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Continued appraisal of domestic CO alarms

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Continued appraisal of domestic CO alarms

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The work reported here supplements that first reported in HSE Contract Research Report 360/2001 "Joint industry project on carbon monoxide issues: Long-term reliability of domestic CO alarms". Since that report, the trials have continued for a further two years, supported by HSE funding. The present report sets out the findings for the alarms tested throughout the project, as a whole.

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FOREWORD BY HSE

The work reported here supplements that first reported in HSE Contract Research Report 360/2001 "Joint industry project on carbon monoxide issues: Long-term reliability of domestic CO alarms". Since that report, the trials have continued for a further two years, supported by HSE funding. The present report sets out the findings for the alarms tested throughout the project, as a whole.

As before, the report and the work described should not be construed as a comprehensive product survey of all CO alarms on the market. Rather the studies were intended to provide an assessment of the stability and long-term reliability of such devices, as a basis for further work. The alarms studied were a representative sample of the sensor types currently available within the UK. As new alarms were introduced onto the market, to replace alarms previous tested and no longer available, they were included in the studies.

All the alarms included in the studies were first subjected to initial laboratory screening, based on the requirements of BS 7860: 1996 "Specification of Carbon monoxide detectors (electrical) for domestic use", with a smaller number being selected for field trials for reliability. Therefore not all the CO alarms available were subject to a full field trial, and it should not necessarily be inferred from the results that those not selected would have performed similarly to those of the same sensor technology. It should also be noted that some manufacturers of models tested have disputed some of the findings.

Although some of the CO alarms were kitemarked to the BS, or purported to be BS compliant, others were not. However, neither the current BS nor the newly introduced European Standard, BS EN 50291: 2001 "Electrical apparatus for the detection of carbon monoxide in domestic premises – Test methods and performance requirements", give a guarantee of long-term service reliability. Therefore, HSE's interest in this area will focus on work to address possible deficiencies in the current standards' criteria and test protocol, with a view to the development of an agreed standard covering long-term reliability. HSE has been in discussion with the Council of Gas Detection and Environmental Monitoring (CoGDEM), with this view in mind, and will pursue the matter further with them. This is consistent with recommendation 33 in the HSC report "Fundamental Review of Gas Safety Regime: Proposals for Change" on the question of encouraging wider use of CO alarms in domestic premises, and the issue of whether possible mandatory requirements in this area might be justified at some stage in the future.

HSE acknowledges that there were limitations in the trials as outlined above and that there have been substantial improvements in sensor technology during the course of the project, as a whole. However, it is publishing this report in the public interest, as a contribution to the wider debate on the potential of CO alarms to assist in achieving the target for improved gas consumer safety, as set out in the HSC's Fundamental Review recommendations.

Continued Appraisal of Domestic CO Alarms

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SUMMARY

This project has evolved from a Joint Industry Programme, initiated in 1998, looking at a range of carbon monoxide (CO) issues. Long-term assessment of domestic CO alarms, including laboratory testing and field trials in the homes of Advantica (formerly BG Technology) staff, on a representative range of models available within the UK, has now taken equivalent service lifetimes up to three years in some cases. Performance requirements have been based on the specification given in BS 7860, but BS EN 50291 has now been issued. A comparison of the two standards concludes that the alarm performance requirements are similar in principle, so that the BS 7860 test procedures could continue to be used for simplicity, and to avoid duplication of work.

A number of specimens have been withdrawn from field trial, mostly for exhibiting sensor drift of a "fail-to-danger" type, but some models continue to perform well, and it is recommended that these should continue on field trial, to generate good quality long-term data. It is estimated that well over one million domestic CO alarms have so far been installed in the UK, and it appears that the UK is still seen as a prime market for such units. This situation is expected to receive a further boost, once models approved to BS EN 50291 start to become available.

From all the results available to Advantica, it has been possible to present an overview for each of the CO alarms that have been assessed, either as part of this project or previously. Note that the actual performance in service will be significantly affected by other factors, such as the positioning of units inside the home. Domestic CO alarms need output signals that are clear and unambiguous, and other design features require careful consideration, to reduce the possibility of unnecessary emergency callouts. New models of domestic CO alarm should be evaluated on a comparable basis to those already investigated, for possible inclusion in long-term assessments

1. INTRODUCTION

This project has evolved from a Joint Industry Programme, initiated in 1998, looking at a range of carbon monoxide (CO) issues. Long-term assessment of domestic CO alarms was one of the areas for investigation, which included laboratory testing and field trials on a representative range of models available within the UK. The initial work has been fully reported (Reference 1) and this report covers an extension of the project, taking equivalent service lifetimes up to three years in some cases.

2. INITIAL ASSESSMENTS

During the continuation period, assessments have been performed on a number of new models of CO alarm, which have come to the attention of Advantica (formerly BG Technology). These assessments have been carried out using test equipment described previously (Reference 1) and based on the alarm test requirements specified in the appropriate British standard (BS 7860, see Reference 2) which can be summarised as:

- No alarm within 60 minutes at 45 ppm CO,
- Alarm within 30 minutes, but not less than 10 minutes, at 150 ppm CO,
- Alarm within 6 minutes at 350 ppm CO, and
- Recovery from the alarm state within 6 minutes in clean air.

Comparisons have previously been made with an earlier generation of domestic CO alarm, epitomised by the SF310 (Figure 1) manufactured by SF Detection Ltd. Although no longer in production, this unit is considered to be representative of a range of similar models utilising the Figaro TGS203 semiconductor sensor, which was effectively the industry "norm" in the early 1990s. Note that the SF310 was not designed to conform to the performance requirements of BS 7860, although it incorporated many of the features later adopted by that standard. Results of more recent assessments, roughly in chronological order, are summarised as follows:

a) SF340E (see Figure 2). This unit is mains powered with 9-volt battery backup, and incorporates the SF Detection Ltd MIDI 40 electrochemical cell. Performance did not conform to BS 7860 requirements, in that alarm calibrations on some units were not sufficiently sensitive. In addition, the sensor module did not appear to fit correctly within the locating clips on some units, so that the top cover would not close fully.

b) Kidde Nighthawk. Problems being encountered with this mains-powered range of CO alarm were detailed in Reference 1, following which it was decided to withdraw the batch on long-term test (designated here as Nighthawk-2) from field trial. The manufacturer supplied replacement specimens (designated as Nighthawk-3) with a charcoal filter incorporated into the proprietary electrochemical sensor, and checks on these units showed generally good performance, except that low temperatures appeared to cause an increase in sensitivity for some units. A further variant with a revised design of sensor (designated as Nighthawk-4) has also been received and, once again, performance was satisfactory. Note that all these variants are physically very similar and are kite-marked to BS 7860, but can only be distinguished by production date code.

c) EI 204/5 (see Figure 3). Visually very similar to the EI 225, these two models are powered by three 1.5-volt batteries and utilise the same electrochemical sensor as the SF330KM. They are kite-marked to BS 7860, and initial tests indicated satisfactory alarm performance.

d) Senco 2001/2/3. The original Senco model ONE (described in Reference 1) has now been re-named the model 2001. Two alternative models have also been introduced (Figure 4) based on the same electrochemical sensing technology with 9-volt battery, but without the digital display. Samples of both the 2002 and 2003 performed well in initial tests.

e) SF350 (Figure 5). This unit has a non-replaceable 9-volt battery and is kite-marked to BS 7860. It uses the proprietary MIDI 40 electrochemical sensor and, when tested, performance was found to be entirely satisfactory.

f) Dicon CO1100 (Figure 6). Powered by a replaceable 9-volt battery, it uses the Quantum reagent gel (sometimes called colourimetric or biomimetic) sensor. No compliance with BS 7860 is claimed, although performance was found to be reasonably close when tested. It was noted that alarm recovery times increased at low ambient temperatures.

Information has also been received that a new model is about to be launched, featuring the Monox electrochemical cell. This sensor has previously been evaluated in a test-bed configuration and has performed satisfactorily, but specimens of a more developed version will be obtained for evaluation as they become available.

3. FIELD TRIAL RESULTS

As described in Reference 1, models of CO alarm that performed satisfactorily during initial evaluation were selected for longer-term assessment. This comprised installation of samples in the homes of Advantica staff, plus single specimens from the same batch energised continuously in the laboratory. Hence, units were exposed to a range of in-service conditions, whilst a reference was kept available for closer monitoring in case of any unexpected occurrences. All the specimens have been regularly re-checked, to identify any drift in alarm calibration or other change in behaviour. The collated results are summarised below, listed in alphabetical order of manufacturer.

a) *Dicon Safety Products*

- CO805B: Units have now been on trial for three years, and results for the field trial specimens are shown in Figure 7. This model was originally selected partly because it utilised a sensor for which long-term data were not readily available. It can be seen that significant variations have occurred in sensor performance, making it very difficult to predict the likely behaviour in future. Six out of the original twenty have now been withdrawn from the trial, mainly due to excessive loss of sensor sensitivity. The manufacturer has indicated that this model was not a commercial success, and only small numbers were sold.
- CO1100: A small number of units have been on trial for six months so far, and performance is shown in Figure 8. As stated earlier, this model has only recently been introduced and is not approved to BS 7860, but behaviour nevertheless looks promising.

b) *EI Company*

- EI 225: The small sample of field trial specimens was withdrawn after 2 years, due to excessive loss in sensor sensitivity. This result is contrary to the manufacturer's experience, which indicates a trend towards increasing sensitivity with time. The sensing technology employed is similar to that used in the SF310, described earlier, and existing data would support the view of the manufacturer, so the reason for this result is difficult to understand. It may be confined to individual batches, which would unfortunately make the cause even harder to identify. It is understood that this model has been installed in significant numbers within the UK, certainly into six figures.
- EI 204 and 205: These two models utilise the same electrochemical sensor as the SF330KM. Only small numbers were therefore thought worth having on field trial, and these have so far lasted two years without incident.

c) *Kidde Safety Europe Ltd*

- Nighthawk-1: As with the EI 225, this model uses the same long-established sensing technology as the SF310. The small sample of field trial units has now completed three years in service, and it can be seen from Figure 9 that performance is becoming increasingly variable. Note that, whilst Nighthawk models with this type of sensor are no longer manufactured, later variations cannot easily be distinguished except by reference to the production date code. As a rough guide, this first version was dated 1998.

- Nighthawk-2: Date-coded 1999, this version (described in detail in Reference 1) was withdrawn from field trial after 18 months, due to an excessive decrease in sensitivity of the proprietary electrochemical sensor (see Figure 10). Production was halted at about the same time, together with a product recall in the USA.
- Nighthawk-3: This version (production date-coded 2000) included a charcoal filter on the sensor. Samples have now been on field trial for 18 months, and Figure 11 shows that performance is satisfactory so far, with only small changes evident. However, it should be noted that low temperatures appear to cause an increase in sensitivity for some units, and that reports have been received of sporadic "fault" alarms for no apparent reason. One unit has failed completely, possibly due to a faulty power transformer, as occurred on an earlier version. The manufacturer has indicated that market figures are in the process of being collated, together with other suppliers, through the Council of Gas Detection and Environmental Monitoring. Numbers in service are likely to be significant, however, as they are retailed through major DIY chains.
- Nighthawk-4: The most recent version (production date-coded 2001) used a slightly different sensor design, intended to improve stability. Figure 12 shows performance of a small batch over six months and, although four are satisfactory, one has been withdrawn due to a faulty buzzer, and another has been withdrawn because of an excessive decrease in sensor sensitivity. The manufacturer is considering these findings, which conflict with their own long-term data.
- Nighthawk Deluxe: As described in Reference 1, this battery-powered unit originally used the same sensing technology as the SF330KM, but now incorporates the Kidde sensor. Only a small sample has been on field trial and, although performance is satisfactory, the casing was thought to be too flimsy and battery lifetime is only about two years.

d) Schlumberger Industries

- XH-443B: Figure 13 shows that significant variations have occurred in alarm performance over three years in service. This model was of interest because it utilised a newer type of semiconductor sensor, the New Cosmos CH-C. Even though the initial calibrations were slightly lower than specified by BS 7860, some specimens have experienced decreased sensor sensitivity by an excessive amount. Buzzer failures have also been noted, and five of the original twenty have now been withdrawn. The manufacturer has indicated that only a small number were sold, and the unit is no longer being supplied.

e) Senco Products

- Model ONE (renamed as model 2001): A small batch has now been on field trial for 30 months, and Figure 14 shows that alarm performance is satisfactory so far. However, battery lifetime is only about two years, and faulty segments have appeared on the digital display of one of the units.
- Models 2002 and 2003: These are visually almost identical, and use the same sensor as the Senco model 2001. Only single specimens are therefore on field trial, and these are still performing satisfactorily after 1 year.

f) SF Detection Ltd

- SF310: As described earlier, this unit is representative of older designs, and Figure 15 shows results for specimens that have been on trial since before the start of the present programme. It can be seen that the alarm performance has been reasonably stable over that time, but note that the unit was never intended to comply with the requirements of BS 7860. Hence, the initial calibration settings would have been less onerous, which may have contributed to an improved reliability.
- SF320: Of similar vintage and sensing technology to the SF310, but based on an existing Japanese design. Performance has shown the same level of alarm stability but, again, the original calibration settings were never intended to comply with the requirements of BS 7860.
- SF330KM: Figure 16 shows that alarm performance over 3 years has been good, with only small variations in sensor calibration. This model utilises the proprietary MIDI 40 electrochemical cell, which is now also incorporated into other makes and models. Some buzzer failures have been noted, although these may have been the result of physical mishandling. Failures of the non-replaceable battery have also occurred, and the larger test sample has enabled a more robust Weibull statistical analysis (see Reference 3) to be undertaken. This indicates a mean service battery lifetime of 4.5 years. This model constitutes a high proportion of the total UK population of domestic CO alarms actually installed in the UK, mainly because it was selected for use by Centrica (ie. British Gas Services) from 1997 onwards. It is estimated that at least one million such units have now been sold into the UK market.
- SF340E: Single samples have been on trial for 20 months, to check both possible operating modes, ie. mains-powered (with battery back-up) and battery-powered only. The sensor is the same as used in the SF330KM, and alarm performance is satisfactory so far, although battery-only operation gives a battery lifetime of only 1.5 years.
- SF350: This model, introduced by British Gas Services in 2000, utilises the same sensor as the SF330KM, and is expected to eventually replace that model in the UK market. It still uses a non-replaceable battery, but incorporates modifications aimed at improving battery lifetimes and buzzer reliability, as highlighted by the results of this project. Figure 17 shows satisfactory alarm performance for the small batch that has so far been on trial for six months.

Single specimens of the models originally assessed and detailed in Reference 1 have continued to be regularly checked, and most have exhibited drifting towards a decrease in sensor sensitivity. Some have drifted excessively, and have now been discarded. It should also be noted that these other units were all considered to be unsatisfactory in one or more respects anyway.

4. DISCUSSION

The methodology used to evaluate CO alarms during this programme of work has been described fully in Reference 1, and is quite straightforward. It has been successfully used to generate comparable data based on the performance requirements of BS 7860. However, one possible complication is the publication of the equivalent European standard for domestic CO alarms, BS EN 50291, as a British standard (Reference 4) together with an accompanying guidelines document, BS EN 50292 (Reference 5). Since it is a direct equivalent, BS 7860 is automatically superseded, although products previously approved will still be valid until April 2006. The two documents are very similar, or even identical, in the majority of respects, but there are differences in the basic alarm performance requirements. The alarm tests specified in BS EN 50291 are as follows:

- No alarm within 120 minutes at 33 ppm CO,
- Alarm within 90 minutes, but not less than 60 minutes, at 55 ppm CO,
- Alarm within 40 minutes, but not less than 10 minutes, at 110 ppm CO,
- Alarm within 3 minutes at 330 ppm CO, and
- Recovery from the alarm state within 6 minutes in clean air.

By comparison with the requirements listed in Section 2, it can be seen that, although similar in principle, the above tests demand a much greater discrimination by the sensor, due to the reduced tolerance bands between the lower CO concentration levels. Judging by the performance observed previously, it seems unlikely that this level of discrimination can be achieved reliably by existing metal oxide semiconductor sensors. The methodology used to evaluate CO alarms could, of course, utilise either of these specifications for producing comparative data. However, for simplicity and to avoid duplication of work, the existing procedure based on BS 7860 will continue to be used, unless and until there is good reason to change.

From all the results available to Advantica, it has been possible to update the summary given in Reference 1, and Table 1 presents an overview for each of the CO alarms that have been assessed, either as part of this project or previously. Note that the actual performance in service will be significantly affected by other factors, such as the positioning of units inside the home, as well as individual design features (as discussed later).

Reference 1 gave a number of reasons why the North American standard (Reference 6) is considered inferior to BS 7860, and the latest data (Reference 7) still show a very mixed situation regarding CO alarm performance in the USA and Canada. It has been suggested that a decrease in alarm activation rates may indicate an improvement in alarm performance, but this could also be caused by a general drift towards decreasing sensor sensitivity, as has been found from this programme. One recent development has been the move towards stringent reliability tests, as described in Reference 1 (see also Reference 8). However, it is too early to tell whether these will be cost-effective in the market place.

Judging from the level of interest being shown by a number of manufacturers, it appears that the UK is still seen as a prime market for domestic CO alarms. This situation is expected to receive a further boost, once models approved to BS EN 50291 start to become available. An earlier exercise aimed at providing information on in-service populations via CORGI inspectors, has not yielded sufficient data to be of practical use, but information has been obtained from various other sources instead. It is evident that large numbers of SF330KM units are already installed, and it seems likely that similar numbers of SF350 units will gradually appear, partly on a replacement basis. It is understood that both EI and Nighthawk mains- and battery-powered models are also readily available through a number of retail outlets, and have been installed in domestic premises in significant numbers, particularly by Local Authorities and other landlord agencies.

As detailed in Reference 1, and reinforced by Table 1, a wide range of sensor types have been used in different models of domestic CO alarm. In general, it seems that semiconductor types of sensors do not give adequate stability in the long term, except for units that do not initially conform to the alarm performance requirements of BS 7860. In addition, they are unlikely to achieve the higher level of discrimination required by BS EN 50291. Improvements in the performance of reagent gel (colourimetric) sensors have been noted, but they are still susceptible to low temperature effects and long recovery times.

Over the duration of this project, significant changes have been achieved in the availability and usage of electrochemical cell types of sensors. Their use in increasing numbers is likely to bring further reductions in the previous cost differential with semiconductor types. Sensors from Kidde Safety Europe Ltd, Senco Products and SF Detection Ltd are performing well on field trial, and those from Monox Ltd also show promise.

One perceived benefit of electrochemical sensors is the possibility of using battery, instead of mains power. Many users have expressed a preference for non-mains units, as being easier and more convenient to install, but the problem of limited battery lifetimes could become an issue. Table 2 summarises typical lifetimes that have been achieved on battery-powered units examined by Advantica. Data are very limited in some cases, but it can be seen that low-battery indications can occur much earlier than the consumer might reasonably expect. In addition, it is extremely likely that low-battery warnings will cause emergency callouts, due to customers becoming confused between different output signals. This could have serious cost implications for emergency service providers.

The potential problem with low-battery warnings highlights the need for clear and unambiguous output signals. A visual warning of low level CO is often useful, because of the long timescales involved at lower concentrations, and a “beep” on connection and/or disconnection is helpful, especially for mains-powered units. However, the temptation to make alarm signals overly complicated will certainly lead to confusion in practice. Similar care should be exercised in the use of digital displays, which may also lead to unnecessary emergency callouts if the readings are in error, or if the user is unable to properly interpret changes in the reading.

Another design feature that may create difficulty in service is the use of “test” buttons which do not give any information regarding the ability of the sensor to actually detect CO. Test kits are available, to enable the application of controlled amounts of CO gas, and hydrogen has also been used as a more convenient cross-interferant gas for some CO sensors. It is worth noting that most failures observed during this project resulted from excessive loss in sensor sensitivity. A domestic CO alarm that loses sensitivity and thereby fails to give adequate protection (a “fail-to-danger”) is potentially even more damaging than one that gives spurious and unnecessary alarms.

17 cases have, in fact, been reported during the period 1996 to 2001 (Reference 9) where CO detectors featured (that is were recorded as being fitted in properties by those investigating incidents and completing the DIDR reporting form).~~CO related incidents.~~ Nine of these concerned the chemical spot type, which does not actually give an audible alarm, and one was not described. However, five were battery-powered (two of which were found to be non-operational, that is recorded by the investigator as not responding to CO) and two were mains-powered. Hence, it is possible that users were denied sufficient warning from serviceable CO alarms (serviceable meaning devices that were either recorded as being capable of responding to CO or actually tested by the investigator and found to be capable of a response) on at least

five occasions over the last five years. Unfortunately, no comparable data exist to indicate how many CO alarms gave correct and timely warning of hazardous conditions during the same period.

Installed CO Alarm Type	***96/97***	***97/98***	***98/99***	***99/00***	***00/01***	***Total number fitted***
CO alarm – chemical spot detector	2	0	4	0	3	9
CO alarm – battery powered detector	0	0	1	1	~~3~~4	~~5~~6
CO alarm – mains powered detector	0	1	1	0	0	2
CO alarm – undefined type	0	0	1	0	0	1

Number of incidents reported as featuring CO alarms over the five year period (out of 430 domestic incidents reported in total)

The extent of information available from the DIDR forms submitted by investigators in these instances is provided below.

4.1 Details of Incidents Involving Non-Operational Devices

Two were related to battery powered CO alarms and in both instances they were fitted in the same room as the incident appliance. Three safety devices were chemical spot detectors and recorded on the database as having been non-operational, although it is unclear how this definition was interpreted by those investigating. In particular, it is unclear whether an investigator recorded a spot detector to have turned black (ie was "operational") when it was unknown whether the device had become black prior to the incident.

4.1.1 Spot Detector

- One incident involved a wall-mounted boiler in the kitchen with the spot detector positioned above the time controller and kitchen work surface but below the level of the appliance. A 78 year old lady died in the bedroom during this incident. Here, the investigator recorded that the CO spot detector did not react to "the CO test" which is taken to refer to blowing CO onto the detector (no standard procedure) to determine if it turned black.
- A second incident involved a floor-standing boiler located in a 'passage' and resulted in a victim being hospitalised (for less than 24hr). She was found in the same place although the spot detector position was not specified. Downdraughting was cited as the cause of this incident. No detail is provided on the database, but the investigator recorded the spot detector as non-operational.
- A third incident resulted in a 42 year old person dying in the living room of a property with a box radiant gas fire installation identified as the cause. The spot detector was located in the dining room/kitchen on the side of a cupboard. Once again, no detail was provided by the investigator but the detector was recorded as non-operational.

4.1.2 Battery-Powered CO Alarm

- One device was positioned at a high level on the landing in a terraced property and failed to alarm. The appliance involved in this incident was a compartment mounted boiler, also at high level on the landing . The incident resulted in 5 people being hospitalised for less than 24hr three of whom were located in the living room and the other two upstairs in the bedroom. The investigator noted that this alarm appeared to conform to BS7860.
- The other instance involved a CO alarm that failed and the following was recorded in the free text field of the DIDR form: "CO detector bought from Services March 1998 – it had

batteries but failed soon after date of installation." A downdraughting boiler was understood to be the problem appliance in this latter incident and featured a 24 year old woman being hospitalised for less than 24hrThe appliance, a wall-mounted combi-boiler, was located in the kitchen and this was in an extension to the house. The CO alarm was also positioned in the kitchen. No information was recorded on whether this device conformed to the British Standard.

4.2 Details of Incidents Involving Devices Described as Operational on the CO Incident Database

4.2.1 Spot Detector

- Two occupants of a terraced house fell ill (one in the kitchen and one in the living room/lounge) after a wall-mounted combi-boiler installation located in the kitchen malfunctioned. No detail was provided on the spot detector location.
- A wall-mounted boiler located in the kitchen of a detached bungalow generated levels of CO that caused an occupant to become unwell. Although the investigator recorded the spot detector to be operational, he reported the device had been removed prior to the investigation and its position on the property was not recorded.
- A spot detector not specified by the investigator as operational (DIDR section not completed) was present in the kitchen of a terraced house where a (floor-mounted) back boiler unit in the living room/lounge malfunctioned. The CO produced affected an occupant in the living room/lounge at the time.
- A faulty installation in a terraced property comprising a wall-mounted boiler installed in a compartment within the kitchen caused a single casualty located in the living room/lounge area. The spot detector was positioned above the boiler compartment door.
- A floor-standing combi-boiler installed in a compartment (bathroom) at a converted flat (tenanted, multiple occupancy, registered social landlord) gave rise to two casualties (located in the bedroom) whilst the spot detector had been positioned in the compartment 2m above floor level.
- No siting information for the spot detector was provided by the investigator of an incident at a converted flat caused by a wall-mounted combi-boiler situated in the kitchen and resulting in three casualties (two in the bedroom, one in the living room/lounge). The property was tenanted (private landlord) and of multiple occupancy.

4.2.2 Battery-Powered CO Alarm

The following details were reported for the four incidents where a battery-powered CO alarm was described as operational.

- Four people suffered injury in a house where a compartment-mounted boiler had malfunctioned. The CO alarm was not on site at the time of the investigation although its location at the time of the incident was specified to have been in the rear lounge of the property and the investigator indicated that it had been on loan to the occupants. Those injured had been located in various rooms within the house.
- A faulty wall-mounted boiler positioned in the kitchen of a residential home (multi-occupancy, private landlord) led to three non-fatally injured people being found in the living room/lounge area. The CO alarm was recorded as being two floors above the level of the incident.
- One person located in the kitchen suffered injury at a terraced property with the cause of CO identified as a cooker. The alarm location was not specified by the investigator.

- Two occupants of a detached bungalow required medical attention for the effects of breathing excessive levels of CO following a cooker grill and hob malfunctioning. In this instance, the CO alarm was positioned in the hallway at a height of 1.5m above the floor.

It can be seen from the above details that not only is there inconsistency in the way investigators are completing the DIDR form with respect to CO alarms, the numbers of incidents where such safety devices have featured has been very small.

5. CONCLUSIONS

1. Laboratory assessments and field trials on domestic CO alarms have been completed for up to three years service, during which time alarm performance was regularly checked against the requirements specified in BS 7860. A number of specimens have been withdrawn, mostly for exhibiting sensor drift of a “fail-to-danger” type, but some models continue to perform well as follows:
   - SF330KM (although early battery and buzzer failures have occurred) plus models that use the same sensor but have not yet been tested for the same duration, ie. SF340E, SF350 and EI 204/5.
   - Senco 2001 (although display faults have occurred) plus models that use the same sensor but have not yet been tested for the same duration, ie. Senco 2002/3.
   - Nighthawk Deluxe, Nighthawk-3 (production date-coded 2000) and possibly Nighthawk–4 (production date-coded 2001).
2. It is estimated that well over one million domestic CO alarms have so far been installed in the UK, and it appears that the UK is still seen as a prime market for such units. This situation is expected to receive a further boost, once models approved to BS EN 50291 start to become available.
3. Domestic CO alarms need output signals that are clear and unambiguous, and other design features require careful consideration, to reduce the possibility of unnecessary emergency callouts.

6. RECOMMENDATIONS

1. Those models of domestic CO alarm identified above as performing well should continue on field trial, to generate good quality long-term data.
2. New models of domestic CO alarm should be evaluated on a comparable basis to those already investigated, for possible inclusion in long-term assessments.

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Table 1. Domestic CO Alarms and Sensors Tested

NOTE: “Test” denotes initial assessment testing. “Trial” denotes extended field trialling.
* Denotes ambiguity between model numbers. ? Denotes results slightly below

Sensing Technology	Sensor Maker	Sensor Reference	CO Alarm Make And Model	Test	Trial	Comment
Reagent Gel	Quantum	Gel cell	BRK CO1000BE	Fail	None	-
			BRK FCD3EC	Fail	None	-
			COSTAR 9L-i	Fail	None	Earlier testing
			Dicon CO1100	?	?	New product
Semiconductor	Figaro	TGS 203	SF310 •	?	?	Earlier testing
			SF320 •	?	?	Earlier testing
			Pama GHD-2010 •	?	Fail	Earlier testing
			EI 225C	Pass	Fail	Significant drift
			Nighthawk 900-0081 *	Pass	?	Old product
		TGS 822	BRK WICOE	Fail	None	-
		TGS 2440	Gas Maestro GSS 2002	Fail	None	-
	FiS	SP-31	GasAlert	Fail	None	Earlier testing
		SB-50	New Age CO200 •	?	None	Earlier testing
			Dee Detecta 7 •	Pass	None	Old product
			Dee Detecta 9	Fail	None	-
		SC-50	Dicon CO805B	Pass	Fail	Significant drift
		SB-95	Simecon PG-21D	?	None	Earlier testing
			Fagor DGM100	Pass	?	New product
	ScimArec	AF22C	Anglo-Nordic 570 1200	Fail	None	-
			GasGuard G021CO HW	Fail	None	-
	New Cosmos	CH-C	Schlumberger XH-443B	Pass	Fail	Significant drift
	Unknown	2M003	Technotrend CO350 •	Fail	None	-
Electro-chemical	City	3E/7E	GasWatch 200	Fail	None	-
		-	AIM SAS-IDR BS	Fail	None	Earlier testing
	SF Detection	MIDI 40	SF330KM	Pass	Pass	Low drift
			SF340E	?	Pass	See SF330KM
			SF350	Pass	Pass	New product
			Nighthawk 900-0089 *	Pass	None	Old product
			EI 204 & 5	Pass	Pass	See SF330KM
	Kidde	-	N/hawk 900-0081 & 2 *	Pass	?	New versions
			N/hawk 900-0089 & 90*	Pass	?	See 0081 & 2
	Monox	-	S-Tech test-bed	Pass	?	Prototype
	Senco	-	Model 2001	Pass	Pass	Low drift
			Models 2002 & 3	Pass	Pass	See Senco 2001

“Pass”.

• Denotes model has been withdrawn from the market.

Table 2. Domestic CO Alarm Battery Lifetimes

Make and Model of CO Alarm	Number of Units Investigated	Number and Type of Battery	Typical Battery Life (years) [1]
Aim SAS-IDR	3	3xNon-replaceable	(1 to 5) [2]
COSTAR 9L-i	1	1x9v PP3	2
Dicon CO1100	5	1x9v PP3	>0.5
EI 204/205	5	3x1.5v AA	>2
FirstAlert CO1000	3	1xSensor Module	(1.5) [3]
FirstAlert FCD3EC	1	1x9v PP3	2.5
Monox/S-Tech	1	1x9v PP3	2
Nighthawk Deluxe	2	3x1.5v AA	2
Senco 2001	6	1x9v PP3	2
Senco 2002/2003	2	1x9v PP3	>1
SF330KM	20	1xNon-replaceable	(4.5) [4]
SF340E	1	1x9v PP3 or mains	1.5
SF350	6	1xNon-replaceable	>0.5

Notes:
1. Greater-than (>) symbol indicates no battery failures recorded so far.
2. Early Aim units had much shorter battery life.
3. FirstAlert CO1000 unit battery outlasts acceptable alarm performance.
4. SF330KM tested in sufficient numbers to allow Weibull statistical analysis (see reference 3).

Figure 1. SF310 Domestic CO Alarm

Figure 2. SF340 Domestic CO Alarm

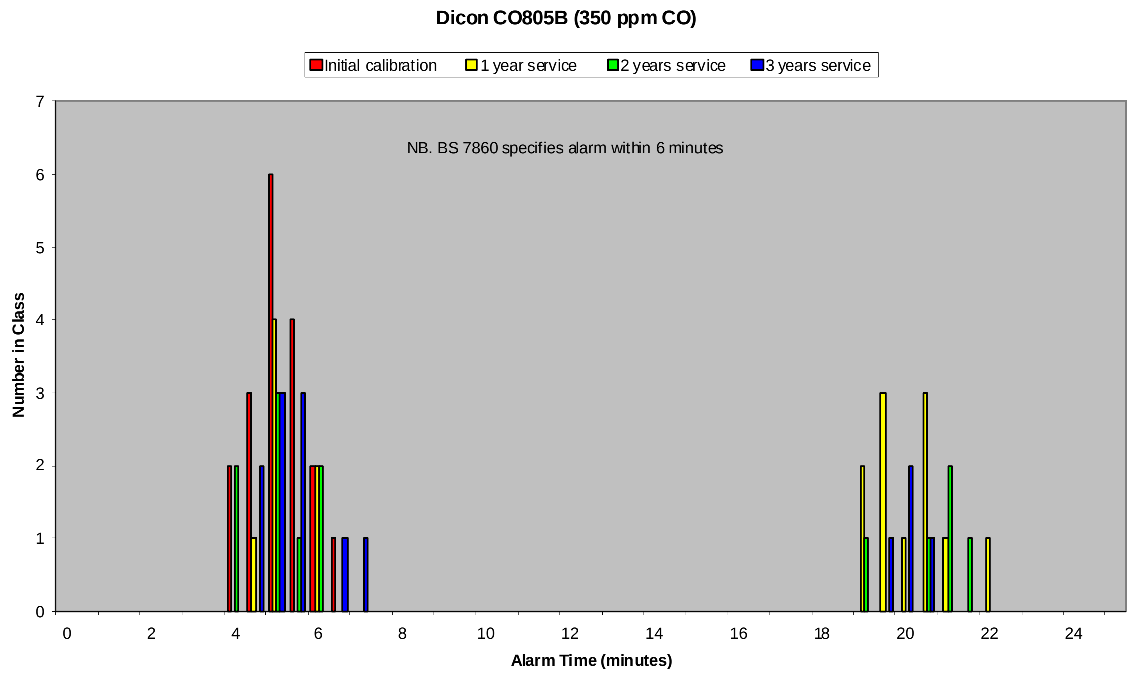
Figure 3. EI 204/205 Domestic CO Alarm

Figure 4. Senco 2002/2003 Domestic CO Alarm

Figure 5. SF350 Domestic CO Alarm

Figure 6. Dicon CO1100 Domestic CO Alarm

Figure 7. Dicon CO805B Field Trial Results



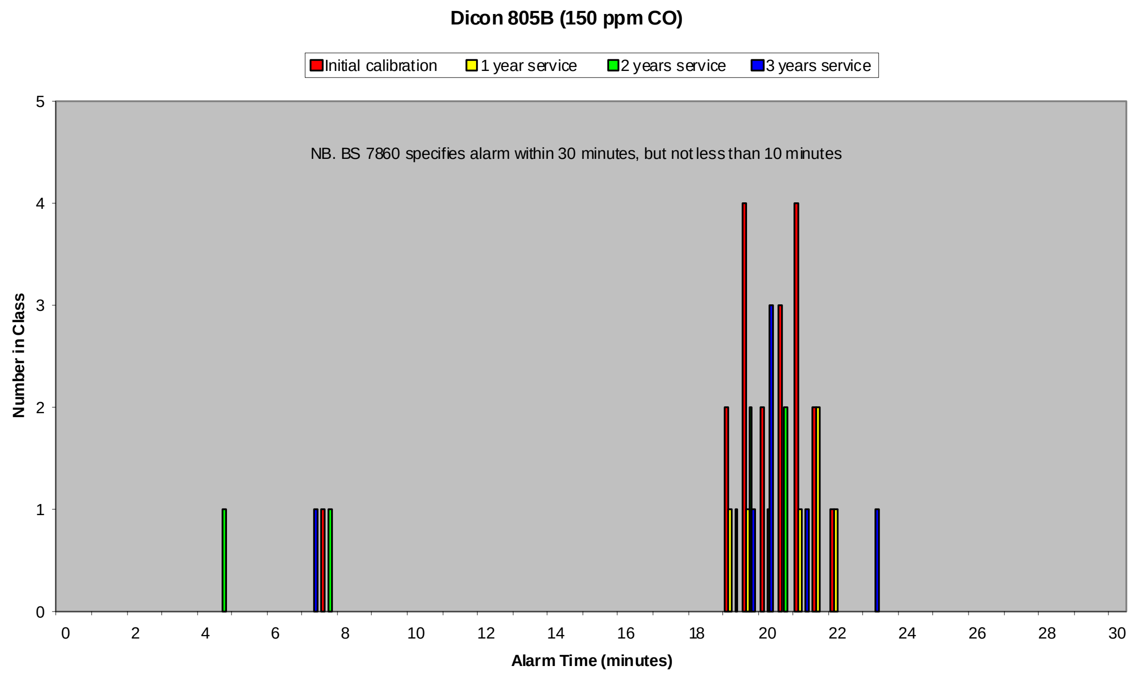
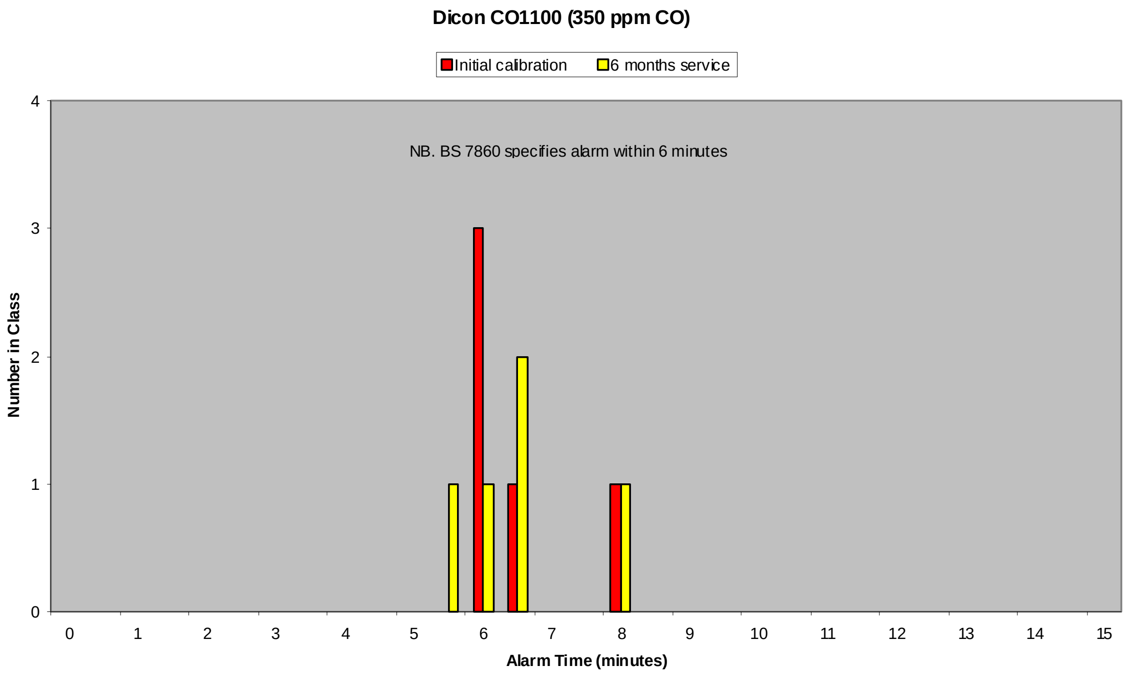


Figure 8. Dicon CO1100 Field Trial Results



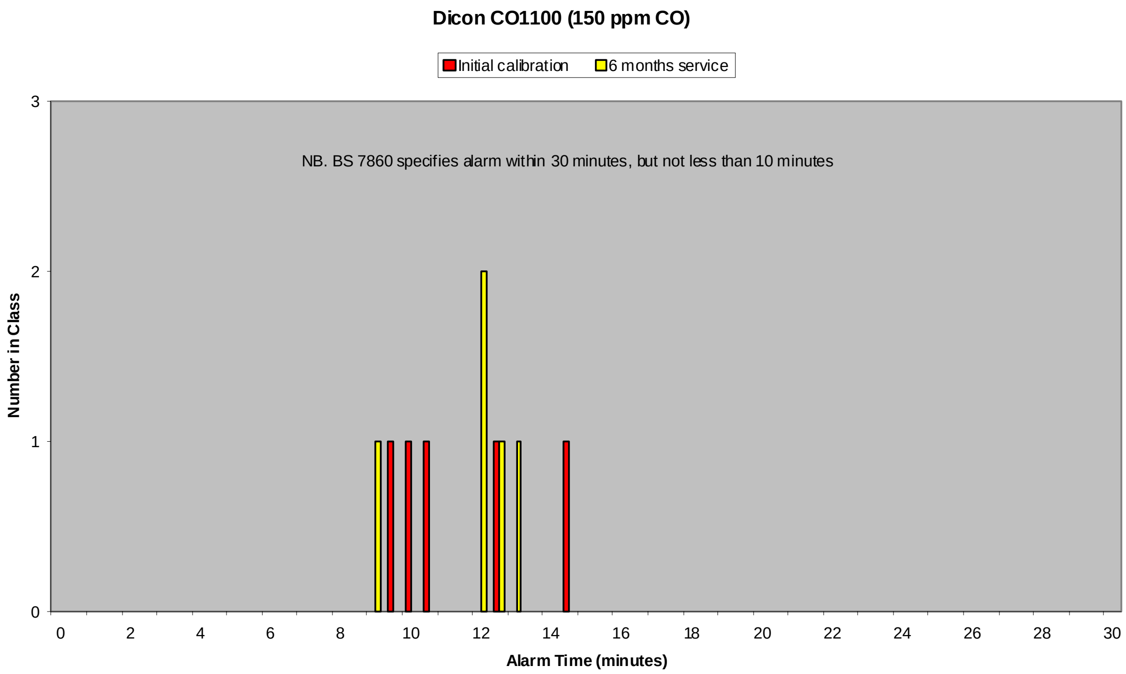
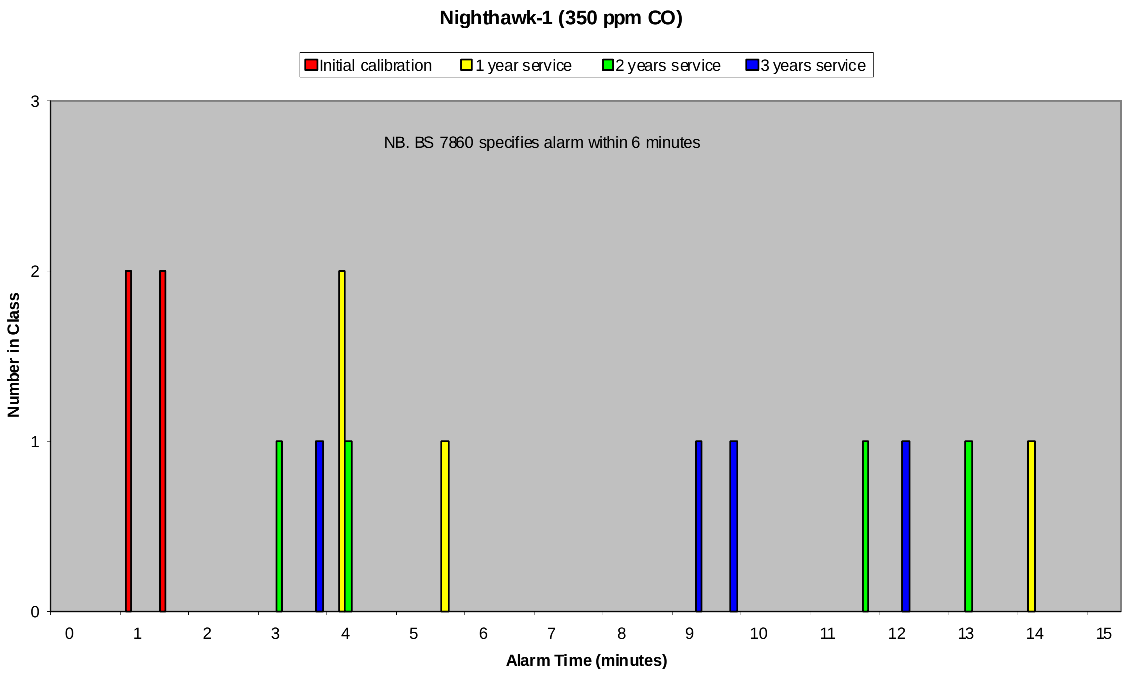


Figure 9. Kidde Nighthawk-1 Field Trial Results



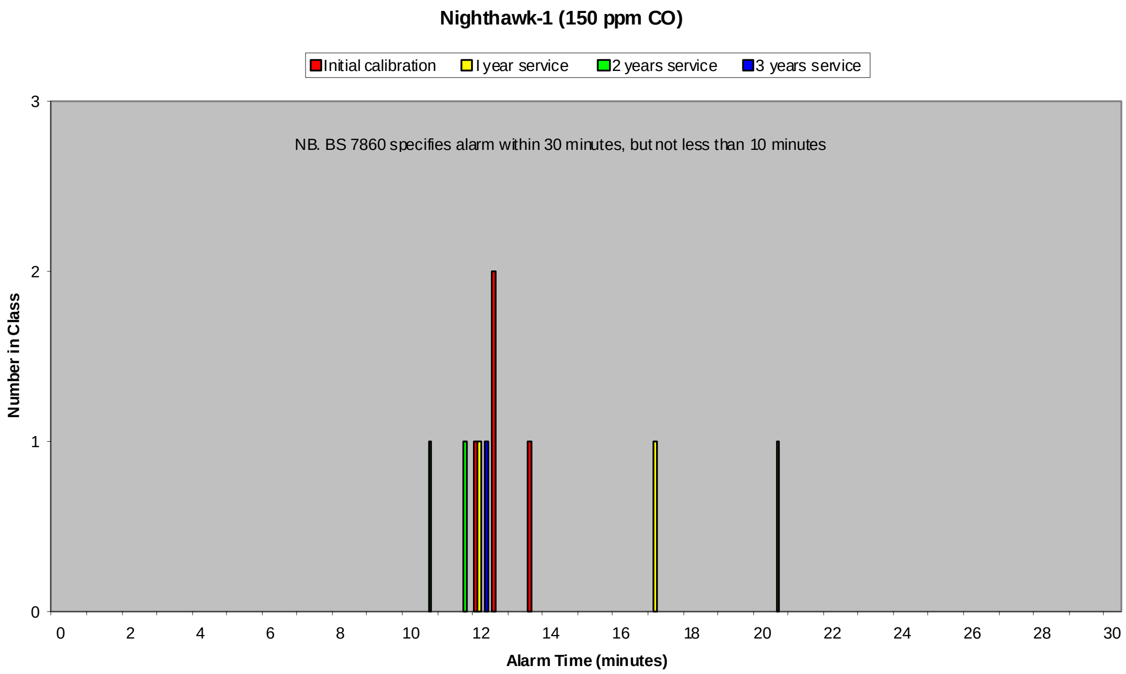
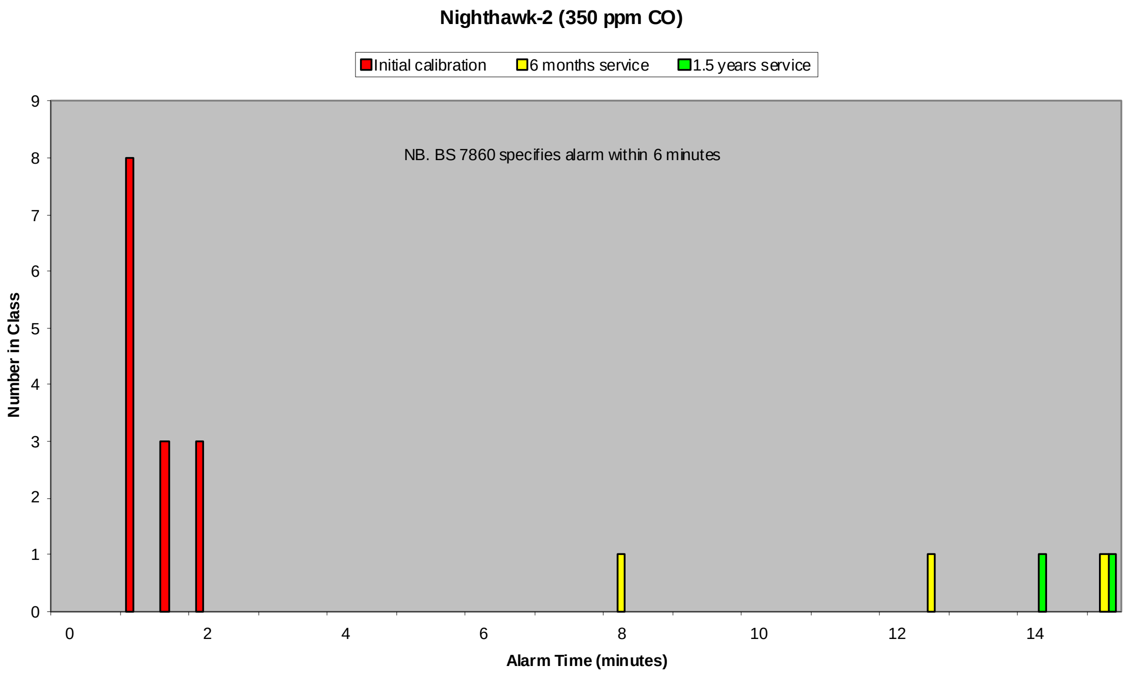


Figure 10. Kidde Nighthawk-2 Field Trial Results



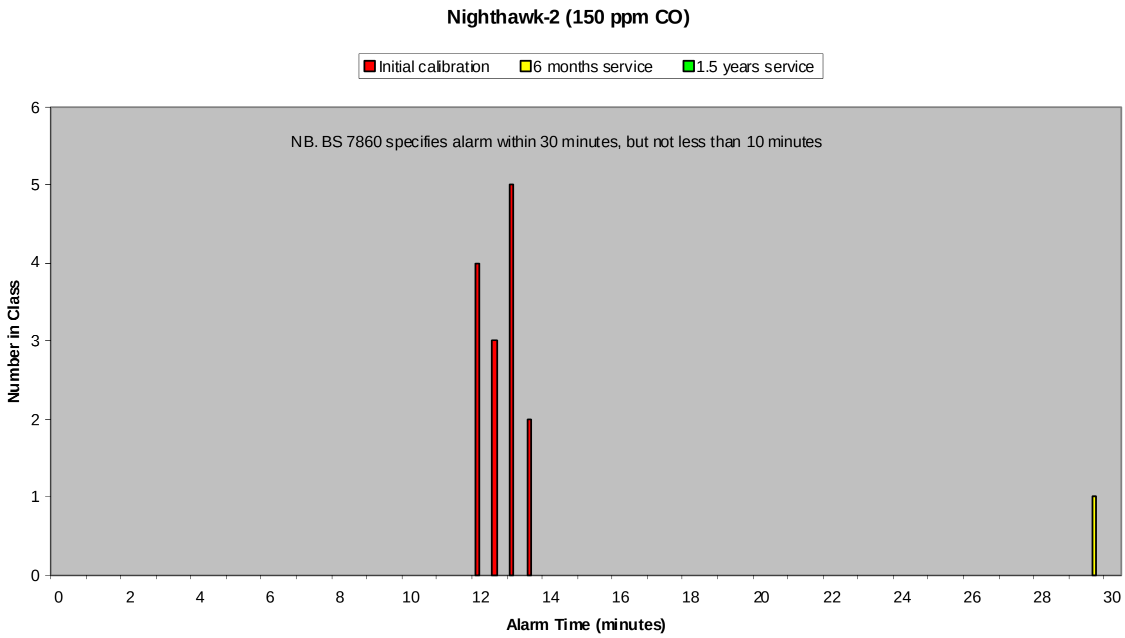
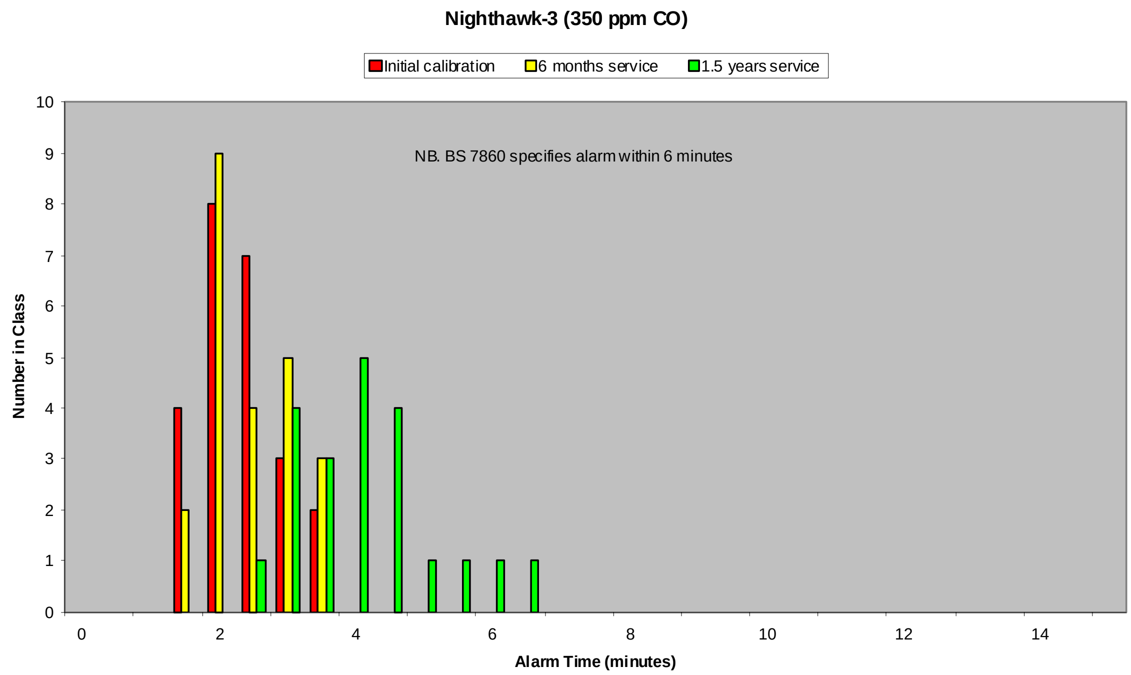


Figure 11. Kidde Nighthawk-3 Field Trial Results



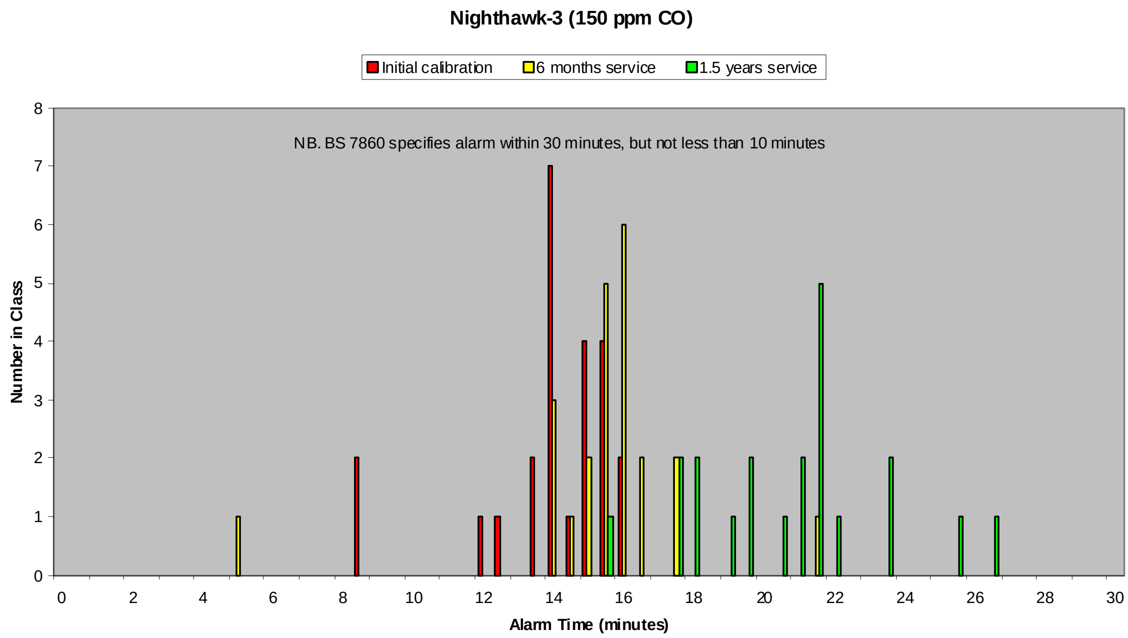
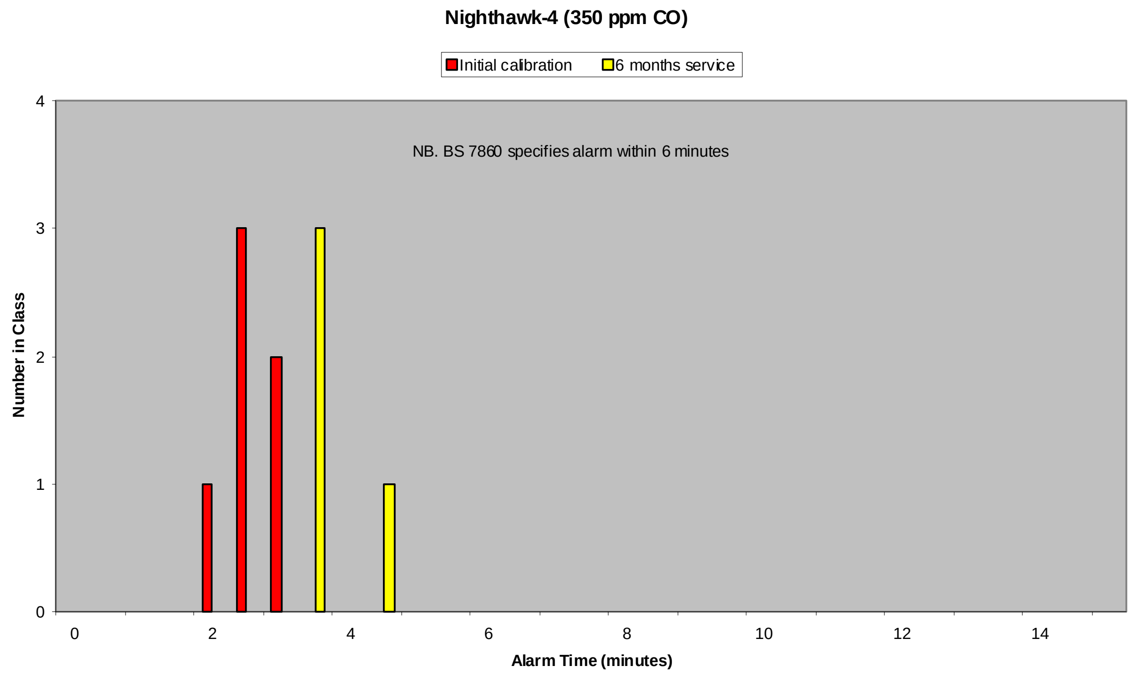


Figure 12. Kidde Nighthawk-4 Field Trial Results



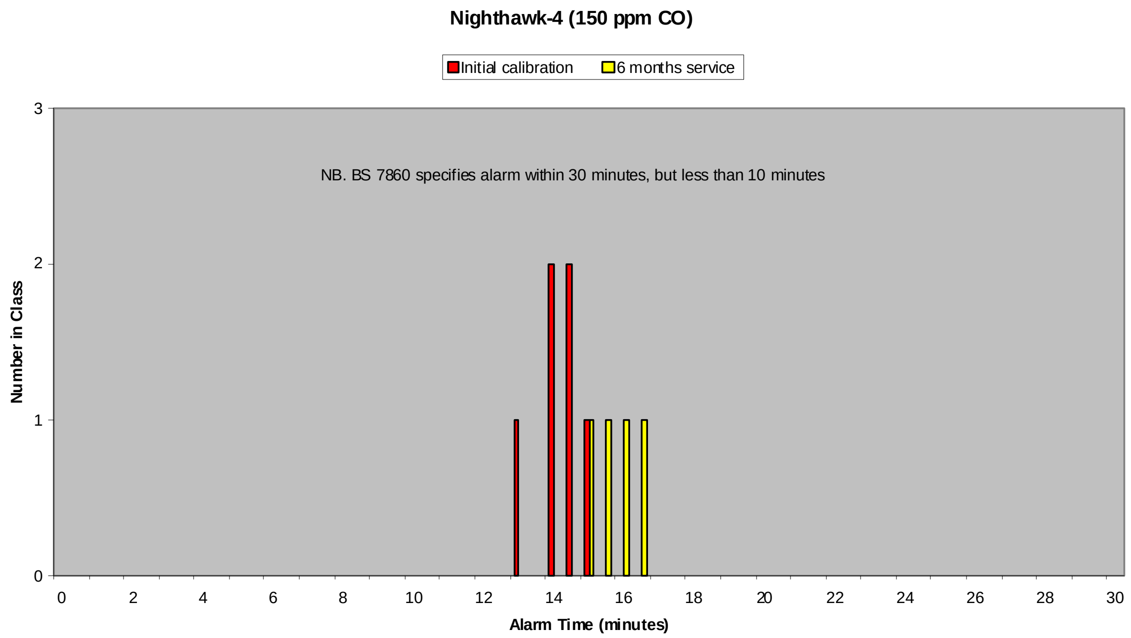
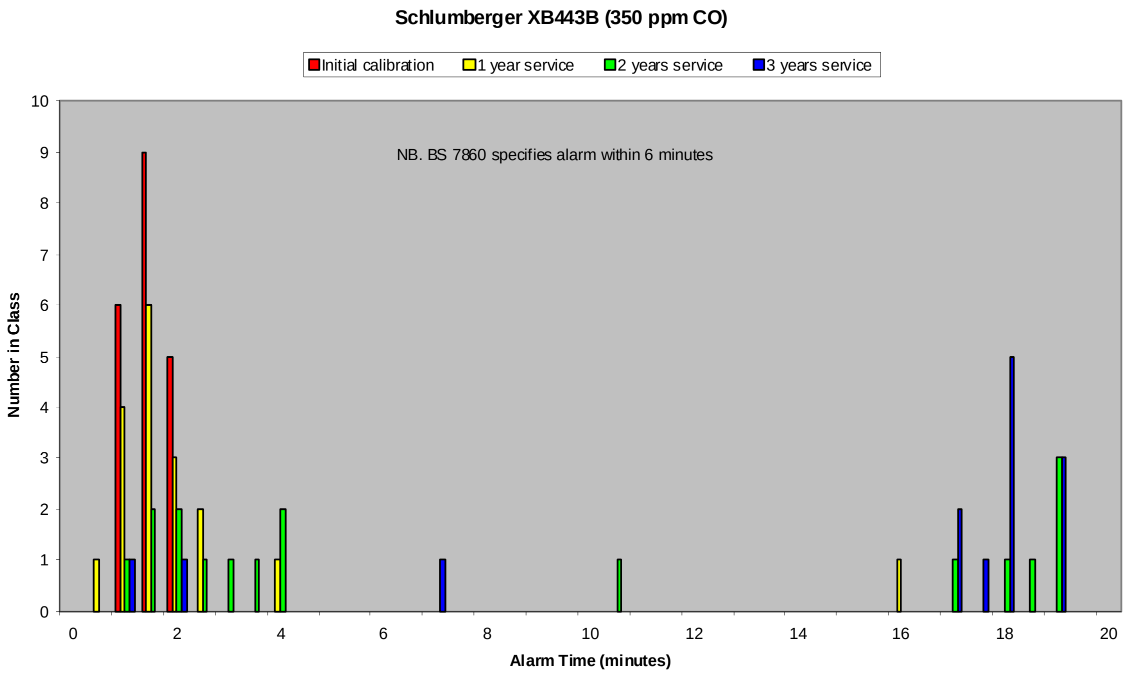


Figure 13. Schlumberger XH-443B Field Trial Results



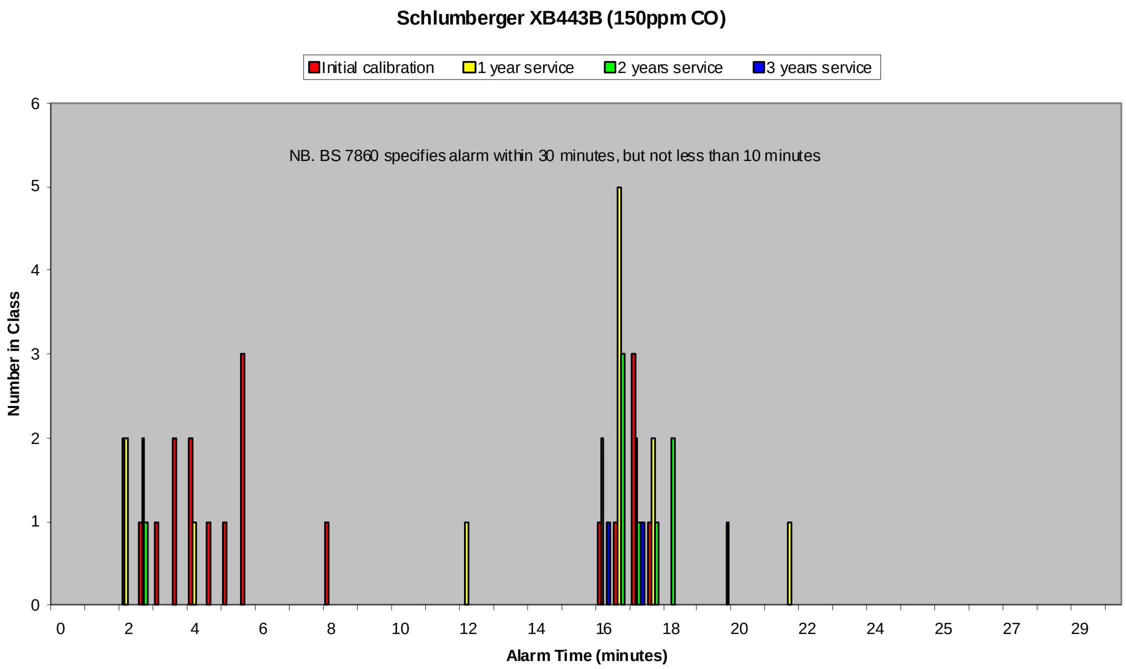
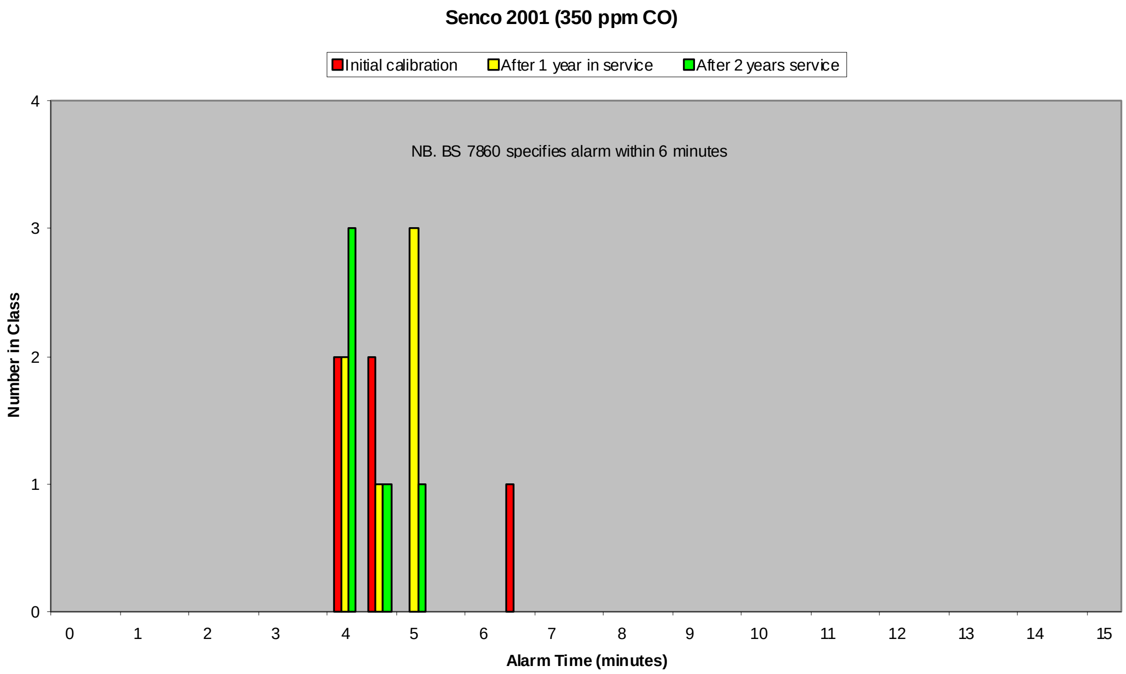


Figure 14. Senco 2001 Field Trial Results



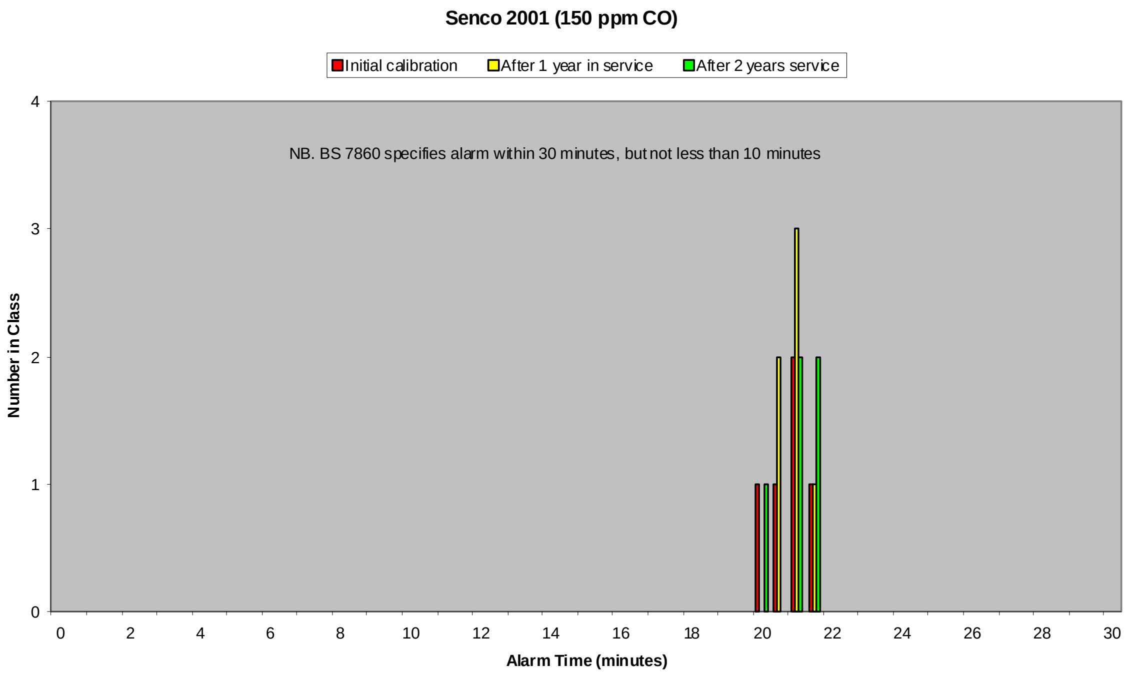
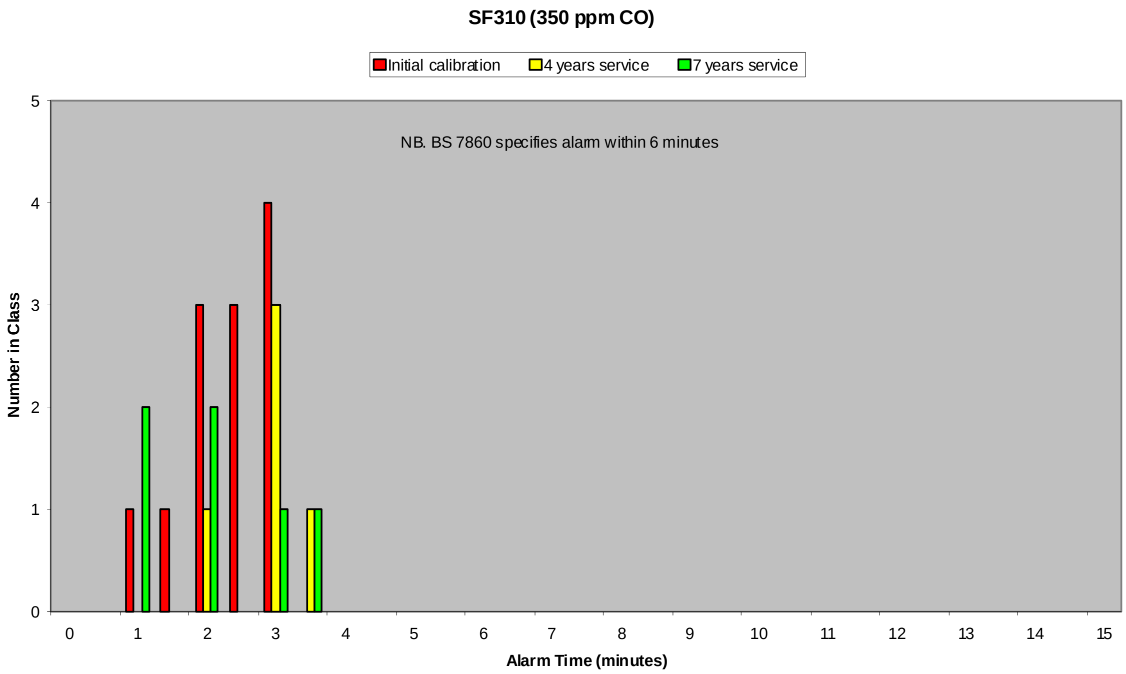


Figure 15. SF310 Field Trial Results



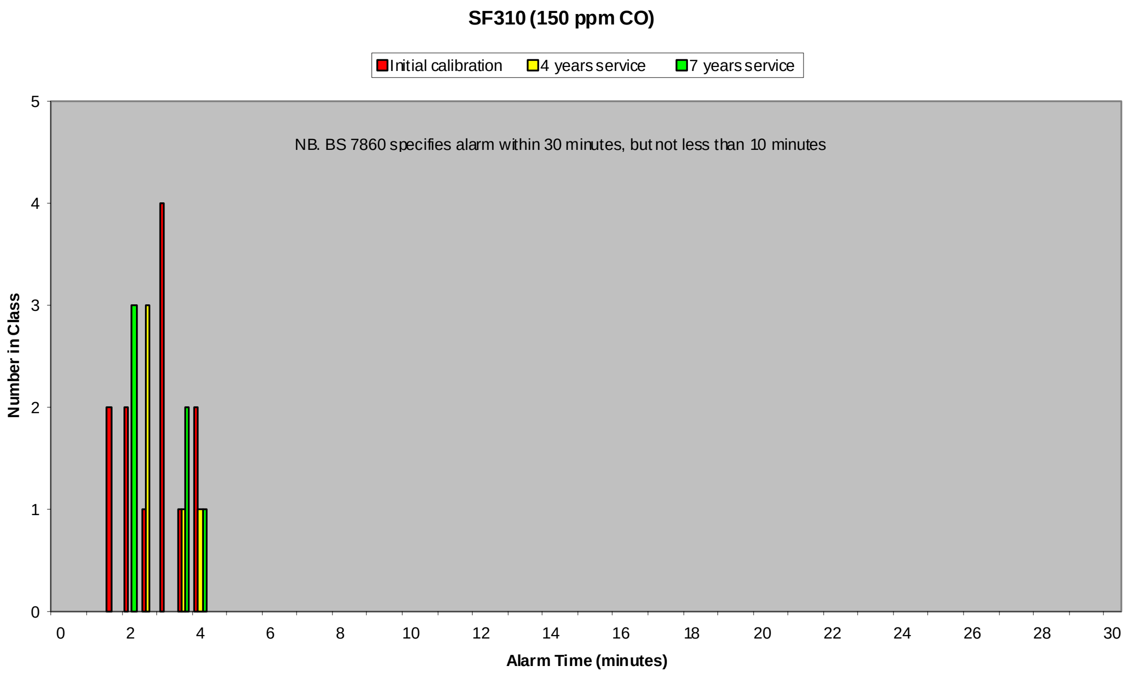
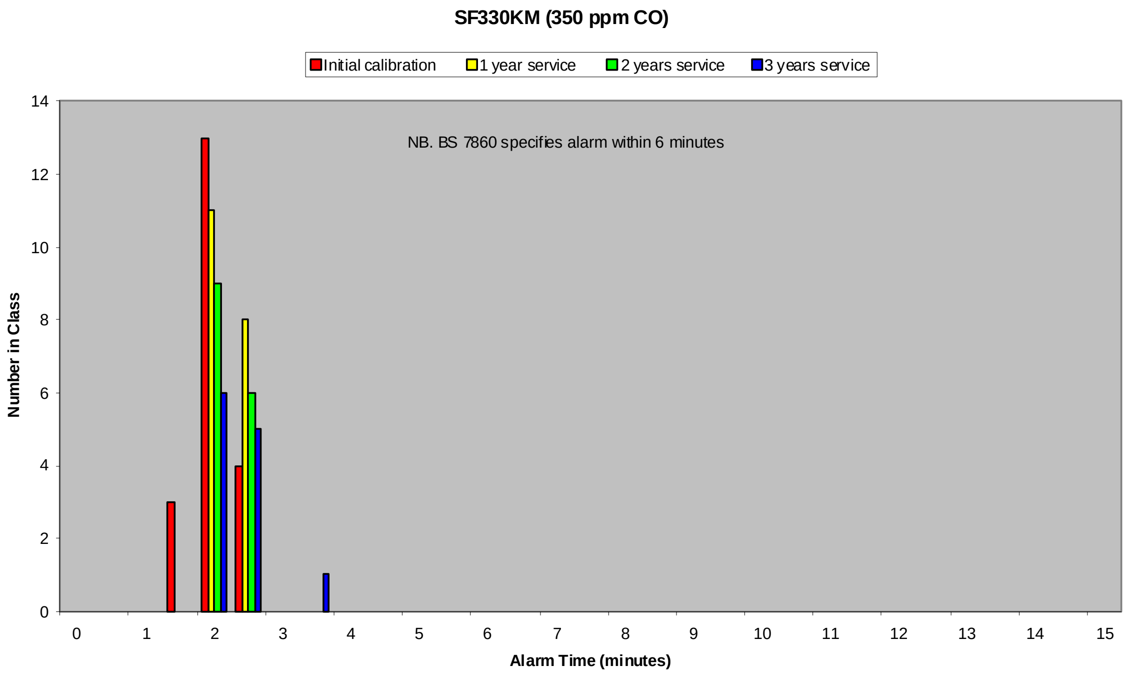


Figure 16. SF330KM Field Trial Results



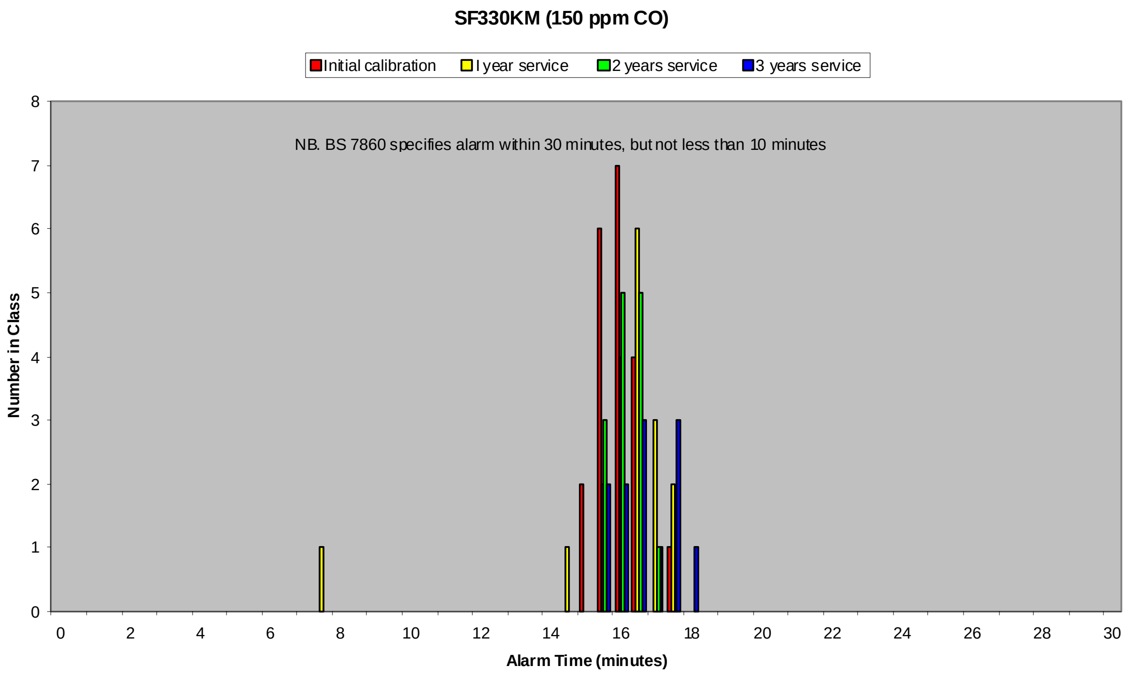
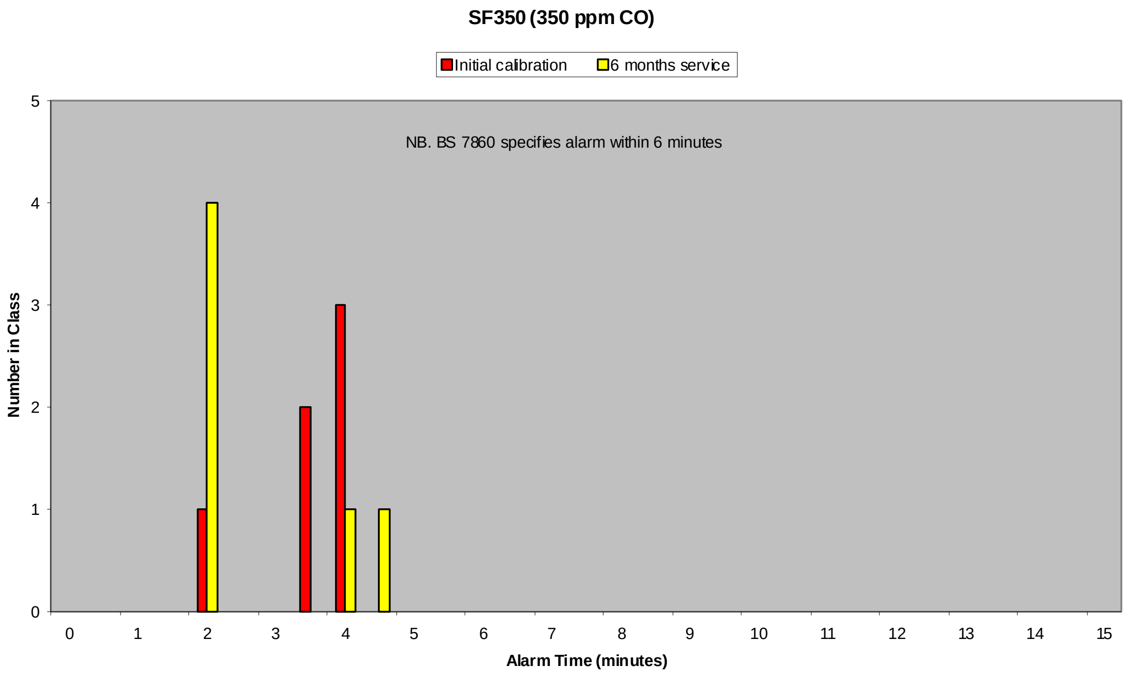
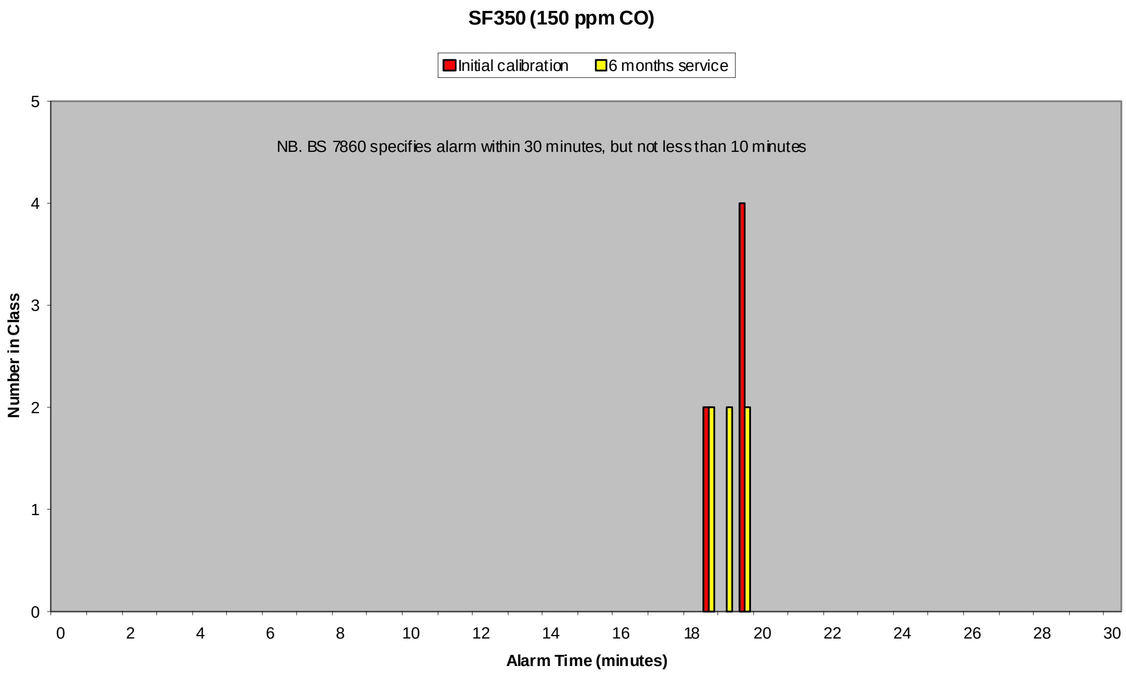


Figure 17. SF350 Field Trial Results





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