

**REPORT INTO THE GAS EXPLOSION INCIDENT
AT 16 BUCKSTONE GROVE, EDINBURGH
ON 30 NOVEMBER 2005**

APRIL 2006

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1. SUMMARY

At approximately 15:20 Hrs on Wednesday 30th November 2005 an explosion and fire affected the property at 16 Buckstone Grove, Edinburgh.

As a consequence of these events, the sole occupant of the property at the time of the incident suffered severe burns, requiring hospital treatment. The property itself was severely damaged.

Subsequent examination and investigation revealed the following:

- The explosion and ensuing fire were as a result of the accumulation of natural gas in the property, the accumulation being concentrated in the void under the ground floor.
- The 4" low pressure, cast iron, gas main located under the public footway to the front of the property was found to have failed in a sagging mode, causing a circumferential fracture.
- Migration of gas from the fractured main is likely to have tracked into the property via unsealed service entry points following permeation through the soil.
- The internal gas pipework within the property was found to be non-gas tight, but evidence indicates this to have been caused either by the explosion or subsequent fire.
- Metallurgical examination of the broken section of gas main showed signs of fissure corrosion¹ along the bottom of the main.
- A concrete section water valve chamber positioned in close proximity to the gas main is likely to have contributed to the failure by acting as a pivot point.
- The 4" cast iron main at Buckstone Grove was part of an established prioritised mains replacement programme. However, as there was no history of problems associated with this section of main, it had a low risk rating and therefore was not scheduled for replacement for a number of years.
- There is no evidence to support that any breach of relevant safety legislation has occurred and consequently HSE do not consider that any enforcement action is appropriate.

¹ Fissure corrosion is a form of stress-accelerated corrosion, which can initiate at tensile stress levels as low as 40% of the failure stress of the material. Cracks form in association with graphitic corrosion, which can then lead to premature failure.

It is concluded that the explosion and fire at 16 Buckstone Grove were caused by an accumulation of natural gas in the under floor void. The gas had accumulated under the property as a result of it tracking through the ground from the fractured gas main in the footway to the front of the property. The source of ignition cannot be established conclusively but it is most likely to have been either the central heating control unit located under the living room floor or the back boiler burner.

2. SITE

2.1 THE PROPERTY

No 16 Buckstone Grove is a semi-detached two-storey dwelling house, of traditional construction, built in the 1960's.

The location of the property is as shown in Figure 3 and a diagram showing the ground floor layout of the property is shown in Figure 1.

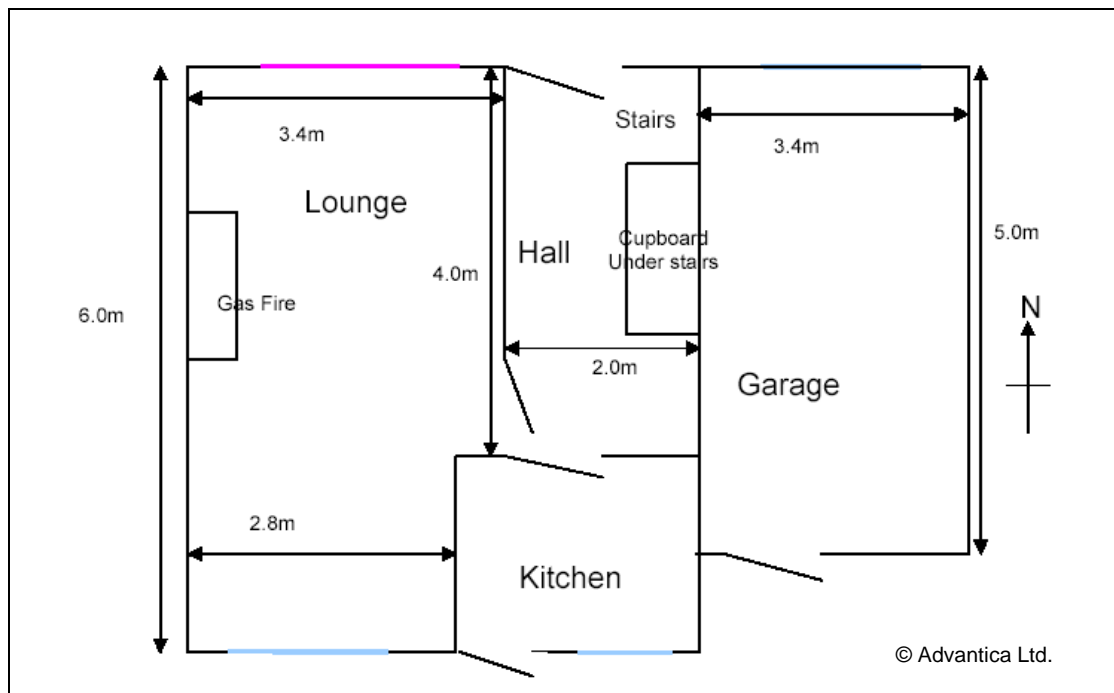


Figure 1 - Ground floor plan of 16 Buckstone Grove

2.2 SERVICES TO THE PROPERTY

2.2.1 Gas

The gas supply to Buckstone Grove was by means of a 4" cast iron, low pressure main, which ran parallel to the front of the property, under the public footway. The main was mechanically jointed and positioned in the centre of

the footway. Prior to the incident the system was operating at 25 – 30 mbar, which was the normal operating pressure for this system. Details of the gas mains in the area of Buckstone Grove are shown in Figure 3.

Leading from the 4" main there was a 25mm polyethylene (PE) service pipe supplying 16 Buckstone Grove. This ran underground, beneath the front lawn up to the front elevation of the property where it surfaced to terminate at an emergency control valve (ECV) within an externally mounted meter box. A semi-rigid steel connector ran from the ECV to a U6 type gas meter.

Copper piping then led from the meter outlet, down to ground level before passing through the house wall into the property, below floor level. This pipe branched in the under floor void below the living room. A short branch led to the living room fire and back boiler. A second branch then travelled parallel to the front of the property into the void under the hall floor before changing level and executing a 90-degree turn and entering the kitchen under floor void to supply the cooker. No other gas appliances were installed in the property.

Prior to the installation of the PE service described above, No 14 and No 16 had originally shared a steel service that also connected to the 4" cast iron main. The steel service branched to supply the two properties, at a point in the front garden of No 16. The branch to No 14 is still operational, but the branch to No 16 was cut and capped at both ends when the PE service was installed. Within the property, it terminated at a capped meter control valve in the under stairs cupboard in the hallway.

The relative positions of the gas mains, services and internal pipework are shown in Figure 2.

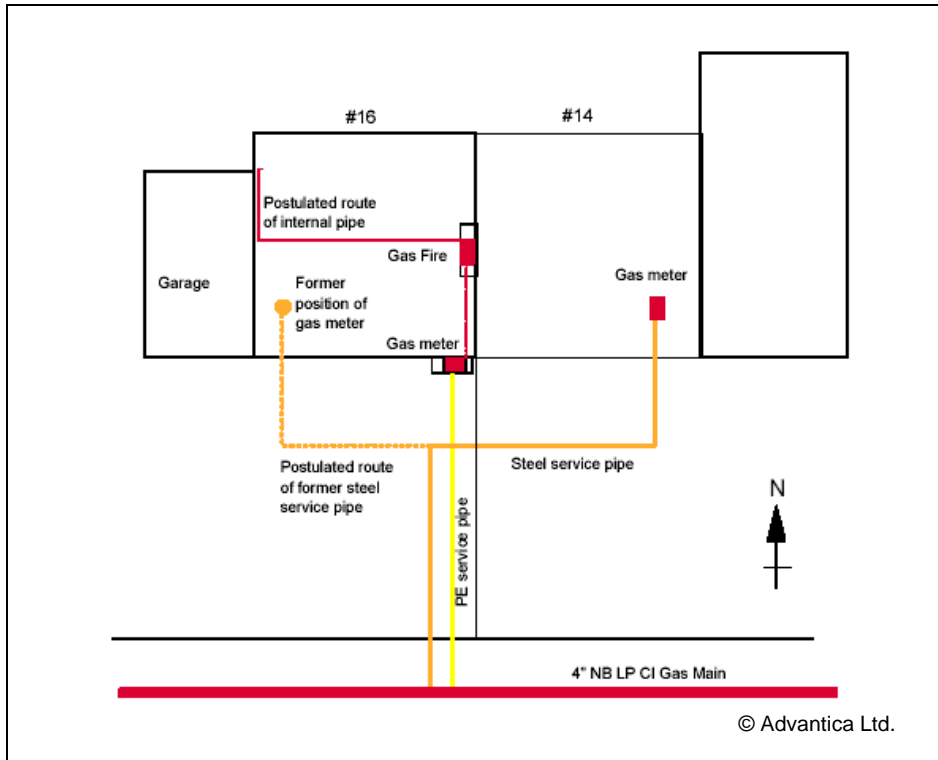


Figure 2 - Gas services to No's 14 & 16 Buckstone Grove

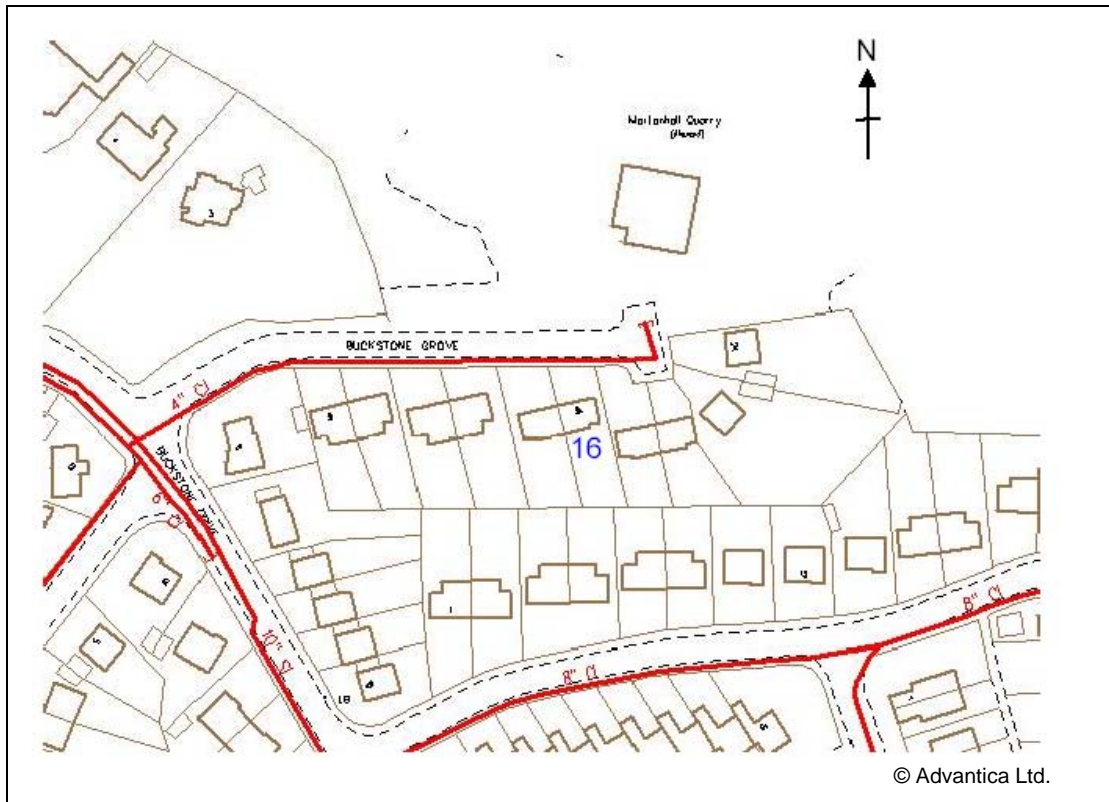


Figure 3 - Gas mains local to Buckstone Grove

2.2.2 Electricity

The electricity supply to Buckstone Grove ran close to and parallel to the gas main under the footway. The supply branch to No 16 ran from the street supply, at a point near the fractured gas main, to the front of no 16 where it entered the property underground, close to the front door. The cable passed under the outer wall of the property via a 4" unsealed clay pipe. The supply terminated at a consumer unit located in the hall of the property.

2.2.3 Other Utilities

The water main to Buckstone Grove also ran close to the gas main under the footway, being above the gas main and located closer to the roadway. The water service to No. 16 passed over the top of the gas main at the point where the gas main failed. Located on the water service was an isolation valve that was contained in a sectional concrete chamber (toby) built over the gas main. The water service entered the property underground at a point close to the electricity supply, in the area of the front door.

Foul and surface water drainage was via the rear of the property to the public sewerage system

A cable television supply ran in the footway parallel to the gas main at a much shallower depth. A branch of this cable supplied No16, passing under the lawn to reach the property at the area of the living room window.

The relative positions in plan of the utilities supplying the property are shown in Figure 4 and the relative positions within the footway of the utilities are shown in Figure 5.

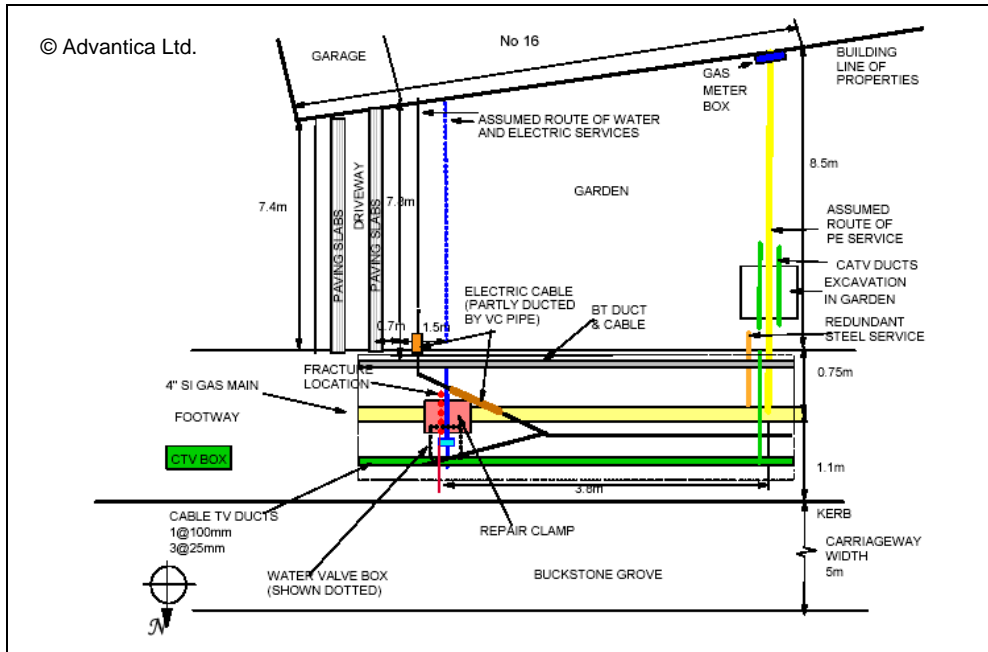


Figure 4 - Plan of utility services outside No 16 Buckstone Grove

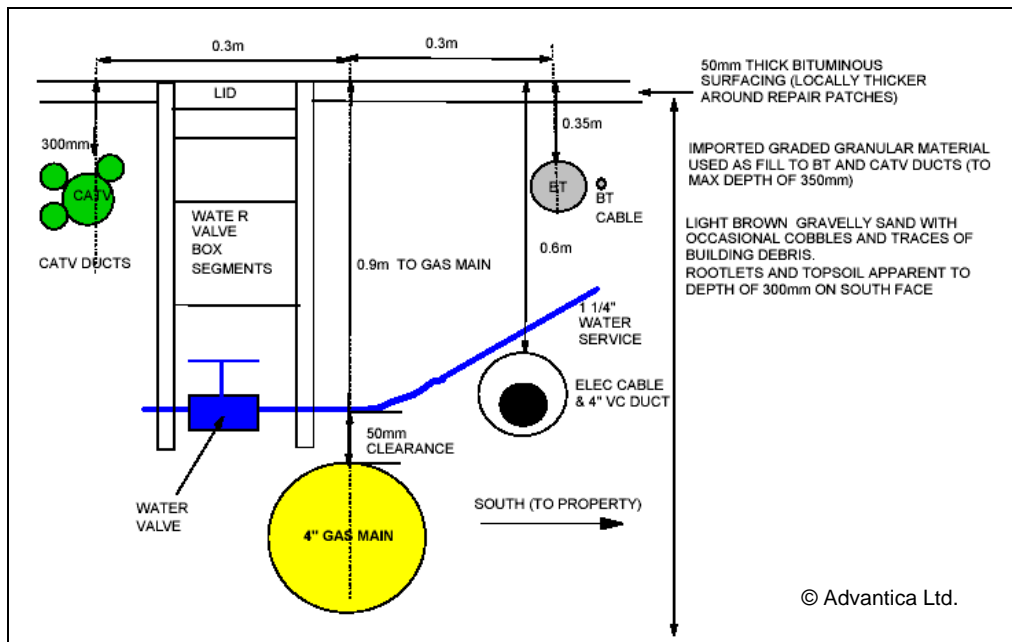


Figure 5 - Section through footway showing utilities at point of pipe failure

3. SEQUENCE OF EVENTS

- 1) Prior to the incident on Wednesday 30th November, there had been no reported gas leaks in the vicinity of Buckstone Grove.
- 2) At approximately 15:20 an explosion and subsequent fire occurred at No 16 Buckstone Grove, Edinburgh
- 3) At 15:24 an ambulance arrives on site and paramedics attend to the sole occupant (at the time of the incident) of 16 Buckstone Grove who has been badly burnt. The injured person is taken to hospital at 15:40 following initial treatment on site.
- 4) The fire brigade arrive on site at 15:30.
- 5) A first call operative from Scotland Gas Networks (SGN) arrives on site at 15:58 and requests further assistance. At this time the fire is well established, particularly in the roof space, front door hallway and the under-stairs area.
- 6) Subsequently further personnel from SGN arrive on site to assist the Emergency Services and undertake work to isolate gas supplies to affected properties and secure the gas escape.
- 7) Personnel from the electricity and water utility companies attend site to shut off their respective supplies.
- 8) By 22:15 SGN personnel locate a fracture on the 4" iron gas main located in the footway outside No 16. They also locate a concrete water toby at the same location, which they remove in order to effect a repair to the gas main.
- 9) At approximately 23:45 repairs are completed to the damaged gas main.
- 10) The cast iron gas mains (including the repaired section) in Buckstone Grove and surrounding area were later replaced by SGN with polyethylene (PE) pipes.

4. INVESTIGATION

4.1 THE PROPERTY

16 Buckstone Grove is a conventionally built, semi detached dwelling. Walls are of brick and block construction with a tiled roof.

The ground floor is of suspended timber construction.

The windows and front door are of sealed unit double-glazed construction in UPVC frames.

As a result of the incident the property was very extensively damaged by the initial explosion and subsequent fire. There was evidence of heave of the living room floorboards indicating an explosion in the under-floor void. Some of the windows and the front door were propelled into the front garden and street and glass fragments were found up to 15m in front of the property, indicating that a significant explosion had occurred. The incident also impacted on adjacent property, with some of the damage caused by smoke and water.

4.2 INTERNAL GAS PIPEWORK

Pressure testing of the internal gas pipework after the incident showed it not to be gas tight. Further investigation revealed this to be as a result of a failed solder joint on a section of the pipework under the hall floor. More detailed examination of the joint showed that it appeared to have been originally sound and was more likely to have been disrupted as a result of the explosion and fire.

4.3 GAS SERVICE

The PE service pipe supplying No16 was pressure tested with air and there were no leaks noted on this pipe.

4.4 CAST IRON GAS MAIN

Initial examination of the 4" cast iron main in situ showed it to be bedded in a sandy/gravelly soil with no noticeable soft spots or hard inclusions within the bedded material. The gas main had fractured circumferentially with the fracture surfaces coming apart slightly at the bottom of the pipe. Inclinometer measurements showed the line of the main to be running downhill slightly

from east to west. However, the angle of slope was greater to the east of the fracture than that to the west of the fracture, indicating a slight sagging at the point of fracture.

A section of the gas main, including the fracture area, was removed for laboratory examination.

Metallurgical examination of the removed section of main showed a circumferential through wall fracture around the majority of the pipe circumference and signs of fissure corrosion along the bottom of the pipe, where the fracture initiated. Otherwise, the pipe was found to be in generally good condition with the fracture propagating mainly through sound material.

The material and physical characteristics of the main were in accordance with the standards in existence at the time that it was laid.

4.5 LOCAL ENVIRONMENT

A majority of the properties in Buckstone Grove, including No16, have been built on land that has been identified as probable infill land resulting from operations at the adjacent quarry. It is understood that the area was used to store materials from the quarry operations and that it would have been levelled prior to house building. Such material would likely have been subject to limited compaction and thus may have a tendency to settle.

Analysis of soil in the excavation close to the fracture showed no factors likely to have caused any significant corrosion of the pipe.

There were no joints in the pipe close to the fracture that could have contributed to the failure. Nor were there any inclusions in the pipe bed itself that may have acted as pivot points.

There was evidence of ground movement in the vicinity; this included kerbs that had been moved, uneven surfaces and cracks and potholes in the footway.

A water toby was located above the gas pipe (see Fig 5), although it cannot be established if it was in direct contact with the pipe. The structure of the toby is shown in figure 6. If not in direct contact it was very close to the pipe and in a position to act as a pivot point or as a means of applying a surface load to the pipe.

The inclusion of a solid object, like the water toby, in the highway material, could effectively transmit any surface stress to the pipe. Highways contractors using heavy goods vehicles were reported as using Buckstone Grove in the period before the incident. In particular there were reports that HGV's were carrying out multiple point turns in the area outside No16, utilising an entrance gateway to the former Mortonhall quarry, directly opposite the property. It is

believed that these manoeuvres involved vehicles mounting the footway outside No16.

The water toby is likely to have contributed to the pipe failure by acting as a pivot point promoting sagging flexure, leading to fissure corrosion along the bottom of the pipe. It is also possible that the toby could have played a part in transmitting force from heavy vehicles driving on the footway, to the pipe. However it is considered that the most likely scenario is that the fracture of the weakened main resulted from ground instability, as a result of the nature of the local ground, allied with the pivot point created by the toby.

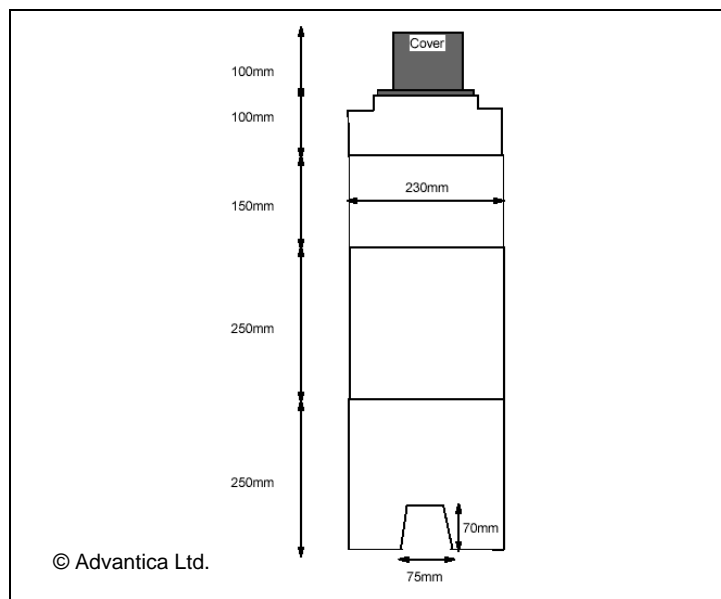


Figure 6 - Diagram to show structure of water toby.

5. MAINS REPLACEMENT

To comply with the Pipelines Safety Regulations [PSR] 1996, gas conveyors/pipeline operators are required to maintain their networks in a safe condition.

In respect of iron gas mains, there is currently no feasible alternative to maintaining the network other than to decommission it and replace it with a more suitable material, usually polyethylene. This is the basis of HSE's enforcement policy, published in September 2001, which required iron gas mains within 30m of property to be decommissioned within 30 years.

In support of that policy PSR was amended in 2003 to make provision for HSE to approve a programme submitted by a pipeline operator for the decommissioning of iron pipes. This includes cast and ductile iron pipes but not pipes made from steel or other materials. The intention was to give legal underpinning to HSE's Enforcement Policy and was principally aimed at major

distribution networks which, because of their size, have practicable constraints on how much main can be replaced each year.

The replacement of iron mains is prioritised using a model initially developed by Transco in consultation with HSE. The model provides a risk score for each section of iron main so that higher risk mains can be targeted earlier within the replacement programme.

If pipeline operators have an approved programme, they have a defence from prosecution if they are complying with it and a failure occurred on a pipe which was not yet due for replacement under the programme.

An approved programme for the Scotland distribution network was put in place by Transco when the network was operated by National Grid Transco. The Scotland network was subsequently sold in 2005 to Scotland Gas Networks Plc, a subsidiary of Scotia Gas Networks Plc who have continued with the replacement programme approved by HSE.

The fractured section of 4" cast iron main at Buckstone Grove was part an established prioritised mains replacement programme. However, as there was no history of problems associated with this section of main, it had a low risk score and therefore was not due for replacement within the programme for a number of years.

More detailed supporting information on the replacement of iron gas mains can be found on the gas supply section of the HSE website:

<http://www.hse.gov.uk/gas/supply/index.htm>

6. CONCLUSIONS

1. The explosion and subsequent fire at 16 Buckstone Grove was caused by an accumulation of natural gas mixed with air in the property. In particular the damage to the floorboards in the living room indicate that the initial explosion occurred in the under-floor void.
2. The source of gas was from a circumferential fracture of the 4" cast iron gas main located in the footway outside the property, which had failed in sagging mode.
3. The gas tracked through the permeable soil at the front of the property and most probably entered the property through the lines of the water and electricity service entries.
4. The water toby is likely to have contributed to the pipe failure by acting as a pivot point promoting sagging flexure, leading to fissure corrosion along the bottom of the pipe. It is also possible that the toby could have played a part in transmitting force from heavy vehicles driving on the footway, to the pipe. However it is considered that the most likely scenario is that the fracture of the weakened main resulted from ground instability, as a result of the nature of the local ground, allied with the pivot point created by the toby.
5. Metallurgical examination of the failed pipe showed that there were signs of fissure corrosion along the bottom of the pipe. This is consistent with the pipe being flexed in a sagging mode over a protracted period of several months or years.
6. The 4" cast iron gas main that failed in Buckstone Grove had been prioritised in line with the SGN mains replacement risk model and programme. Its risk score prior to the incident was such that it would not have normally been identified for replacement for a number of years.

7. FOLLOW UP ACTIONS

Investigation of this incident has revealed no evidence of any breach of relevant safety legislation and consequently HSE do not consider that any enforcement action² is appropriate in this case. However, there are some issues and actions arising from the incident that either already have or will be taken forward as follows:

- 1) A programme of iron mains replacement was completed in the Buckstone Grove area, following the incident. This was undertaken by SGN, in addition to pipes previously identified for replacement under their 2005/06 iron mains replacement programme, to help reassure local residents.

- 2) A review of the issues associated with the installation and close proximity of sub-surface structures to iron gas mains is to be undertaken between SGN and the other utility companies concerned. The key objective is to determine the likely significance and extent of the issue and to identify any reasonably practicable measures which can be implemented to help reduce the likelihood of similar incidents.

- 3) SGN are to review their mains replacement survey criteria to take account of any new potential ground movement factors noted from the circumstances surrounding this incident.

² HSE Inspectors use various enforcement techniques to deal with risks and secure compliance with the law, ranging from the provision of advice to enforcement notices. They can also initiate or recommend prosecution where the circumstances warrant punitive action.