented for any of the appliance groups. This has the advantage that tables with the same code may be readily identified, which can aid the comparison on a year-by-year basis. However, groups may not have been implicated in incidents in any particular year, so they are indicated in this appendix as "no reported incident".

The appliance groups have been ordered in the same way as section 2.5.2 of the report.

Table B1 – Summary of incident fault analysis and summary tables presented

Appliance group	Appliance sub-group	Code	Incidents	Appendix tables
Central Heating Boilers	Back unit	1.1	6	B.1.1a & b
	Floor standing	1.2	14	B.1.2a & bi & bii
	Floor standing combi	1.3	0	*No reported incident*
	Thermal storage unit	1.4	0	*No reported incident*
	Wall mounted	1.5	33	B.1.5a & bi-iv
	Wall mounted combi	1.6	15	B.1.6a & bi & bii
	Warm air unit	1.7	2	B.1.7a & b
Cookers	Free standing	2.1	6	B.2.1a & b
	Built-in oven	2.2	0	*No reported incident*
	Built-in hob	2.3	0	*No reported incident*
Space Heaters	Balanced flue g .f.	3.1	0	*No reported incident*
	Cabinet heater	3.2	0	*No reported incident*
	Decorative g .f.	3.3	0	*No reported incident*
	Flueless heater	3.4	0	*No reported incident*
	Inset live fuel effect g .f.	3.5	1	B.3.5a & b
	Rad. & rad. con. g .f.	3.6	15	B.3.6a & bi & bii
	Wall heater	3.7	0	*No reported incident*
Dryers	Tumble Dryers	4.1	0	*No reported incident*
Water Heaters	Bulk storage	5.1	0	*No reported incident*
	Circulator	5.2	1	B.5.2a & b
	Multi-point	5.3	0	*No reported incident*
	Single-point	5.4	4	B.5.4a & b

In addition, these codes have been used within the tables in this appendix :

Table B12 – Appliance location and flue type codes

Appliance location	Code	Flue type	Code
Other	0	Other	0
Attic	1	RS/Indiv/Natural draught/BF	1
Bathroom	2	RS/Indiv/Fanned draught	2
Bedroom	3	RS/Shared/Se-duct	3
Bedsit	4	RS/Shared/U-duct	4
Cellar	5	Open/Indiv/Natural draught	5
Dining Room	6	Open/Indiv/Fanned/Integral	6
Utility Room	7	Open/Indiv/Fanned/Add on	7
Garage	8	Open/Shared/Natural draught	8
Hall	9	Open/Shared/Fanned draught	9
Kitchen	10	Closed	10
Landing	11	Flueless	11
Living Room/Lounge	12	Unbalanced	12
Shower room	13		

B.1 CENTRAL HEATING BOILERS

B.1.1 BACK BOILER UNIT

Table B.1.1a - Central heating boilers : back boiler unit : Summary fault analysis

number of incidents=6

Fault group	Number of faults	Fault group	Number of faults
Burner		**Incident testing**	
Corrosion	0	High CO/CO_2 ratio	1
Defective flame picture	1	Failed spillage test	4
Linting	3	Overrated	0
Over-pressure	0	Underrated	1
Under-pressure	1	**Terminal**	
Other	1	Down draught	0
Flue		Bad siting	0
Blockage	0	Unapproved design	0
Corrosion	0	Other	0
Flue not to any standard	1	**Ventilation**	
Installation defect	1	Air vent/vents ineffective	4
Other	1	Air vents obstructed - intentionally	4
Heat exchanger		Air vents obstructed - unintentionally	0
Blockage - shale	1	Compartment/cupboard not to any standards	0
Blockage - soot	5	No permanent ventilation provided	1
Cracked	0	Ventilation provided was not to any standard	2
Other	0	**Miscellaneous**	
Safety device		Local topography	0
Failed CO alarm	0	Weather	1
Failed down draught detector	0	Signs of spillage	2
Failed vitiation device	0		

Table B.1.1b - Central heating boilers : back boiler unit : incident summary

Post Code	Number of casualties: fatal (non-fatal)	Appliance age (yrs)	Appliance location	Installer	Flue to standards	Ventilation to standards	Appliance make & model	Flue type	Fault
G45	0 (11)	7	12	Unknown	Current		Baxi Bermuda 401	5	When tested no appliance faults found, the appliance had been serviced before investigation took place. Most likely cause was CO from the BBU and either spillage from the draught diverter or leakage from the base of the combustion chamber due to soot blocking the heat exchanger. The ventilation was sub-standard and performance may have been affected by a ceiling mounted recirculation fan. Weather was bad on day of incident.
RG31	0 (4)	27	12	Unknown	Current	Current	Potterton Fireside FS 51/52 13E	5	Boiler heat exchanger had been partially blocked by soot, and appliance cleaned before investigation took place. Most likely the soot caused products to spill from below the combustion chamber into the room. It was found that there was a misaligned injector, which may well have reduced the appliance's tolerance between service visits causing deterioration of the combustion process earlier than expected. The replacement burner improved the performance of the appliance.
HA4	0 (2)		12	Unknown	Current	Current	Baxi Bermuda 551 BBU	5	The flue was not clearing the products correctly. Lack of servicing had allowed heat exchanger to become restricted. This affected the combustion leading to high levels of CO in the products. Ventilation for appliance was blocked.
W14	0 (1)		12	Unknown	Current		Baxi Bermuda 552	5	The back boiler unit was incorrectly installed and was not fully clearing its products. No ventilation provided. Fault around chimney stack.
C02	0 (2)	35	12	Unknown		Current	Baxi Bermuda 372	5	BBU needed servicing and was producing high levels of CO . Heat exchanger severly restricted by soot. Air vent completely restricted by cardboard. Flue not clearing all of the products of combustion and not installed to current standards.
ST2	0 (6)		12	Unknown	Current		Glow worm Capricorn 240/6	5	The BBU was in need of servicing and boiler heat exchanger was blocked by soot preventing products of combustion from passing through the heat exchanger. The BBU produced high levels of CO from the boiler and caused vitiation of the burner.

B.1.2 FLOOR STANDING BOILER

Table B.1.2a - Central heating boilers : floor standing boiler : Summary fault analysis

number of incidents=14

Fault group	Number of faults	Fault group	Number of faults
Burner		**Incident testing**	
Corrosion	0	High CO/CO_2 ratio	11
Defective flame picture	4	Failed spillage test	3
Linting	7	Overrated	2
Over-pressure	3	Underrated	0
Under-pressure	0	**Terminal**	
Other	2	Down draught	4
Flue		Bad siting	7
Blockage	1	Unapproved design	0
Corrosion	0	Other	0
Flue not to any standard	9	**Ventilation**	
Installation defect	9	Air vent/vents ineffective	2
Other	0	Air vents obstructed - intentionally	1
Heat exchanger		Air vents obstructed - unintentionally	0
Blockage - shale	4	Compartment/cupboard not to any standards	4
Blockage - soot	4	No permanent ventilation provided	3
Cracked	0	Ventilation provided was not to any standard	7
Other	3	**Miscellaneous**	
Safety device		Local topography	0
Failed CO alarm	0	Weather	8
Failed down draught detector	0	Signs of spillage	2
Failed vitiation device	0		

Table B.1.2bi - Central heating boilers : floor standing boiler : incident summary

Post Code	Number of casualties: fatal (non-fatal)	Appliance age (yrs)	Appliance location	Installer	Flue to standards	Ventilation to standards	Appliance make & model	Flue type	Fault
W14	2 (0)		10	Unknown		Current	Ideal Mexico Super CF 30/40	5	The c/h boiler was in need of service and was producing high levels of CO . The flue system had a poorly sited terminal outlet. At the time of the investigation it was not possible to reproduce high levels of CO within the room at a level required to cause death. The performance of the flue was affected by wind velocity and direction.
LU5	0 (2)		10	Unknown			Potterton Kingfisher CF55	5	The c/h boiler was producing high levels of CO , which were leaking into the property due to flue downdraught and an incorrectly fitted flue hood cover. The flue was sub standard, as was the ventilation. The appliance was in need of servicing.
B17	0 (1)		5	Unknown	Current when installed	Current	Potterton Kingfisher CF80	5	Boiler had flue defects and was producing high levels of CO . At time of investigation, spillage was not proven to be taking place - boiler was likely to be subject to spillage.
NW2	0 (1)		10	Unknown	Current		Potterton Kingfisher II	1	The room sealed boiler was producing high levels of CO due to a lack of servicing. No evidence of leakage into the property of any products at time of investigation.
HX2	0 (3)	25	5	Unknown			Potterton Dipolmat 41/48	5	The appliance was producing high levels of CO and was in need of servicing.the heat exchanger was partially blocked by soot and products were spilling from the base of the combustion chamber. Boiler flue unsatisfactory. No permanent ventilation provided.
KY8	0 (3)		10	Unknown			Glow Worm Hideaway 60	5	Boiler flue terminal was not to an acceptable standard and would be pressurised under some wind conditions and lead to spillage. No ventilation was provided to kitchen. The boiler needed servicing, but only 130ppm of CO was being produced. Continual spillage would have needed to occur and the atmosphere to be vitiated to cause the high level of CO experienced at the property.
SW11	0 (4)		10	Unknown			Potterton Kingfisher	5	A c/h boiler produced high levels of CO . The flue position was incorrect and could lead to downdraught - it was not to correct standards. Appliance ventilation was sub-standard. Adverse weather could cause downdraught.

Table B.1.2bii - Central heating boilers : floor standing boiler : incident summary

Post Code	Number of casualties: fatal (non-fatal)	Appliance age (yrs)	Appliance location	Installer	Flue to standards	Ventilation to standards	Appliance make & model	Flue type	Fault
SL8	0 (2)	10	7	CORGI			Glow Worm Hideaway 120	5	The cold static weather conditions had provided no flue lift & due to lack of ventilation the flue was further impeded in its operation. The restricted air movement in the compartment is likely to have led to vitiation and high levels of CO production, which then entered the property.
OX7	0 (2)	13	9	CORGI	Current when installed		Potterton Kingfisher CF50	5	Flue pipe blocked by corrosion products from the stainless steel flue liner, which was extensively corroded, and debris that entered the flue after the wall failed. A build up of fine particles on the heat exchanger led to high levels of CO in the combustion products.
M9	0 (2)	10	10	CORGI	Current when installed		Glow Worm Hideaway 60	5	Following fitting of a cupboard around the boiler the air routes were against British Standards recommendations. Cross flow may have ocurred taking flue products into th e property.
CV34	0 (4)		9	Unknown			Potterton Kingfisher CF55R	5	Could not prove CO was being produced by the boiler. Also not proven family suffered CO as no blood tests taken by hospital. Flueing and ventilation were sub-standard.
MK41	0 (2)	16	9	Unknown	Current		Potterton Kingfisher CF50	5	The boiler was producing high levels of CO due to being over-rated. CO entered the property as the flue was not clearing the products satisfactorily. Ventilation was not to standards.
SO30	0 (4)		10	Unknown			Potterton Kingfisher CF50	5	The boiler required servicing and was found to be producing high levels of CO . It was over-rated. The flueing and ventilation were not to current standards.
CT16	0 (5)	17	7	Unknown		Current	Potterton Kingfisher CF50	5	The boiler was in need of servicing and was producing high levels of CO . The terminal position was substandard and under certain weather conditions spillage may have taken place.

B.1.3 FLOOR STANDING COMBI – NO REPORTED INCIDENT

B.1.4 THERMAL STORAGE UNITS – NO REPORTED INCIDENT

B.1.5 WALL MOUNTED BOILER

Table B.1.5a - Central heating boilers : wall mounted boiler : Summary fault analysis

number of incidents=33

Fault group	Number of faults	Fault group	Number of faults
Burner		**Incident testing**	
Corrosion	1	High CO/CO_2 ratio	26
Defective flame picture	8	Failed spillage test	14
Linting	19	Overrated	3
Over-pressure	4	Underrated	1
Under-pressure	1	**Terminal**	
Other	6	Down draught	7
Flue		Bad siting	8
Blockage	1	Unapproved design	1
Corrosion	0	Other	2
Flue not to any standard	17	**Ventilation**	
Installation defect	16	Air vent/vents ineffective	8
Other	0	Air vents obstructed - intentionally	3
Heat exchanger		Air vents obstructed - unintentionally	3
Blockage - shale	5	Compartment/cupboard not to any standards	8
Blockage - soot	13	No permanent ventilation provided	5
Cracked	0	Ventilation provided was not to any standard	15
Other	11	**Miscellaneous**	
Safety device		Local topography	3
Failed CO alarm	0	Weather	12
Failed down draught detector	0	Signs of spillage	15
Failed vitiation device	0		

Table B.1.5bi - Central heating boilers : wall mounted boiler : incident summary

Post Code	Number of casualties: fatal (non-fatal)	Appliance age (yrs)	Appliance location	Installer	Flue to standards	Ventilation to standards	Appliance make & model	Flue type	Fault
ST7	0 (2)		9	Unknown	Current	Current	Glow Worm Fuelsaver 30R MK2	5	Appliance was producing high levels of CO and had several faults:excessive main burner pressure; faulty pilot burner which had been enlarged resulting in overgassing; partially resistricted heat exchanger - blocked by soot.
WG7	0 (3)	3	9	Unknown		Current	Glow Worm Economy Plus EP300	5	The c/h boiler required servicing and was producing high levels of CO . Flue installation sub-standard due to poor terminal position, which is likely to have led to downdraught under certain weather conditions.
ST5	0 (2)	8	10	Unknown	Current		Glow Worm Fuelsaver MK2 40	5	COHb had been proven and the boiler was most likely source. Having been tested and cleaned before investigation it is unclear if it had been producing high levels of CO . Ventilation undersized. Cold weather may have reduced flue performance and led to spillage. Spillage was indicated within the appliance.
NR18	0 (5)		10	Unknown			Ideal WLX CF40	5	The boiler was in poor condition and requiried servicing. It produced high levels of CO , some of which was spilling from the base of the heat exchanger. Ventilation was inadequate. At time of testing could not get a high level of CO build up in the room.
L62	1 (0)	8	10	Unknown	Current		Potterton Netaheat MKIII 10/16	2	The boiler was producing high levels of CO in property due to an incorrectly fitted case.
L65	0 (5)		9	Unknown	Current		Worcester Heatslave	5	It was not possible during the investigation to associate any of the gas appliances with the CO poisoning. The compartment ventilation could affect flue performance in some weather conditions, which may have occurred on the day of the incident when there were severe s-w winds. Flue reversal may have occurred.
OL15	0 (1)	21	10	Unknown	Current		Potterton Netaheat 10/16 MKII	5	Products of combustion containing high levels of CO were leaking from case seal of a room sealed c/h boiler due to the boilers buckled back plate, likely to have been a recent occurrance.
E43	0 (1)	6	9	Unknown			Glow Worm Fuelsaver 50R Mark2	5	Boiler in need of servicing and was producing high levels of CO . Fluein g and ventilation were sub-standard and may have affected flue performance under some weather conditions.

Table B.1.5bii - Central heating boilers : wall mounted boiler : incident summary

Post Code	Number of casualties: fatal (non-fatal)	Appliance age (yrs)	Appliance location	Installer	Flue to standards	Ventilation to standards	Appliance make & model	Flue type	Fault
LU4	0(5)	3	10	CORGI	Current	Current	Glow Worm Fuelsaver MKII 30R	5	The boiler was in poor condition and in need of servicing. Got intermittent spillage, may have spilled under certain conditions due to flue reversal and due to soot blockage of the heat exchanger.
GU25	0 (4)		10	Unknown	Current		Glow Worm Fuelsaver MKII CF 50	5	The c/h boiler was producing high levels of CO due to over set burner pressure and it's need of a service. An extract fan caused spillage when in use. No ventilation had been supplied for the c/h boiler.
OX15	0 (2)	13	9	Unknown	Current		Thorn Apollo 15/30C	5	A central heating boiler was producing high levels of CO due to poor maintenance. It was also over-rated. There was indication of spillage occurring over a long period of time. Ventilation was sub-standard.
HP3	0 (2)	11	12	Unknown			Potterton Flamingo 20-30 CF	5	The c/h boiler was producing high levels of CO due to its poor condition. Flue was not to manufacturers specifications and was not clearing the combustion products satisfactorily. Purpose provided ventilation to boiler room had been blocked.
PE2	0 (5)	8	10	Unknown	Current when installed		Myson Apollo 15/30C	5	The central heating boiler was producing high levels of CO . It was in poor condition and in need of servicing. Flue not clearing all the combustion products. Flue termination sub-standard. No purpose provided ventilation. Boiler modified to work without an overheat protection thermostat.
SW15	0 (2)	15	10	Unknown	Current	Current	Thorn Apollo 15/30C	5	Due to partial flue blockage, combustion products were not cleared completely. Appliance was producing high levels of CO due to restriction in the heat exchanger.
ST14	0 (2)	6	10	DIY			Glow Worm Fuelsaver MK2 40R	5	The central heating boiler was producing high levels of CO . Flue system poorly installed and not to standards. No ventilation was provided.
SG14	0 (4)	10	10	Unknown		Current	Glow Worm Fuelsaver 30 MKII	5	Central heating boiler was producing high levels of CO . This was due to heat exchanger restriction & lack of servicing, flue not fully cleaning products & not to standards. Ventilation was restricted.

Table B.1.5biii - Central heating boilers : wall mounted boiler : incident summary

Post Code	Number of casualties: fatal (non-fatal)	Appliance age (yrs)	Appliance location	Installer	Flue to standards	Ventilation to standards	Appliance make & model	Flue type	Fault
BH12	0 (5)		10	Unknown			Glow Worm Fuelsaver MK2 50R	5	The boiler was producing high levels of CO and was in need of servicing. The flue and ventilation were not to standards and manufacturers instructions. With intermittent spillage and poor combustion probable that under certain weather conditions CO would enter the property.
NG3	0 (2)	8	10	Unknown		Current	Glow Worm Fuelsaver 30R MK2	5	The boiler was producing high levels of CO and was in need of servicing. Flue installation sub-standard and could have led to downdraught under certain weather conditions.
SA3	0 (2)			DIY			Thorn Apollo 15/30C	5	The c/h boiler was producing high levels of CO due to ineffective servicing. Ventilation and the flue system were sub-standard.
L14	0 (2)		10	Unknown		Current	Glow Worm Fuelsaver MK2	5	The boiler was spilling products of combustion. It was in poor condition, with an ineffective flue which was sub-standard. It was in need of servicing and the ventilation grilles were blocked.
C04	0 (3)	22	10	Unknown	Current		Potterton Netaheat 10/16	2	The fan flued, room sealed c/h boiler was producing high levels of CO . The boiler is of the internally pressurized type and the casing was loose due to one missing case screw and the remaining 3 being loosely fitted. This allowed CO into the property where high levels of CO built up.
M34	0 (3)		10	Unknown	Current	Current	Chafoteaux Challenger 40 BF	1	Customer misuse of casing on room sealed boiler caused CO escape
CA28	0 (1)		10	Unknown	Current		Glow Worm Spacesaver 45-60B	1	Poor case seal on boiler allowed products of combustion into the property which contained small levels of CO . Property on coast facing west winds which blew onto b/f terminal and pressurised it and thence the boiler case.
KY3	0 (2)	10	11	Unknown	Current		Glow Worm Fuelsaver 40-50	5	The boiler required servicing and was producing high levels of CO . The flue was not clearing the products of combustion satisfactorily.

Table B.1.5biv - Central heating boilers : wall mounted boiler : incident summary

Post Code	Number of casualties: fatal (non-fatal)	Appliance age (yrs)	Appliance location	Installer	Flue to standards	Ventilation to standards	Appliance make & model	Flue type	Fault
EH12	0 (1)	11	3	Unknown			Glow Worm Fuelsaver	5	The flueing and ventilation were not to standard. The boiler required servicing and was producing high levels of CO .
SS7	0 (2)		7	Unknown			Ideal WCF 460	5	The boiler was producing high levels of CO and needed servicing. Flue and ventilation were not to standards.
EH26	0 (1)		10	Unknown	Current		Thorn Apollo Fanfare 15/30	2	Boiler had a fault with its case seal. It was producing high levels of CO , via leak in missing case seal, into the property.
RM6	0 (4)		10	Unknown			Glow Worm Fuelsaver MK2 OF 50	5	The boiler was producing high levels of CO and was in need of servicing. The ventilation and flue were not to standards. Possible that flue reversal took place due to use of a solid fuel boiler.
KA26	0 (2)		10	Unknown	Current		Baxi WM552 OF	5	The boiler was producing high levels of CO and was in need of servicing. No ventilation was provided and products were spilling into the property due to restriction in the heat exchanger.
WN2	0 (2)	8	10	CORGI			Glow Worm Fuelsaver MK2	5	The boiler was producing high levels of CO and required servicing. Flueing and ventilation was sub-standard. No spillage measured at time of investigation, but on day of incident severe weather may have led to spillage.
BN13	0 (2)		10	Unknown		Current	Potterton Flamingo	5	CO was produced due to an obstruction to the burner. The flue was substandard and the terminal was damaged. This led to flue performance being unsatisfactory.
RH20	0 (2)		10	Unknown			Potterton Flamingo	5	The flue was substandard and with the high winds on the day of the incident it may have resulted in flue reversal and vitiation taking place. There was also inadequate ventilation to the compartment.
NG5	1 (1)	10	7	Unknown			Glow Worm Fuelsaver 50MK2	5	The flue installation was substandard and signs indicated downdraught may have taken place under certain weather conditions. The ventilation was substandard. The boiler was producing high level of CO due to lack of servicing which lead to blockage of the heat exchanger.

B.1.6 WALL MOUNTED COMBI BOILER

Table B.1.6a - Central heating boilers : wall mounted combi boiler : Summary fault analysis

number of incidents=15

Fault group	Number of faults	Fault group	Number of faults
Burner		**Incident testing**	
Corrosion	0	High CO/CO_2 ratio	11
Defective flame picture	2	Failed spillage test	5
Linting	6	Overrated	1
Over-pressure	2	Underrated	2
Under-pressure	1	**Terminal**	
Other	2	Down draught	3
Flue		Bad siting	7
Blockage	0	Unapproved design	0
Corrosion	1	Other	0
Flue not to any standard	10	**Ventilation**	
Installation defect	10	Air vent/vents ineffective	3
Other	0	Air vents obstructed - intentionally	3
Heat exchanger		Air vents obstructed - unintentionally	0
Blockage - shale	4	Compartment/cupboard not to any standards	3
Blockage - soot	2	No permanent ventilation provided	4
Cracked	0	Ventilation provided was not to any standard	8
Other	6	**Miscellaneous**	
Safety device		Local topography	0
Failed CO alarm	0	Weather	8
Failed down draught detector	0	Signs of spillage	2
Failed vitiation device	0		

Table B.1.6bi - Central heating boilers : wall mounted combi boiler : incident summary

Post Code	Number of casualties: fatal (non-fatal)	Appliance age (yrs)	Appliance location	Installer	Flue to standards	Ventilation to standards	Appliance make & model	Flue type	Fault
NW6	0 (2)		10	Unknown			Vaillant VCW 20/1 T3 WH	5	The c/h boiler was producing high levels of CO due to a lack of adequate servicing. This entered the property due to a sub-standard flue system. The ventilation was also sub-standard.
UB1	1 (0)		10	Unknown	Current		Vokera 21-84 MCF	6	Boiler was tested and found to operate satisfactorily at time of investigation. No ventilation provided for the boiler. Weather conditions could affect the performance of the boiler with the air pressure switch disconnected. With this fault the burner could operate without the flue clearing the products and CO could quickly build up in the premises. No other occupants suffered effects of CO , including those nearer the appliance.
BS11	0 (1)		9	Unknown			Worcester 9-24 Electronic Combi OF	5	When operated at the full gas rate, and due to a lack of servicing, the appliance was producing high levels of CO due to heat exchanger blockage by deposits. It is likely that a lack of combustion ventilation led to vitiation during downdraught conditions. There was no provision of combustion air from o/s the property and the flue terminal position was not to standards.
B17	0 (2)		10	Unknown		Current	Ferroli Combi 76 CF	5	The c/h boiler was producing some CO , but during testing no spillage was proven. The heat exchanger was partially restricted by minor amounts of debris. This caused baffling back of products that affected the combustion process. The flue installation was sub-standard and spillage may well have taken place on the day of the incident due to this.
TW5	0 (5)		10	Unknown			Vaillant VCW 25/1 T3 WH	5	The c/h boiler had been incorrectly installed and was producing high levels of CO due to lack of servicing. No combustion ventilation was provided. It was fitted to an incorrectly installed and poorly sited flue system, which was affected by wind velocity and direction.
SE20	0 (1)		10	Unknown			Vokera 18-72 DMCF Combi	5	The c/h boiler had not been correctly installed and required servicing. This resulted in high levels of CO being produced by boiler and intermittent flue spillage during adverse wind conditions. Ventilation and flue system were sub-standard. Flue performance would have been adversely affected by s-w wind.
UB2	0 (4)	13	10	Unknown			Vaillant VCW 20/1 T3W	5	The boiler was producing high levels of CO . The majority of combustion products were spilling from the base of the combustion chamber due to blockage of the heat exchanger. Also inadequate ventilation and the flue was not installed to current standards.

Table B.1.6bii - Central heating boilers : wall mounted combi boiler : incident summary

Post Code	Number of casualties: fatal (non-fatal)	Appliance age (yrs)	Appliance location	Installer	Flue to standards	Ventilation to standards	Appliance make & model	Flue type	Fault
CA1	0 (1)		9	Unknown	Current		Vaillant VCW GB 240H	5	Products of combustion were entering property from the c/h boiler. No ventilation provided and under certain conditions spillage was taking place.
OX1	0 (3)		9	Unknown		Current	Vaillant VCW 25/1 T3 WH	5	An open-flued boiler was producing high levels of CO due to poor maintenance. The terminal was poorly sited and under certain weather conditions spillage may have taken place. To a lesser extent damage to the burner was having an adverse affect on the performance of the appliance.
B55	0 (3)	11	10	Unknown			Vaillant VCW 20/1 T3 WH	5	Under some weather conditions flue would spill. Flue not terminating to acceptable position and affected by wind. Boiler producing high levels of CO due to partially blocked heat exchanger. Ventilation was undersized.
RG2	0 (2)		10	Unknown		Current	Vaillant Combi VCW 25/1 T3 WH	5	The c/h boiler needed servicing and the heat exchanger was 50% blocked with verdigris and debris. It was most likely to be producing high levels of CO . Flue was sub-standard and terminated in a wall adjacent position.
M7	0 (4)	9	5	Unknown			Saunier DuvalSD 235C	5	The boiler was not proven as a source of CO during the investigation. Ventilation and flueing were sub-standard. It is possible that under some wind conditions the flue could spill products of combustion into the property.
YO25	0 (1)	6	9	Unknown	Current		Ocean OF	5	The c/h boiler provided source of CO due to incomplete combustion as a result of a restricted heat exchanger and damaged burners. Rivit joint failure of the draught diverter front & rear sections allowed products of combustion to leak into the property. Most likely scenario was rivits failed, parts of flue diverter fell down and obstructed the top of the heat exchanger. Passage of flue products obstructed and may have caused products to baffle back. Reflected heat could have damaged the burner.
WV2	0 (3)		6	Unknown	Current		Vaillant VCW20/1 T3WH	5	Lack of servicing and combustion ventilation, with signs of spillage on inside of casing indicate CO was passing into property and not being cleared by the flue.
WS2	0 (9)		10				Vaillant Combi VCW BG 240H OF	5	The boiler was producing high levels of CO which entered the property. Main fault was the burner was over pressure / over-rated. Flueing and ventilation were not to standards.

B.1.7 WARM AIR UNIT

Table B.1.7a - Central heating boilers : warm air unit : Summary fault analysis

number of incidents=2

Fault group	Number of faults	Fault group	Number of faults
Burner		**Incident testing**	
Corrosion	0	High CO/CO_2 ratio	2
Defective flame picture	1	Failed spillage test	1
Linting	1	Overrated	1
Over-pressure	0	Underrated	0
Under-pressure	0	**Terminal**	
Other	0	Down draught	0
Flue		Bad siting	0
Blockage	0	Unapproved design	0
Corrosion	0	Other	0
Flue not to any standard	1	**Ventilation**	
Installation defect	1	Air vent/vents ineffective	0
Other	0	Air vents obstructed - intentionally	0
Heat exchanger		Air vents obstructed - unintentionally	0
Blockage - shale	0	Compartment/cupboard not to any standards	2
Blockage - soot	1	No permanent ventilation provided	1
Cracked	0	Ventilation provided was not to any standard	1
Other	0	**Miscellaneous**	
Safety device		Local topography	0
Failed CO alarm	0	Weather	0
Failed down draught detector	0	Signs of spillage	0
Failed vitiation device	0		

Table B.1.7b - Central heating boilers : warm air unit : incident summary

Post Code	Number of casualties: fatal (non-fatal)	Appliance age (yrs)	Appliance location	Installer	Flue to standards	Ventilation to standards	Appliance make & model	Flue type	Fault
LU3	0 (3)	5	9	Unknown			Halstead GNA 46W	5	The warm air unit/circulator was creating high levels of CO and was connected to a blocked flue causing CO to enter the property. No permanent ventilation supplied. Heater not fitted to manufacturers specifications. Appliance required servicing. The flue had been built incorrectly.
CR0	0 (5)		12	Unknown			McClary Economaire BGS 30/RCF	5	The warm air heater was producing high levels of CO due to need for servicing. The flue had become separated allowing products into the property. Ventilation requirements & flue termination not to standards.

B.2 COOKERS

B.2.1 FREE STANDING

Table B.2.1a - Cookers : free standing : Summary fault analysis

number of incidents=6

Fault group	Number of faults	Fault group	Number of faults
Burner		**Incident testing**	
Corrosion	0	High CO/CO_2 ratio	2
Defective flame picture	3	Failed spillage test	0
Linting	2	Overrated	0
Over-pressure	0	Underrated	0
Under-pressure	0	**Terminal**	
Other	3	Down draught	0
Flue		Bad siting	0
Blockage	0	Unapproved design	0
Corrosion	0	Other	0
Flue not to any standard	0	**Ventilation**	
Installation defect	0	Air vent/vents ineffective	0
Other	0	Air vents obstructed - intentionally	0
Heat exchanger		Air vents obstructed - unintentionally	0
Blockage - shale	0	Compartment/cupboard not to any standards	0
Blockage - soot	0	No permanent ventilation provided	0
Cracked	0	Ventilation provided was not to any standard	0
Other	0	**Miscellaneous**	
Safety device		Local topography	0
Failed CO alarm	0	Weather	0
Failed down draught detector	0	Signs of spillage	0
Failed vitiation device	0		

Table B.2.1b - Cookers : free standing : incident summary

Post Code	Number of casualties: fatal (non-fatal)	Appliance age (yrs)	Appliance location	Installer	Flue to standards	Ventilation to standards	Appliance make & model	Flue type	Fault
N16	1 (0)		10	Unknown			Newhome Cabaret	11	The gas fired grill on the cooker was creating high levels of CO into the property. This was due to the poor condition of the grill.
IP1			10	Unknown			Leisure Star	11	The gas cooker was in poor condition resulting in poor combustion at dangerous levels in the kitchen
AL7	0 (1)		10	Unknown			New World Flair	11	The gas cooker gave off moderate levels of CO, over extended periods, as used to heat kitchen area & due to it's poor service condition.
CF3	1 (0)	20	10	Unknown			Parkinson Cowan1100 deluxe	11	The grill on the cooker was producing high levels of CO.
M14	2 (0)		10	Unknown			New World Contrast Elite	11	The cooker was in poor condition and producing high levels of CO. It was in need of servicing.
KT1	0 (2)		10	Unknown			Parkinson Cowan1900 De Luxe Automatic	11	The grill burner of the gas cooker was left on for 6.5 hours and may have been responsible for the incident if combustion had deteriorated.

B.2.2 BUILT-IN OVEN – NO REPORTED INCIDENT

B.2.3 BUILT-IN HOB – NO REPORTED INCIDENT

B.3 SPACE HEATERS

B.3.1 BALANCED FLUE GAS FIRE – NO REPORTED INCIDENT

B.3.2 CABINET HEATER – NO REPORTED INCIDENT

B.3.3 DECORATIVE GAS FIRE – NO REPORTED INCIDENT

B.3.4 FLUELESS HEATER – NO REPORTED INCIDENT

B.3.5 INSET LIVE FUEL EFFECT GAS FIRE

Table B.3.5a - Space heaters : inset live fuel effect gas fire : Summary fault analysis

number of incidents=1

Fault group	Number of faults	Fault group	Number of faults
Burner		**Incident testing**	
Corrosion	0	High CO/CO_2 ratio	1
Defective flame picture	0	Failed spillage test	0
Linting	0	Overrated	0
Over-pressure	0	Underrated	0
Under-pressure	0	**Terminal**	
Other	0	Down draught	0
Flue		Bad siting	0
Blockage	0	Unapproved design	0
Corrosion	0	Other	0
Flue not to any standard	0	**Ventilation**	
Installation defect	0	Air vent/vents ineffective	0
Other	0	Air vents obstructed - intentionally	0
Heat exchanger		Air vents obstructed - unintentionally	0
Blockage - shale	0	Compartment/cupboard not to any standards	0
Blockage - soot	0	No permanent ventilation provided	0
Cracked	0	Ventilation provided was not to any standard	0
Other	0	**Miscellaneous**	
Safety device		Local topography	0
Failed CO alarm	0	Weather	0
Failed down draught detector	0	Signs of spillage	0
Failed vitiation device	0		

Table B.3.5b - Space heaters : decorative gas fire : incident summary

Post Code	Number of casualties: fatal (non-fatal)	Appliance age (yrs)	Appliance location	Installer	Flue to standards	Ventilation to standards	Appliance make & model	Flue type	Fault
CT9	0 (1)	1	12	Unknown			Valor Ultimate	5	The fire was producing significant amounts of CO. This may have been due to the incorrect alignment of the coal bed.

B.3.6 RADIANT AND RADIANT CONVECTOR GAS FIRE

Table B.3.6a - Space heaters : radiant and radiant convector gas fire : Summary fault analysis

number of incidents=15

Fault group	Number of faults	Fault group	Number of faults
Burner		**Incident testing**	
Corrosion	0	High CO/CO_2 ratio	7
Defective flame picture	6	Failed spillage test	13
Linting	11	Overrated	2
Over-pressure	3	Underrated	2
Under-pressure	0	**Terminal**	
Other	1	Down draught	0
Flue		Bad siting	0
Blockage	8	Unapproved design	2
Corrosion	0	Other	2
Flue not to any standard	7	**Ventilation**	
Installation defect	4	Air vent/vents ineffective	0
Other	1	Air vents obstructed - intentionally	0
Heat exchanger		Air vents obstructed - unintentionally	0
Blockage - shale	0	Compartment/cupboard not to any standards	0
Blockage - soot	0	No permanent ventilation provided	0
Cracked	0	Ventilation provided was not to any standard	0
Other	0	**Miscellaneous**	
Safety device		Local topography	0
Failed CO alarm	0	Weather	0
Failed down draught detector	0	Signs of spillage	7
Failed vitiation device	0		

Table B.3.6bi - Space heaters : radiant and radiant convector gas fire : incident summary

Post Code	Number of casualties: fatal (non-fatal)	Appliance age (yrs)	Appliance location	Installer	Flue to standards	Ventilation to standards	Appliance make & model	Flue type	Fault
W10	0 (1)		12	Unknown			Robinson Willey Firegem Deluxe	5	The gas fire was producing CO due to dirt in the injectors and burners. Also the flue was not completely effective in clearing the flue products.
BD2	2 (0)	12	12	Unknown			Baxi Belmont	5	The gas fire produced CO into the property due to catchment space being totally blocked. The combustion deteriorated due to vitiation and levels of CO rose to fatal levels.
HA30	0 (4)		12	Unknown	Current		Robinson Willey Firegem 20E	5	The lounge fire was in poor condition and spilled products of combustion into the room until the flue warmed and became effective. Flue had a non-approved terminal which under certain weather conditions may have restricted the flue. There were indications of long term spillage having taken place.
BA2	0 (1)		12	Unknown	Current		Flavel Regent-free standing	5	The appliance was producing low levels of CO due to being over rated and linting around the injector. Spillage was taking place. With the spigot restrictor fitted it is likely that a greater level of spillage would take place.
WD1	0 (1)		12	Unknown			Robinson Willey Firegem Visa II	5	The air relief opening and the flue were restricted, but the fire when tested cleared its combustion products. Possibly under certain weather conditions the flue may not clear the products.
LL18	1 (0)		12	Unknown	Current		Cannon Misermatic	5	The gas fire was producing high levels of CO which were spilling into the property due to a blocked flue.
B97	0 (1)		12	Unknown			Flavel Debonair Superb	5	The gas fire was not clearing its products of combustion due to partial flue blockage. This material had been present for over 10 years. The appliance was in poor condition and in need of a service as injectors and burners linted.
G21	0 (2)	5	12	Unknown	Current		Robinson Willey Firegem Visa 2 D/L	5	The gas fire was spilling products of combustion. The fire was in need of servicing and was spilling due to the closure plate being no longer sealed to the wall.

Table B.3.6bii - Space heaters : radiant and radiant convector gas fire : incident summary

Post Code	Number of casualties: fatal (non-fatal)	Appliance age (yrs)	Appliance location	Installer	Flue to standards	Ventilation to standards	Appliance make & model	Flue type	Fault
WA8	0 (2)	2	12				Parkinson Cowan Windsor	5	With all doors and windows closed the gas fire and flue system worked correctly, but: fire & flue were in poor condition; fire not installed correctly; downdraught when doors opened in property letting hot air into colder parts of the house. Got up to 360ppm CO for short periods. Fire was in need of servicing.
BL3	0 (4)		12	Unknown		Current	Cannon Miserrmatic	5	Fire spilled products due to flue being sealed. The fire was also in need of a service.
SR2	1 (0)	19	3	DIY	Current when installed		Glow Worm Allegro Super N	5	As a result of a flue blockage combustion products from a fire spilled into a bedroom. This led to high levels of CO in the room and death to the occupant.
RM2	1 (0)	10	6	DIY	Current		Berry Magicoal Sunberry	5	The gas fire in dining room was producing high levels of CO. It was connected to a blocked flue. Gas fire in poor condition and needed servicing.
KY6	1 (0)	5	12	CORGI			Flavel Welcome	5	Lack of servicing led to fire producing high levels of CO. Total flue blockage caused products to enter the property.
BB9	2 (0)		3	Unknown			Main Prima TC	5	Spillage of products of combustion from the gas fire resulted from flue blockage.
FK5	2 (0)		12	Unknown			Economic HI GLO 4	5	The gas fire was producing high levels of CO due to lack of servicing. The flue was poorly constructed and did not clear the products adequetly.

B.3.7 WALL HEATER – NO REPORTED INCIDENT

B.4 DRYERS

B.4.1 TUMBLE DRYERS – NO REPORTED INCIDENT

B.5 WATER HEATERS

B.5.1 BULK STORAGE – NO REPORTED INCIDENT

B.5.2 CIRCULATOR

Table B.5.2a - Water heaters : circulator : Summary fault analysis

number of incidents=1

Fault group	Number of faults	Fault group	Number of faults
Burner		**Incident testing**	
Corrosion	0	High CO/CO_2 ratio	0
Defective flame picture	0	Failed spillage test	0
Linting	0	Overrated	0
Over-pressure	0	Underrated	0
Under-pressure	0	**Terminal**	
Other	0	Down draught	0
Flue		Bad siting	0
Blockage	0	Unapproved design	0
Corrosion	0	Other	0
Flue not to any standard	1	**Ventilation**	
Installation defect	1	Air vent/vents ineffective	0
Other	0	Air vents obstructed - intentionally	0
Heat exchanger		Air vents obstructed - unintentionally	0
Blockage - shale	1	Compartment/cupboard not to any standards	1
Blockage - soot	0	No permanent ventilation provided	0
Cracked	0	Ventilation provided was not to any standard	1
Other	0	**Miscellaneous**	
Safety device		Local topography	0
Failed CO alarm	0	Weather	0
Failed down draught detector	0	Signs of spillage	0
Failed vitiation device	0		

Table B.5.2b - Water heaters : circulator : incident summary

Post Code	Number of casualties: fatal (non-fatal)	Appliance age (yrs)	Appliance location	Installer	Flue to standards	Ventilation to standards	Appliance make & model	Flue type	Fault
KY1	0(1)		10	Unknown			Crane Heatnaire/ Dean Maxol WAH3	8	Both flueing and ventilation were substandard. There was no indication of regular servicing having been carried out. Most likely that the circulator was spilling due to blockage of the heat exchanger.

B.5.3 MULTI-POINT – NO REPORTED INCIDENT

B.5.4 SINGLE-POINT

Table B.5.4a - Water heaters : single-point : Summary fault analysis

number of incidents=4

Fault group	Number of faults	Fault group	Number of faults
Burner		**Incident testing**	
Corrosion	0	High CO/CO_2 ratio	2
Defective flame picture	1	Failed spillage test	0
Linting	1	Overrated	1
Over-pressure	1	Underrated	1
Under-pressure	1	**Terminal**	
Other	0	Down draught	0
Flue		Bad siting	0
Blockage	0	Unapproved design	0
Corrosion	0	Other	0
Flue not to any standard	0	**Ventilation**	
Installation defect	0	Air vent/vents ineffective	0
Other	0	Air vents obstructed - intentionally	0
Heat exchanger		Air vents obstructed - unintentionally	0
Blockage - shale	0	Compartment/cupboard not to any standards	0
Blockage - soot	2	No permanent ventilation provided	1
Cracked	0	Ventilation provided was not to any standard	0
Other	0	**Miscellaneous**	
Safety device		Local topography	0
Failed CO alarm	0	Weather	0
Failed down draught detector	0	Signs of spillage	0
Failed vitiation device	0		

Table B. 5.4b - Water heaters : single-point : incident summary

Post Code	Number of casualties: fatal (non-fatal)	Appliance age (yrs)	Appliance location	Installer	Flue to standards	Ventilation to standards	Appliance make & model	Flue type	Fault
BB11	3 (0)		10	Unknown	Current		Main Mitre	11	Due to continous operation of the water heater dangerous levels of CO were achieved in the bedrooms.
E7	0 (4)		10	Unknown			Vaillant 327/7	11	A cooker and an instantaneous water heater in the kitchen both created high levels of CO and were both in use at the time of the incident. This led to dangerous levels of CO in the property
PR1	0 (3)		10	Unknown	Current		Main Mitre	11	A single point water heater was producing high levels of CO due to oversized pilot flame impinging with main burner flame to create soot upon the heat exchanger. The appliance was overgassed.
BB1	0 (2)		10	Unknown			Vaillant MAG 125/7	11	Probable source of CO was the water heater. Due to a leak on the tap the water heater may have stayed on all night. This affected the casualties who were sleeping in an adjacent room with the access door open. It is likely that the main burner was extinguished by vitiated air and that due to a faulty F.F.D. unburnt gas was then released.

APPENDIX C DETAILS OF LPG INCIDENTS THAT TOOK PLACE DURING 1997/98, AND AN ANALYSIS OF THE DATA

There was one LPG incident reported using the DIDR Form during 1997/98. The incident, which led to one fatal casualty, occurred during December and involved a portable radiant convector heater. The victim was a council tenant who lived in a maisonette in a 6 storey block. The post code for the incident site was CR4.

The appliance was located in a bedroom and this is where the casualty was also found. Being a portable appliance there was no flue. There were no safety devices fitted to the appliance. At the time of testing the appliance was producing CO, but the levels were found to be lower than that generally required to cause death. There was a large LPG bottle fitted to the appliance and this was found to be empty. It is possible that the appliance had been run continuously for some time. Ventilation into the room was inadequate and had been intentionally obstructed.

Details of the incident appliance make and model are given below in Table C1.

Table C1 – LPG incidents : appliance, Installation, Standards and Cause of Incident

Post Code	Number of casualties: fatal (non-fatal)	Appliance age (yrs)	Appliance location	Installer	Flue to standards	Ventilation to standards	Appliance make & model	Flue type	Fault
CR4	1 (0)			N/A	N/A	Intentionally blocked	Aluima s.a. carasol 2c		All mains appliances were operating satisfactorly – not thought a cause. An LPG portable radiant convector heater was producing low levels of CO and may be the cause. It was possibly functioning until the gas bottle emptied. The amount of CO being produced could not be proven to be adequate to cause death. However moving the appliance may have improved the combustion characteristics and long term operation may have led to vitiation and higher levels of co.

APPENDIX D DETAILS OF NON-DOMESTIC CO INCIDENTS THAT TOOK PLACE DURING 1997/98, AND AN ANALYSIS OF THE DATA

BUSINESS INCIDENTS: -

During the reporting year 1997/98 there were 4 CO incidents reported using the DIDR form that involved piped natural gas within business properties.

One incident occurred in April, one in August and two in December 1997. Details of these four incidents and the resulting casualties are given in Table D1 below. The first incident was in a church (A), one was in a launderette (B) and the remaining two incidents occurred in industrial properties (C&D). The postcodes for these incidents were NN14, G4, BD7 and S73.

Table D1 - The number of CO incidents and casualties

Incident	Postcode	Appliance involved	Flue type	Number of fatal casualties	Number of non-fatal casualties			
					N1	N2	N3	N4
A	NN14	Wall mounted boiler	O,I,ND	0	0	64	0	0
B	G4	Bulk storage water heater	O,I,FD,AO	0	0	4	0	0
C	BD7	Wall mounted boiler	O,I,ND	0	0	8	6	0
D	S73	Steam boiler	Closed	0	0	2	0	0

Note: O,I,ND = Open, Individual, Natural draught flue.
O,I,FD,AO = Open, Individual, Fanned draught, Add on flue.

In incident A the boiler flue, which was of poor design, was blocked, the ventilation was inadequate and the appliance was in need of a service.

The bulk storage water heater in incident B was fitted in a launderette. There were a number of faults with the flueing system, the main one being a missing outlet fan. The ventilation was also inadequate and due to the operation of other fanned appliances combustion products were able to enter rooms of the flats above the launderette. The casualties were located in these rooms.

In incident C the appliance was in need of servicing, the ventilation was inadequate, and the poor terminal position led to downdraught in some wind conditions.

In the remaining incident, CO escaped from a steam boiler due to defective seals. The operation of fans operating in the vicinity of the boiler allowed CO to be passed around the factory which affected some of the employees. There were also a number of maintenance faults noted with the appliance.

Casualty and appliance locations are given in Table D2.

Table D2: Appliance and casualty locations

Incident	Appliance location	Casualties & location
A	Cellar	Inside the church
B	Launderette store room	Adjacent properties
C	Mess room kitchen	Kitchen
D	Boiler room	Around the factory

The following details in Table 3 give the total numbers of faults found upon all the incident appliances.

Table D3 - Incident appliance faults

Fault group	Number of faults	Fault group	Number of faults
Burner		**Incident testing**	
Corrosion	1	High CO/CO_2 ratio	2
Defective flame picture	2	Failed spillage test	3
Linting	2	Overrated	1
Over-pressure	1	Underrated	0
Under-pressure	1	**Terminal**	
Other	2	Down draught	1
Flue		Bad siting	1
Blockage	2	Unapproved design	0
Corrosion	0	Other	0
Flue not to any standard	4	**Ventilation**	
Installation defect	4	Air vent/vents ineffective	2
Other	1	Air vents obstructed - intentionally	1
Heat exchanger		Air vents obstructed - unintentionally	1
Blockage - shale	1	Compartment/cupboard not to any standards	0
Blockage - soot	3	No permanent ventilation provided	0
Cracked	0	Ventilation provided was not to any standard	4
Other	0	**Miscellaneous**	
Safety device		Local topography	0
Failed CO alarm	0	Weather	1
Failed down draught detector	0	Signs of spillage	3
Failed vitiation device	0		

Note: In Table 3 the numbers quoted are the number of appliances found with the fault listed.

In all cases CO was proven to be able to enter the incident property when tested in the as-found condition. None of the appliances were fitted with any safety devices for detecting CO. In one case the appliance age was unknown, the others were aged between 6 and 10 years.

In two cases problems were caused by fans operating in the same rooms as the incident appliance. One of these was in a the factory and the other in the launderette.

Details of each incident including the appliance make and model are given in Table D4.

Table D4 - Appliance, Installation, Standards and Cause of Incident

Incident	Appliance type	Appliance make & model	Installer and if CORGI Regist'd	Flue to Standards	Ventilation to standards	Fault
A	Wall mounted boiler	Ideal Mexico Super 2 cf100	Not known	No	No	Boiler in poor service condition and attached to dangerous flueing configuration. Ventilation was inadequate. The combustion was poor and high levels of CO were produced. The flue was blocked and spillage led to products entering the church. Other exit was via compartment door and wind effects would vary its effectiveness.
B	Bulk storage water heater	Andrews Sykes 63/321	Not known	No	No	There was inadequate ventilation for the incident appliance and other appliances in the launderette. Incomplete combustion likely result and due to action of other fanned appliances then flue products spilled into launderette. Signs of spillage evident. The exhaust fan was missing and its condition is unknown. This may also have led to additional flue restriction. With fan missing combustion products vented directly into launderette.
C	Wall mounted boiler	Glow Worm Fuelsaver 75 mk2	Not known	No	No	A c/h boiler was producing high levels of CO due to its need for servicing. It was spilling due to an unsatisfactory flue terminal position liable to cause downdraught in some wind conditions. Ventilation requirement was sub-standard.
D	Steam boiler	Fulton Series e Model 30	Not known	Yes	Yes – at time of installation	CO escape from steam boiler due to defective seals. High CO due to lack of maintenance and flue faults. CO escaped and probably was drawn into air intakes of 2 air compressors and then to factory machines where it was emitted around the operators.

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