

**SHERIFFDOM OF GRAMPIAN, HIGHLAND AND ISLANDS at LERWICK**

**FAI 2010 10**

**DETERMINATION**

**by**

**SHERIFF GRAEME NAPIER ESQ**

**in**

**THE INQUIRY UNDER THE FATAL  
ACCIDENTS AND SUDDEN DEATHS  
INQUIRY (SCOTLAND) ACT 1976**

**Held on 18 & 19<sup>th</sup> August 2008, 19<sup>th</sup>, 20<sup>th</sup>  
and 21<sup>st</sup> and 22<sup>nd</sup> January 2009, 24<sup>th</sup>  
February 2009, 23<sup>rd</sup> March 2009 and 21<sup>st</sup>  
& 22<sup>nd</sup> April 2009**

**Into the death of**

**JAMES WILLIAM THOMSON**

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**LERWICK, 12 February 2010.**

The sheriff, having considered all the evidence presented to him, **DETERMINES:**

1. In terms of Section 6(1)(a) of the Fatal Accidents & Sudden Deaths Inquiry (Scotland) Act 1976, that James William Thomson who was born on 11<sup>th</sup> February 1981 and resided at 14 Grindahoul Brae, Shetland died at about 1000 hours on 10<sup>th</sup> March 2007 at Upperton, Levenwick, Shetland as a result of the injuries sustained by him in an accident which occurred then and there whilst he was working in the course of his employment as a joiner with Dennis Thomson Builders Limited, Brae, Shetland.

2. In terms of Section 6(1)(b) of the said Act, that the death of James William Thomson was due to haemopericardium, consequent upon a laceration of the right ventricular myocardium. This was a necessary and rapidly fatal consequence of blunt force trauma to the chest sustained when he was stuck by part of a container of expanding foam, which container

had exploded whilst he was holding it. The cause of that explosion was an increase in the pressure of the contents of the container due to it having been exposed to a temperature beyond the temperature it would normally be expected to be exposed to.

3 The evidence presented does not allow me to make any determination as to the circumstances which led to the exposure of the canister (the ‘failed canister’) to that excessive temperature and I can accordingly make no determination in terms of Section 6 (1)(c) of said Act as to whether any reasonable precautions might have avoided the accident. There were no reasonable precautions which might have avoided the death of the deceased following the occurrence of the accident.

4 There was no evidence of any defects in any system of working which contributed to the death or the accident.

5 In terms of Section 6(1) (e) of the said Act, the following facts are relevant to the circumstances of the death:

5.1 James William Thomson was employed by Dennis Thomson Builders Limited of which company his father, Gilbert Dennis Thomson, was sole director. James William Thomson was a qualified joiner and had worked with the “family company” for about seven years prior to his death. He was a normally fit young man who was known to smoke.

5.2 The company, Dennis Thomson Builders Limited, carried out general building work, mainly domestic house building, agricultural building and small light commercial building.

5.3 The company was employed to build a new single storey timber framed and timber clad house at Upperton Levenwick, Shetland. On 10<sup>th</sup> March 2007, that new house was structurally complete with partitioning, linings and insulation in place and work had started putting the trimming items in place. That day the deceased was working at the house along with his colleague, James Sandison. He was not wearing gloves.

5.4 The deceased was already at the house when Mr Sandison arrived at shortly after 08.00 hours. He was already engaged in 'foaming the windows'. This involved using an aerosol canister of Evostik expanding foam to seal around the windows to prevent draughts. It was the common practice of the deceased to heat up these canisters to improve the efficacy of their operation. The deceased and his colleague were not involved in any work which required the use of a blow torch and there was not one at the house site. There was no hot plate at the house site. The only device which the deceased had access to which would have allowed the temperature of the canisters of foam filler to be raised was a small domestic fan heater. This was provided for use in conjunction with a dehumidifier which was in operation within the house. Used in that way it was intended to aid the dehumidification process by circulating air within the house. It could also be used to raise the ambient air temperature within the house or a room within the house.

5.5 At about 10.00 hours, Mr Sandison, who had been working in another part of the house, heard a loud noise and having gone to investigate saw the deceased coming out of the doorway to the sitting room. The deceased called to Mr Sandison and collapsed and lost consciousness. The emergency services were contacted and attended at about 10.31 hours. In the interim period, under instructions of the emergency services, Mr Sandison attempted to resuscitate the deceased but his efforts and those of the emergency services, once they attended, were unsuccessful these efforts were continued until 11.00 hours when a doctor arrived and pronounced life extinct.

5.6 On 12<sup>th</sup> March 2007, a postmortem examination and dissection of the body of Mr Thomson was carried out by Doctor James Henderson Kerr Grieve, Senior Lecturer in Forensic Medicine at the University of Aberdeen. He concluded that the deceased died as a result of haemopericardium, that is a collection of blood in the pericardial sac surrounding the heart. This was consequent upon a laceration of the right ventricular myocardium, a necessarily and rapidly fatal consequence of blunt force trauma to the chest. While the skin of the anterior abdominal wall had an abrasion and bruise at the site of impact there was remarkably little damage to the chest wall itself. There was, however, additionally serious injury to the upper abdominal organs, including the liver, the pancreas, the spleen and the left kidney.

5.7 Even if the functioning of the heart had not been compromised by the build-up of blood in the pericardial sac, for example if it had also lacerated, the loss of blood consequent upon laceration of the right ventricular myocardium was such that even if the deceased had suffered that injury when skilled medical assistance was immediately available, there were no actions which could be taken which would have saved his life.

5.8 The canister of Evostik foam filler which the deceased was using at the time of his death was one of a number which had been provided at the house site by the deceased's employer. 14 other canisters were recovered from the room adjacent to the hallway where the deceased collapsed and died. These other canisters were found standing upright some feet away from where the fan heater was positioned.

5.9 The deceased had been holding the 'failed' canister when it exploded. In that explosion the top section of the canister separated from the body which was propelled against the deceased's abdomen. Foam filler was expelled from the canister. Both the fan heater and the 14 other canisters were located in an area which showed evidence of contamination by expelled foam filler. The pattern was consistent with that having been deposited there when the canister Mr Thomson was holding exploded.

5.10 The failed canister and the 14 recovered canisters came from 2 different production batches. Each canister had a batch number and best before date stamped on it by the manufacturer. There were batch number 495241/10L1 with a best before date of 10 January 2007; and batch number 425037/10L3 with a best before date of 15 December 2006. The 'failed' can came from the batch with the best before date 10 January 2007. The best before date is not significant for this accident.

5.11 The Evostik foam filler is manufactured for Bostik Limited by Polypag AG at their premises in Switzerland. The production process involves the manufacture of the container (canister) and the filling of this with the appropriate formula of chemical constituents and a propellant (in the form of liquid gas).

5.12 The canister is constructed from 4 parts. The cylindrical body is formed by rolling thin sheet metal and joining the 2 ends with a longitudinal welded seam. The bottom, circular section and the top conical section are joined to the cylindrical body by

forming a crimped seam. A valve is then inserted into the top conical section. Separately a plastic lid is provided to cover the conical top.

5.13 Polypag AG operates a quality management system for its production process which meets the standards set by the appropriate Standards Authority in Germany.

5.14 No defect in the manufacturing or testing processes or the materials used for the container or chemical constituents is implicated in the accident. Each canister is tested to check that it does not leak.

5.15 The product performs best at a temperature of around room temperature (stated as between 20°C and 25°C). The canisters have labels which warn about exposure to excessive heat, and in particular to temperatures in excess of 50°C. The reason for this is that increasing the heat of the contents increases the internal pressure of the canister. The canisters are normally expected to operate with internal pressures (measures in multiples of atmospheric pressure or bars) not exceeding single figures. They are designed and tested to withstand much higher pressures. A temperature of around 50°C would normally be expected to equate to an internal pressure of around 12 bar. The canisters are tested to ensure that they can withstand around 18 bar (that is with a safety margin of 50% over the stated maximum). Above that pressure the canisters will start to fail. Initially the failure is expected to occur at the crimped top joint. This results in an unfolding of that joint, an increase in the height of the conical top section and a popping sound. If there is higher pressure the whole joint can fail and there would be a high energy explosion.

5.16 In addition to the failure of the canister which impacted with the deceased, 3 of the recovered canisters, 2 from the same production batch as the failed canister, one from the other batch showed signs of having been subject to increased pressurisation as their tops had popped up. The most likely explanation for this is exposure to temperatures well in excess of 50°C.

Sheriff

**NOTE/**

**NOTE:****Procedural history**

1. This is a mandatory Fatal Accident Inquiry held in terms of Section 1(1) (a) (i) of the Fatal Accidents and Sudden Deaths Inquiry (Scotland) Act 1976. The application was warranted on 19<sup>th</sup> May 2008 and dates were allocated by the sheriff clerk to allow an Inquiry to commence on 18<sup>th</sup> August 2008. A preliminary hearing intended, amongst other purposes, to identify the issues for the Inquiry and to ensure that parties were prepared was assigned for 10<sup>th</sup> July 2008. On that date I was advised that the Crown had intimated the Inquiry, in terms of the Act to the deceased's widow (Mrs Karen Thomson), his employer, Dennis Thomson Builders Limited and that intimation had also been made to Bostik Limited, the distributor of the canister of foam filler implicated in the death of the deceased. On 10<sup>th</sup> July 2008, in addition to the procurator fiscal, attending there was representation of the widow and Bostik. An agent who appeared with the deceased's father, described as the principal of the company which employed the deceased, was also in attendance. At that stage I was advised that the focus of the Inquiry would be the accident which led to the death; that the representative of the widow had still to decide whether to instruct an expert; and that Bostik had not yet decided whether they would lead evidence. In the circumstances the preliminary hearing was continued until 11<sup>th</sup> August 2008.
2. On 11<sup>th</sup> August 2008, parties again appeared and confirmed that the Inquiry would be able to be dealt with in the timetable set, that is during the week commencing 18<sup>th</sup> August 2008.
3. On 18<sup>th</sup> August 2008, the Inquiry opened. I heard evidence from the deceased's father, Gilbert Dennis Thomson; the pathologist, Doctor Grieve; the investigating police officer, Detective Sergeant Tulloch; and a Gordon Cumming Laurenson. On the following day I heard from William Todd, an inspector with the Health & Safety Executive (HSE); and Kenneth George Hanlon, a site quality manager with Bostik Limited. During the last mentioned witnesses' evidence he was asked about the manufacturing process for the expanding foam product marketed by his company. It transpired that his evidence was limited as the product was manufactured in Switzerland by a company Polypag A.G. which was not at that stage a party to the Inquiry. Bostik simply retailed the product

which they did not test in any way. As one of the possibilities in this case was that a manufacturing defect had led to the fatal failure of the canister involved in his death it appeared to me to be expedient to take no further evidence until the Inquiry had been intimated to the manufacturers (which it had not previously been) and the Crown had arranged for evidence of the manufacturing process to be led from someone with appropriate knowledge. Accordingly, the Inquiry was continued to 8<sup>th</sup> September 2008.

4. On 8<sup>th</sup> September 2008, I was advised that Polypag would enter proceedings and were proposing to lead evidence once the HSE reports had been considered. The Procurator Fiscal Depute also advised me that HSE were attempting to make enquiries into other potentially similar failures of foam containers. The matter was continued to 19<sup>th</sup> January 2009 for that purpose and to hear the further evidence that had been due to be heard in August. By 19<sup>th</sup> January 2009, I had become aware that Polypag did not propose to be represented but had agreed that two witnesses would be made available to provide evidence via a video-link from Switzerland. Arrangements were made for this and the attendance of a German interpreter in the courthouse in Lerwick. The Inquiry then heard further evidence on 19<sup>th</sup>, 20<sup>th</sup> and 21<sup>st</sup> January with the 22<sup>nd</sup> January intended to be utilised for submissions.
5. Between 19<sup>th</sup> & 21<sup>st</sup> January, I heard from Juerg Eugster and Torsten Kellner by video-link from Polypag's premises in Switzerland; Janet Joel, Darrell Bennett and Doctor John Whyte of the Health & Safety Executive; James Sandison, the deceased's colleague; and Doctor John McCulloch, an expert instructed for the widow.
6. I then heard submissions. Although parties were content to close the evidence I considered that two further matters required to be addressed before I was satisfied that all relevant issues had been dealt with. Firstly, during the course of the evidence of the witnesses from the Health & Safety Laboratory became apparent that although a fan heater which had been recovered from the premises had been sent to them it had not been tested to ascertain the maximum heat it could produce. This might be relevant to my determination. What was described as a similar fan heater had been so tested. The original fan heater had not been lodged in court by the Crown and was not immediately available for further testing. Moreover, there was significant criticism by one of the Health & Safety Laboratory experts of the science behind the evidence of one of the Polypag

witnesses which criticism had not been put to that witness in chief or in cross-examination for comment. I considered that it was appropriate to continue the Inquiry firstly to allow the Crown to identify the whereabouts of the fan heater which had been recovered from the locus of the incident, and which might then be made subject to further testing; and secondly to allow the criticisms of his evidence to be put to the Polypag witness for comment. My view was that at least in the first instance both matters might be dealt with by way of written statement, however, this was complicated by the need to have the shorthand notes of the evidence of the critical HSE witness (Dr White) extended, translated into German, forward it to the witnesses in Switzerland for comment and for that comment then to be retranslated into English. In the first instance the Inquiry was continued until 24<sup>th</sup> February 2009 to allow this to be done, but due to a delay in the arrangements for the transcription of the matter required to be further continued until 23<sup>rd</sup> March 2009 and then to 21<sup>st</sup> and 22<sup>nd</sup> April 2009. By that time the Crown had lodged a written note explaining that the fan heater had been misplaced by the Health & Safety Executive; and a written response had been received from the Polypag witness.

7. Parties were then allowed to make further submissions in writing with respect to the response from the Polypag witness. Whilst I was considering these I learned from the Procurator Fiscal that a further witness had come forward with potentially relevant evidence about an explosion of an aerosol canister. It was agreed that the information received would be passed to HSE to clarify whether that could in any way be relevant to the accident involving Mr Thomson. Their response, which was that it was not, was communicated to all parties and I received confirmation in October 2009 that no party considered that matter relevant and did not wish to lead any further evidence or make any further submissions.
8. Despite the extended nature of this Inquiry I am not satisfied that I can make any determination as to the cause of the explosion of the canister that lead to the death of Mr Thomson junior, other than to conclude that it was due to a an over-pressurisation probably due to exposure to excessive heat of an unidentified nature. I share the frustration of the family, witnesses and agents that no clearer explanation is available particularly as the Inquiry took place over such an extended period. In the circumstances I consider that it is appropriate for me to provide an extended note explaining my conclusions.

## **The evidence**

### **Dennis Gilbert Thomson**

9. Mr Thomson senior was the first witness to give evidence. He was the 58 year old father of the deceased, whose personal and employment details the witness was able to confirm. The witness was the sole director of Dennis Thomson Builders Limited, the company which employed the deceased at the time of his death on 10<sup>th</sup> March 2007. The witness was aware that his son was working on the company's site building a new house at Upperton Levenwick, Shetland.
10. According to the witness and also to the HSE Inspector, the company had never been criticised for the way it operated its business and it was apparent to me from the evidence, including the photographs produced to the inquiry, that the company and its employees operated a tidy site.
11. I considered Mr Thomson senior, to be a careful, conscientious and truthful witness who did his best to provide information which would be of assistance to the Inquiry in understanding the circumstances that led to his son's tragic death. Although he was not present at the site on the day of his son's death he had, according to him, been at the site the previous evening and was able to provide evidence as to the stage of the building process. He confirmed that the new house was structurally complete with internal partitions, lining and insulation in place. The external timber cladding had also been affixed. (Internal) trimming items were being added. His son and another employee, the witness James Sandison, were working at the house on 10<sup>th</sup> March 2007. He would have been expected them to start work at 08.00 hours. Mr Sandison was completing work on floor tiling in a bathroom. The deceased was due to be fitting timber ingoes (that is the inner wooden facings) to the window openings. That activity would have involved the use, by the deceased, of expanding foam. This is used to fill gaps to limit draughts coming in through the fabric of the building.
12. The witness was able to tell me that in November 2006 he had purchased a quantity of expanding foam filler for this job. He had purchased 36 canisters of Evostik branded foam filler from a local Shetland supplier of building materials. This purchase comprised

three sealed cartons, each containing twelve canisters. These canisters are similar to standard (domestic) aerosols.

13. This supply of foam canisters had been taken by him to the Levenwick site where it was placed in storage on a shelf in a steel shipping container used for general storage of material for the site. This container was kept locked when there was no one working on site. The container had no heat source. Dennis Thomson had used this type of foam filler for about 20 years, since it was first introduced to the building industry. He had no brand loyalty and would use whichever type of filler was available from his supplier. In this case it was Evostik brand which the Inquiry heard was manufactured in Switzerland by Polypag A.G. and was retailed in the United Kingdom by Bostik under the Evostik brand name.
14. Mr Thomson senior was aware that there were directions for use on the canisters and also a best before date. The Inquiry heard from a representative of Bostik that there was also a Data Sheet available which contained further product and use details. There was no evidence that the deceased or Mr Thomson senior or any of his employees had access to a data sheet.
15. Mr Thomson senior was aware, at least by the time of the Inquiry, that the best before dates on the canisters which he had purchased in November had expired. As I will explain, this fact seems to be unconnected with the accident.
16. Although the deceased had not always worked with his father, he had done for the seven years prior to his death. The deceased was a qualified joiner. He had learned the building trade from his father. Throughout the time he worked with his father he would have been used to using expanding foam of the type involved here.
17. According to Mr Thomson senior when a new product was introduced to the company a 'tool box' briefing would take place but he had never considered this necessary in relation to this product which is so readily available and use of which was without obvious risks. Although he was aware that the expanding foam aerosols did not always operate well in Shetland's climate (and he spoke to a failure rate of some 20%) he had never experienced one of these products exploding.

18. Mr Thomson senior explained that the small electric fan heater (which was found in the house near to a collection of canisters of foam filler in the room the deceased was in at the time of the explosion) had not been intended to be used for heating those canisters. It had had not even been intended to heat the house but rather to assist the operation of a dehumidifier, which was located in another room in the house, as shown in photograph 37 of the book of photographs, Production 1. That dehumidifier had originally been brought to the house about a month before the accident, to help to dry out the wood used for the external cladding of the house. The fan assisted in circulating air within the house which in turn assisted the operation of the dehumidifier. Mr Thomson senior was adamant that the fan was not in the room where it was found after the accident at about 5.00pm the previous day when he had last visited the house. However he accepted that from the configuration of the fan and the canisters, it looked very much as if it had been positioned there to assist in increasing the ambient temperature of the room and thus the temperature of the canisters.
19. He agreed that these canisters would work better at warmer temperatures and although the instruction labels warned against exposure to temperatures of over 50°C, the suggested working temperature, which seemed to vary depending on the brand of foam, was around 20°C. This was not a temperature which would normally be found out of doors in Shetland at that time of year; nor in the storage container which had no heat source; nor indeed in an unheated house. Mr Thomson thought that the outside temperature at around the time of his son's death would be likely to be around 8-12°C.
20. Although Mr Thomson senior was aware that the (electric)under floor heating system for the house had been installed and that there was an electricity supply to the house, he did not know whether that would have been switched on on the day of his son's death.
21. He was aware that some brands of foam filler suggested immersing the canisters in water and gradually increasing the temperature if that was necessary to bring them up to 'room temperature'. The Evostik canisters did not contain this suggestion. His company had no policy for heating up the canisters and he would not have expected any of his staff to apply direct heat to them to do this. He would not, however, have been alarmed if he had

discovered his son using the fan heater to increase the room temperature around the canisters.

22. Mr Thomson senior gave very clear evidence, which I accepted, that there was no equipment on the site which would allow the canisters to be heated to 120°C. He was asked by the procurator fiscal to comment on apparent rumours that the deceased may have been using a blow torch to heat the canisters. He discounted this as the only blow torch used by the company was some 40 miles away at the time.
23. He was also asked to speculate on what might have caused the accident which led to his son's death but could offer no explanation. He had no experience of such canisters exploding: not even of their caps becoming displaced.
24. He was not asked about having attended the locus the day following the accident but it appears from the hearsay evidence of the witness Detective Constable Tulloch that Mr Thomson had done so and reported having found and recovered a top from one of these canisters, apparently somewhere in the vicinity of where his son's body had been found.
25. Some time was also taken up during his evidence exploring the provenance of the fan heater which had been produced in court by the Crown. It transpired that just as Mr Thomson said, the fan heater produced in court was not in fact the one recovered by the police from the locus which had been passed by the police to the Health & Safety Executive where it had gone missing after they had carried out tests on it.

### **James Sandison**

26. The deceased's colleague Mr Sandison was the final witness called by the Crown. He gave evidence on 21<sup>st</sup> January 2009, five months after I had heard from Mr Thomson senior.
27. Mr Sandison was 57 years of age when he gave evidence. He was a joiner who had worked with Dennis Thomson for some 20 years. My notes record that he was a careful witness who tried his best to remember the circumstances leading up to what was for him a traumatic incident. He was able to speak about not only the incidents of the day of

James Thomson's death but also about the arrangements for the building of the new house leading up to that tragic event.

28. As one of the people most closely involved in the building work, I should have been able to place significant weight on his evidence. However I bore in mind in assessing his evidence that it was now almost 2 years after the incident which must have been fairly traumatic for him, although that did not fully explain the various versions he gave about the deceased's practice in relation to the heating of the canisters of foam before use. Although I will cover his evidence on that aspect in more detail it seemed to me to be of safe to accept his evidence that when dehumidifying a house, the dehumidifier would be left running for 24 hours a day as would a fan heater which was used to assist with circulation of the air. He also thought, but could not be sure, that the under floor heating in the house at Levenwick might have been switched on. He described that as being a normal practice when drying out a house. He simply was not sure whether that had applied in this case. The only significance of this is that it would mean that the ambient temperature within the house might be higher than it otherwise would be, that is it is possible that with the fan in operation and the under floor heating in operation the room temperature would be closer to that at which foam aerosols were said to work best (around 20degrees centigrade).
29. Mr Sandison accepted that it would be normal practice to use a fan heater, if trying to bring expanding foam canisters up to a working temperature, but without placing the canisters too close to the heat source. He suggested that two to three feet away from the heat source would be appropriate. Otherwise he thought that canisters would become too hot to handle.
30. Mr Sandison also described the process of using the expanding foam in which is to invert the can and shake it, to make it work better. He thought that there might be some instructions about immersing a can in heated to increase its temperature.
31. The only direction he was aware of was in relation to the use of the foam was not to exceed the temperature specified in the warning on the canister. He was not aware of any specific recommended working temperatures for the canisters. Mr Sandison's evidence was consistent with the deceased having taken no active steps which would have caused

the canister of expanding foam he was using to have its temperature raised to a level which would normally be considered dangerous.

32. Some issues were raised during the witness' examination as to the consistency of his evidence in court with what had been said in a police statement. The full terms of the police statement were not put to him, it was not a production and nor were they spoken to by the officer who was said to have noted the statement.
33. On the day of James Thomson's death, Mr Sandison was working with the deceased at the new house site in Levenwick. The witness had arrived just after 0800 hours and the deceased was already getting ready to "foam" the windows, as the deceased's father had described in evidence. By this he meant that the deceased had been "gathering the tins" or aerosols of expanding foam and was working with them in the unfinished sitting room. This is the room in which the collection of 15 aerosol canisters produced at the Inquiry and the fan heater (sent to the HSE) were found after the accident (these are shown most clearly in photograph 21 of Crown Production 1). It appears from what was said in cross-examination that the deceased was actually working in the sun porch adjacent to the living room where the canisters were. At some point the deceased went out to the storage container to obtain further supplies.
34. The witness explained that about 1000 hours he became aware of what he described as "a bang". He went towards the sound to discover James Thomson, junior, coming out of the door opening between the sitting room (where the canisters and heater were found) and a hallway. The now deceased said "Jim, help" and then collapsed, losing consciousness immediately. Mr Sandison attempted to obtain assistance and contacted the ambulance service from a nearby house, maintaining contact with them via a mobile phone as, following their instructions, he returned and attempted to give mouth to mouth resuscitation until ambulance personnel arrived. It was clear from this witness' evidence that the explosion of the canister, which is what I accept the bang he heard was, was followed very rapidly by the collapse of the deceased and from that point he showed no vital signs.
35. The witness' initial position in evidence was that the deceased would not have heated the canisters before using them but almost immediately accepted that some heat would have

been needed to be applied to the canisters to make them work better. Indeed in cross-examination by the solicitor for Bostik, he accepted that he had probably said to the police that James **had** heated the canisters up using a small heater. However he did not think that the deceased was wearing gloves (and certainly there were none shown on the photographs of the body or recorded in the pathologist's report (Production No. 2)). In my view that is significant if it is suggested that the deceased had heated the canister to a high temperature before using it. I am prepared to accept that the fan heater was used to assist in heating up the canisters which were to be used.

36. The witness was not able to assist the Inquiry as to when the electric heater might have been moved in to the unfinished living room area where it was found after the accident. I had no real reason to disbelieve Mr Thomson senior's evidence that it was not there the previous evening about 5 pm. It may have been put there by the deceased that morning. The evidence on the point was not clear. Under cross-examination Mr Sandison accepted that he saw a number of canisters on the floor of the sitting room in a position similar to that shown in the photographs taken post-accident. He said that previously the deceased had warmed up canisters by placing them in a room with a fan heater in it but not very close to them, and they would just be left in the room to heat up and used as necessary". The witness accepted that he had given a statement to a police officer within 2 hours of the accident. He accepted saying "The foam seal[ant] James was using, he heats it by a small heater, a fan one, just to warm up the tins as the foam works better when it is warmed slightly". In evidence he was unable to explain whether that comment was a reference to what the deceased had been doing on the day prior to his death or to his normal practice. The circumstances seem to me to point to that being what the deceased had in fact been doing that morning.

37. From all the circumstances I am satisfied that when he made this statement to the police officer he was talking about what had happened that morning. Moreover I am satisfied that this description from the witness accords with the normal practice of raising the temperature of these canisters using the fan heater and that as it would be left running 24 hours a day to assist in the drying out process, it would be normal for canisters of foam to be left in a room to come up to an appropriate ambient room temperature. That is all consistent with the stage at which the building work was at the time of the deceased's death. It is possible that the under floor heating was on and I am satisfied that it is likely

that the fan heater would have been left running, even though Mr Thomson senior's evidence was that the fan heater was not on when he had visited the house the previous day.

38. Canisters of expanding foam work best at around room temperature and there would be no sense in heating them too much as they would be too hot to handle. However, the fan heater might be used to raise their temperature and this would be done by placing them in front of the heater.
39. The witness explained that when it is used the canister it is inverted. Two hands are used; one to hold the canister and press the release valve and one to operate the directional tube which is attached to the aerosol nozzle. It is normal practice to shake the canisters before use.
40. The witness said that he and James (the deceased) had had no specific training in the use of expanding foam. There were instructions on the canisters. There are gloves provided with chemicals, not from heat. The cans were re-used, that is they were used from day to day until empty. The witness said he had no experience of coming across canisters with 'popped' tops or displaced caps or bulges in them, although he had seen some with dents. The witness considered that there was no reason to remove caps from the canisters before they were brought into use.
41. The witness did not see the canister involved after the incident and when shown a photograph of the can in its post-accident position (photograph 20 of Crown Production1) he noticed that no labelling was now on it. He could not explain the relevance of the apparently broken piece of wood lying adjacent to it.

### **Other 'civilian' Witnesses**

42. **Gordon Cumming Laurenson** was called by the procurator fiscal depute. He was a partner in a local business selling trailers and camping equipment. The business had previously sold chemicals. He was called to speak about his recollection of an incident when a canister of what was described as foam filler 'Ever Build' type had, in his words, "exploded" in his premises.

43. His evidence was that he had been storing a box of such canisters against a corrugated wall where they had been for many months over the winter, and following a very hot week he discovered a can had “blown up” spreading foam 10 feet up to the ceiling. He could not describe the damage to the container itself and whether bits had been blown off it or a seam had burst. He was not very clear about when the explosion he was talking about had occurred. Mr Todd from HSE who interviewed the witness could not remember when the witness said the incident had been but suggested that it may have been 2006. Mr Laurenson thought that the breach of the integrity of the canister was “more out of the side” and also described its failure by saying that the can was “just burst”. Rather than producing small droplets of foam such as were found in the Levenwick house he said that his explosion had produced large quantities or lumps of foam.
44. Whilst there is no reason to doubt the witness’ evidence, the mechanism and circumstances of the failure of Mr Laurenson’s foam canister are not clear and I do not consider it safe to draw any inferences from it in relation to the subject matter of this Inquiry.
45. His evidence was that the explosion might have been associated with exposure to high temperature generated by the heat of the sun on the corrugated wall against which the box of expanding foam canisters had been resting. His evidence was that this could get exceedingly hot (although, he said, not so hot you could not put your hand on it). He had subsequently moved the remaining canisters to a cooler storage area.

### **The Police Investigation**

46. **Detective Sergeant Tulloch** (who was 36 years of age with 16 years police service at the time of giving evidence) was the only police officer called by the Crown. His evidence was in relatively short compass. With the benefit of hindsight, his investigation appears not to have been very thorough.
47. DS Tulloch had been recalled to duty at about 1000 hours on Saturday 10<sup>th</sup> March 2007 and attended at Upperton, Levenwick, at about 1030 hours. Other police officers and paramedics were already in attendance. He gave evidence that the paramedics stopped

working on the deceased by 1106 hours and a Doctor Bohn, who had been called to attend, pronounced live extinct at 1220 hours.

48. The deceased body appears to have been still in the position he was found immediately after the accident. He was lying on his back with an obvious significant injury to his chest. The compressed body section of an expanding foam canister was found lying near to the deceased's feet (as shown in photograph 19 of Crown Production 1). This canister was recovered and produced at the Inquiry as Label 2.
49. D.S. Tulloch was responsible for taking a series of photographs which he then compiled into a book (Production 1). He also seized 15 (complete) canisters of foam filler (Labels 5 to 19). He took possession of the fan heater shown in the photographs which he then transferred to the Health & Safety Executive (from where it was subsequently lost). That fan heater was photographed as found by the Detective. By the time he photographed the heater he had not touched it. The witness was able to say that the heater was switched off at the wall and "both gauges were turned to the maximum output". I understood this to mean that the fan was set to run to maximum capacity as was the heating element. A number of the recovered canisters were found in a position such that he described them as 'arranged' in front of the fan heater. The recovered canisters (including the empty, compressed body and the top subsequently found by Mr Thomson senior) were also sent to the Health & Safety Executive.
50. The witness confirmed that the body of the deceased was taken to Aberdeen for postmortem examination. The deceased had been dressed in a fleece which was contaminated to the front with droplets of expanding foam. He was not wearing gloves and none were found in the vicinity. There was no evidence of scorching on the floor around the deceased (or indeed elsewhere).
51. It was from this witness that I learned that Mr Thomson senior called at the police station (in Lerwick) and handed in separated top of the foam canister. As I have noted this matter was covered in the witness Thomson's evidence so that the circumstances of its finding are not clear. It was simply put to the officer that it "was found within the locus at [the] partly built house". He agreed but could not remember where. It had accordingly

been overlooked in the police investigation and is not shown on any photographs that I saw.

52. The officer also spoke to the extensive foam filler contamination of the floor in the living room area. This he suggested indicated that there had been an ‘explosion’ in that room. He was unable to determine a centre of spread but suggested that it had have come from the doorway area, that is “the door that leads into the hallway where Mr Thomson was lying”.
53. From the position of the canisters in the living room and their relationship to the fan heater, taken in conjunction with information he had received of what Mr Sandison had said at the time, the witness concluded that the deceased had been heating the canisters in front of the fan heater. Before one exploded, spilling its contents. Unfortunately the witness had not measured the distance between the remaining canisters and the heater. Nor did he note the temperature in the house. He described it as being not particularly cold for early spring, in Shetland and suggested it was probably not more than 10°C. He did not think that there was heating on in the house but was not 100% sure. In this context he commented that he had not noticed “any machinery that would cause any heat in the house” which, of course, he would not as it appears to have been equipped with under floor heating.
54. The witness suggested that the ‘explosion’ of the canister had sufficient force to propel labelling from the canister, or at least some of it (as disclosed by photograph 50), on to the ceiling of the living room. Other than contamination with foam there was no other damage within the room. However from the evidence of the foam contamination and the labelling on the ceiling I am content to agree with his conclusion that the canister was within this room when it exploded.

### **Pathologist**

55. Doctor **James Kerr Henderson Grieve** MB, ChB, FRC Path., gave evidence. He is a senior lecturer in forensic medicine at Aberdeen University. He carried out a postmortem examination and dissection of the body of the deceased on 12<sup>th</sup> March 2007. He prepared a report on his examination which is Crown Production No. 2.

56. His opinion is that the deceased died as a result of haemopericardium, that is bleeding into the pericardial sac. This resulted from a laceration of the right ventricular myocardium. Dr. Grieve described this as a necessarily and rapidly fatal consequence of blunt force trauma to the deceased's chest. Whilst the skin at the anterior abdominal wall had an abrasion and bruise at the site of impact there was remarkably little damage to the chest wall itself. There was, however, serious injury to the upper abdominal organs including the pancreas, spleen and left kidney.
57. Although the immediate cause of death was the accumulation of blood in the pericardial sac effectively preventing the heart beating, even if the sac had ruptured (so that the heart was not so constrained) Dr. Grieve's view was that the loss of blood was so great the injury was virtually unsurvivable. The witness suggested that even if medical assistance had been immediately available, such as if the accident had occurred in a major teaching hospital such as Aberdeen Royal Infirmary, nobody could have done anything to repair the damage in sufficient time for Mr Thomson junior to have survived, even though he was a normally healthy adult male and was clearly not under the influence of any alcohol or drugs.
58. Doctor Grieve had not seen the 'exploded' canister before he gave evidence, that is he had seen neither the recovered failed canister base nor the recovered failed canister top. Having been shown these, however, he was satisfied that the injuries were entirely consistent with the deceased's chest having been struck with significant force either by the body of the 'exploded canister' or by the top section. As I understood his evidence he thought that the pattern of injury and the damage he saw to the bottom of the body section of the canister made that the more likely candidate. He considered that the circumference of either was consistent with the ring pattern which was found on the deceased's body, however, given the appearance of the injury and the 'concertina' type damage to the bottom section of the canister, he concluded that this was the more likely of the two to have made contact with the deceased. Damage to the deceased's clothing was also consistent with such a mechanism.
59. Dr Grieve thought that the injury pattern which looked elliptical, could have been caused if the deceased had been bending over slightly with the bottom of the canister towards his

body (as it would be if he was shaking or holding it in the inverted position described by Mr Sandison).

60. Doctor Grieve's evidence was clear that to have caused the internal damage which he found on dissection the canister must have impacted against the deceased's chest with very considerable force. He described it as a "high energy impact" with the force being transmitted to various organs situated some distance from the impact site. Indeed he thought that the injuries were consistent with "the sort of energy that you get from a major explosive close to the body". There was, however, no sign of scorching or burning.

### **The Health & Safety Executive**

61. **William Todd** is one of Her Majesty's Inspectors of Health & Safety and had been for almost 13 years when he gave evidence to the Inquiry. Mr Todd holds a BA degree in Management Technology and a Diploma in Occupational Health & Safety. Most of his time with the Executive had been with the Construction Group carrying out inspections and investigations in the construction industry. His experience related to both domestic and commercial property and included traditional stone/brick and timber framed buildings. Although he had experience of timber framed buildings, timber framed and timber external cladding of the house at Levenwick involved in this incident was not usual on mainland Scotland. Mr Todd was accordingly not particularly experienced in this type of construction.
62. Mr Todd visited Shetland following Mr Thomson's death (there was at one point some dispute as to when he had come to Shetland but it appears that he attended some 11 days after the death (21<sup>st</sup> March 2007)). In the course of his inquiries, he appears to have spoken to Mr Thomson senior and a number of employees of his firm. He was shown an invoice (which was not produced at the Inquiry) confirming the purchase on 20<sup>th</sup> November 2006 of 36 canisters of Evostik foam filler.
63. He was apparently also provided by Mr Thomson senior with details of six individuals who had come forward, following Mr Thomson's son's death, to say that they had experience of 'exploding' foam canisters. It appears that he could only trace four of the six individuals and when he did so, only two could remember incidents involving

canisters. One of these was Mr Laurenson. The witness was vague about when the incident Mr Laurenson referred to was said to have occurred. As far as he could recollect it was said to have occurred sometime in 2006. The other person spoken to was a Mr Burns who referred to an incident which was said to have occurred approximately 10 years beforehand and who had, when climbing a ladder with such a canister, experienced it exploding. Mr Burns did not give evidence and no detail of the circumstances of that explosion was provided to the Inquiry. Accordingly I do not consider it safe to draw any inference from this hearsay evidence.

64. Mr Todd made no inquiry as to whether the use of this filler was standard in Shetland. He saw no need to do so. He had no experience of it being used in the way described by Mr Thomson senior or Mr Laurenson. He had nothing to add in relation to how such foam filler should be used. He thought that the canister involved was a two piece construction but accepted in evidence that it looked as if it was constructed in three pieces (it transpired to be a 4 part assembly including the valve). He had not seen the canister top recovered by Mr Thomson senior, before he was shown it in court.

65. Mr Todd said he had no experience of foam filler being used as it was here to seal window ingoes. He made no inquiry as to whether the use of this filler was standard in Shetland. He saw no need to do so. I do not consider much turns on that. He had nothing to add in relation to how such foam filler should be used.

66. He thought that the canister involved was a two piece construction but accepted in evidence that it looked as if it was constructed in three pieces (it transpired to be a 4 part assembly including the valve). He had not seen the canister top recovered by Mr Thomson senior, before he was shown it in court.

67. When Mr Todd came to Shetland he visited the locus which was apparently in the same condition as it had been immediately after the accident, with the exception of the removal of the fan heater, canisters and the deceased's body. He arranged for the heater and canisters to be passed to the Health & Safety Executive Laboratory for further analysis. Mr Todd confirmed that the fan heater produced by the Crown was not the one recovered from the scene but one purchased by the Health & Safety Laboratory to carry out tests.

68. Mr Todd's inquiry disclosed that the Evostik brand of foam filler involved in the incident is sold by the company Bostik Limited, but that their role was limited to selling it, the canisters and contents being manufactured in Switzerland. He described Bostik as having been co-operative in his inquiries. From discussion with them he confirmed that although there is a best before date printed on each canister that relates only to the quality of the contents not to the safety of the canister.
69. The witness had no concerns about the deceased's employer's role in this case.
70. He also advised the inquiry that prior to Mr Thomson's death the Health & Safety Executive had never been notified of any similar incident.
71. My conclusion was that this witness did not have a particularly inquiring mind and that once he had handed the matter over to his expert colleagues, that was very much the end of his investigation. Whether any of the areas which were not fully investigated would have led to any more helpful information is, of course, unclear. It would certainly have been helpful to have independent evidence about whether there was heating on in the house and whether there were any means of heating the canisters in the way suggested as a possibility by his colleagues in the Health and Safety laboratory (that is on a hot plate).

### **The Retailer**

72. Bostik Limited, Common Road, Stafford, was accepted to be the retail distributor of the foam filler canisters involved in this case. These are sold under the brand name 'Evostik Foam Filler'. The product is described on the canister as a "Multi-purpose Expanding Foam Filler".
73. The only witness from Bostik led at the Inquiry was **Kenneth John Hanlon**, Quality Manager at the Stafford site. He had been with the company for 39 years, had been involved in quality control/assurance for 30 of those years and had held his current post for 8 years.

74. The witness confirmed that the product (canisters and contents) were manufactured for Bostik by a Swiss company, Polypag A.G. and contained Polypag's formulation B3 Foam.
75. Because Bostik are not involved in the manufacture of the product Mr Hanlon was unable to give direct evidence as to the manufacturing process. At the stage of this being called I was advised that no witness from the Swiss manufacture Polypag A.G. would be called to give evidence. That position ultimately changed. However, that was not anticipated when Mr Hanlon gave evidence. Accordingly Mr Hanlon spent a large part of his time dealing with matter more appropriately directed to the manufacturer. As the manufacturers ultimately gave evidence through two employees, it is their description of the manufacturing process that I rely upon in my determination, not Mr Hanlon's hearsay version.
76. According to Mr Hanlon, Polypag manufacture for a large number of companies including several Evostik associated companies in Europe. He understood that the products were the same, the only difference being the label on the canister.
77. Having been manufactured in Switzerland, the product is shipped Evostik's Stafford plant. The supply is accompanied by a Certificate of Conformity for each manufactured batch. This details the test results for the batch, comparing those results to the test limits. The shipments take the form of pallets. Each pallet contains 64 cartons. Each carton contains 12 canisters (as described by Mr Thomson senior). The only checks carried out by Evostik are visual inspections to check that the quantities conform to the order and to examine whether there were any patent defects to the packaging. That is whether the cardboard boxes, not the individual canisters, which are not visible, are damaged. The product is then held in storage ('warehoused') as supplied, that is as wrapped, pending distribution. Distribution is effected by a transport firm collecting the product from the warehouse. Pallets might remain at Stafford warehouse for up to 3 or 4 months or even longer. Best before dates and batch details are stamped on the product in Switzerland.
78. Evostik carries out no separate safety assessment of this product. The safety checks which they rely on are those carried out at the instance of Polypag. Effectively they rely upon Polypag having a satisfactory quality management system and having manufactured the

product safely and in accordance with specification. The witness gave evidence about his understanding of the quality checks incorporated in the manufacturing process but his knowledge was not comprehensive and again, so far as this is relevant to my conclusions I rely upon the version provided by the Polypag witnesses.

79. To supply this product to the Evostik group Polypag had to be an 'approved supplier'. This meant that at the time approval was granted they (Polypag) would have described to Evostik what their manufacturing process and testing procedures involved. Polypag appear to have held approved supplier to Evostik for some 10 years. According to the witness they were regularly assessed by Bureau Veritas which the witness described as the equivalent of the British Standards Institute in Europe. Both Evostik and Polypag have ISO (International Safety Organisation) 9000 accreditation for their quality management system.
80. Apart from the incident involving Mr Thomson, Mr Hanlon was unaware of any other safety concerns about this product having been passed to the manufacturer by Evostik. On learning of this fatality, Evostik held meetings involving the Stafford site Health & Safety Officer, the Business Manager, the witness Hanlon, the Complaints Co-ordinator and the person responsible for purchasing. The purpose of the meeting was to decide whether or not to continue to sell the product. Despite the meeting having taken place at a stage prior to the conclusion of the investigation into Mr Thomson's accident, it was decided by those present to continue to sell the product: but to inform the manufacturer of what had happened; and to seek information from the manufacturers, including whether there had been any similar incidents elsewhere. At the time he gave evidence, Mr Hanlon indicated that he understood that the manufacturers were aware of two other (non-injury) incidents of canisters apparently spontaneously exploding. He understood that one of these had been in Denmark the other in Czechoslovakia, although when the Polypag witnesses gave evidence it transpired that these were in Denmark and Switzerland.
81. This witness said that Evostik only became aware of any earlier incidents involving Polypag products within the week or so before the commencement of the Fatal Accident Inquiry, despite the incidents apparently having occurred in 2004. There was no evidence that Evostik pursued active inquiries on their own account: rather they took a passive approach reacting to information only as and when it was provided to them.

82. It was suggested to Mr Hanlon's that Evostik should not simply rely upon a third party manufacturers' safety system and should carry out its own testing. He dismissed this saying: "The aerosol is manufactured and tested and supplied to ourselves with a Certificate of Conformance that it meets all the requirements we have asked for". I heard no evidence to suggest that there was anything inappropriate in that approach.
83. Essentially that summed up Evostik's position. The further, lengthy, examination of the witness on various hypotheses about the manufacturers' systems was ultimately of no value. He was not in a position to answer from first hand knowledge. The most he could say was that he had been given information to such and such effect. That meant that he could not be effectively examined on that matter.
84. The witness was asked about the operating parameters and environment for these canisters but clearly had little knowledge and had not taken any steps to read up on the matter before giving evidence. He was asked about the warnings contained on the canisters about exposure to high temperatures. He referred to the instructions contained within a 'data sheet' for the product (Production No. 5) but had no other knowledge about the science behind that. He also spoke of an optimum operating temperature being 20° centigrade. It transpired that he took this information from the product data sheet – but was unable to find any reference to such an instruction on the label on the canister which simply says "Do not apply below 5° and above 25° centigrade". The product label also states "Use cool". However he was not sure what that meant although he did suggest that what it might mean was that if the canister became too hot it should be allowed to cool before use. It also transpired that the product data sheet (available to anyone who asked for it apparently) suggested that the product should be warmed slowly to 20°C – but that information was not contained on the canister and would not therefore be known by anyone who had simply taken such a canister to use and had not accessed the data sheet.
85. In response to extended examination about the advantages of heating a canister in liquid (such as in a container of water) as opposed to having hot air blown onto it by a fan, the witness pointed out that the liquid method would be the more effective method as it would provide a heat source to all surfaces in contact with the water not just the one in front of the fan heater. However if a heater rather than being used as a direct heat source

was simply used to raise the ambient room temperature, for example to bring a room up to working temperature of around 20°C, with the canister in the room, then he thought that would be an equally effective technique.

86. The witness also indicated that the canister labels include a direction not to expose the can to a direct source of heat. However he accepted that the canister notice actually reads:

“Caution, pressurised container. Protect from sunlight and do not expose to temperatures exceeding 50°C.

AVOID HOT CONDITIONS, E.G. DIRECT SUNLIGHT, MOTOR CARS IN THE SUN, HOT RADIATORS ETC. USE COOL. DO NOT PIERCE OR BURN THE CAN EVEN AFTER USE. DO NOT SPRAY ON A NAKED FLAME OR ANY INCANDESCENT MATERIAL. DO NOT USE NEAR OPEN FLAMES. DO NOT SMOKE”.

87. The witness conceded that his company reacted to this incident on the assumption that their guidance, that is the guidance contained upon the canister, had been contravened. As I have made clear, however, the precise cause of the incident remains unclear but it is likely that that it was exposed to excess heat at some point even though there is no evidence that the deceased was responsible for any such contravention of the instructions. The investigation by Bostik seems limited to sending a Sales Manager to speak to builders merchants, not I would have thought the most proactive exercise, a point they might wish to consider for any other incidents. It should be a concern for the company, albeit not germane to my determination, that this witness had not seen the Health & Safety Executive expert’s test reports. The witness did not appear particularly familiar with the product which his company was retailing. He was asked (page 138 19<sup>th</sup> August 2008) to clarify the contents of the canisters. He described it as “two chemicals” which have “long names”. He could not explain precisely how the chemicals were added to the pressurised container. He was surprised at the suggestion that customers on Shetland might have experienced up to a 20% failure rate. He seemed not to know that the instructions on the can were that it worked best when shaken before use.

88. The witness gave evidence that it was possible for a person to handle something such as a heated canister which was around 50° but it was not possible to handle something at 60°.

I would normally have assumed that this would have been outwith his area of expertise but he said in evidence (page 150 19<sup>th</sup> August 2008) “I have put things in and out of 50° and at 60°”. This evidence was contradicted by Doctor McCullough’s evidence but arguably his comments were outwith his area of expertise and it is perhaps not outwith judicial knowledge that a plate placed in an oven at around 50° can be handled.

89. In summary I did not find Mr Hanlon to be a particularly impressive witness but partly I am sure that was because he was being invited to give evidence on matters which were really outwith his personal knowledge. When dealing with the manufacturing process he repeated himself and was clearly out of his depth. It was of some concern that his evidence suggested that Evostik had not been rigorous in their own investigations into how this incident, involving as it did one of their branded products, could have occurred. It seemed to me that once some information indicating that the deceased may have been acting contrary to the instructions on the container (that is the suggestion that he had applied direct heat to it) which information he had obtained from a sales representative Evostik’s investigations were not taken further.

### **The manufacturer**

90. When the Inquiry moved into its second phase, on 19<sup>th</sup> January 2009, arrangements had been made to take evidence from two Polypag A.G witnesses, **Juerg Eugster and Torsten Kellner** (although it transpired that Mr Kellner was employed by a company called Rathor). This was facilitated by means of a video-link to the court from Switzerland with a German interpreter present in the court to translate questions into German and replies from the witness into English as necessary. Both witnesses had a reasonable command of English. A Scottish solicitor, Mr Mallie, from Andersons, Glasgow, was present with the witnesses in Switzerland.

91. Through these witnesses the Inquiry heard more about the manufacturing process, the standard testing procedures carried out by the company and the company’s knowledge of similar incidents. Unfortunately, during the examination and cross-examination process, no party put to either of the Swiss witnesses a significant chapter of evidence which I heard the following day from the Health & Safety Executive witness, Doctor White, who raised doubts about the science behind some of the evidence which had been given by Mr

Kellner. Accordingly, at my request, arrangements were made for a transcript of the relevant evidence from Doctor White to be translated into German and provided to Polypag witnesses to allow them to respond. This delayed matters somewhat but the purpose of allowing the witness to respond as if he had been cross-examined was achieved.

**Juerg Eugster**

92. Mr Eugster was a quality manager with Polypag but only since 1<sup>st</sup> September 2007 (that is after the accident). He was 50 years of age and originally trained as a mechanical engineer latterly having trained in quality management in which area he had been working since 1990. He had no qualifications in chemistry.

93. He described the company as being a manufacturer of foam in aerosol cans. The company manufactures the containers, purchases constituent chemicals, mixes those to different formulations and fills the containers (canisters) with these ‘formulations’ together with propellants. The company also label the cans for and supply them to retailers such as Bostik. Polypag have been in this business since 1980.

94. Each container consists of four constituent parts. First there is the cylindrical body of the canister is formed from metal plate; secondly, there is a circular base section (formed from the same material as the body; thirdly, there is a ‘domed’ metal top section; and fourthly, there is a valve which is inserted into the top section. The contents of the canisters vary according to which ‘formulation’ is used. There is also a plastic cap which is designed to fit onto the top of the canister. The formulation is expelled as foam from the canister when the valve on the top is depressed. The cylindrical body is sealed by a longitudinal weld. The top and bottom sections are attached by a mechanical process of crimping.

95. The company operates four production lines for the filling process. Each line is used for different processes. No one line is dedicated to Bostik products. At the end of one production run all the parts of the production line are cleaned and then the system is programmed for the next run. On average some twenty million aerosol canisters are

produced each year. The only incident attributed to their product, which involved any injury, that the witness was aware of, was the incident involving Mr Thomson.

96. As the witness explained it, the chemical constituents are added before the valve is inserted. Each can is then sealed by inserting the valve. The propellant gas in liquid form is then inserted through the valve. This produces a raised internal pressure. The witness understood that this was such as would stop any water entering even if there was a leak at any of the seams or joints which had not been detected in the safety tests.

### *Safety testing*

97. Mr Eugster described the company's safety testing procedure. The tests were said to be dictated by the appropriate German safety standards. A standard 'leakage test' is carried out on 100% of the cans produced by Polypag. This involves testing the canisters by using air pressure to raise the pressure to 8 times atmospheric pressure (8 bar) and confirming that there are no still no leaks. The company also carry out a 'burst test' on a sample of about one in 2,000 canisters produced. In this the sample canister is tested to destruction by increasing the internal pressure (the testing mechanism appears to be to fill the canister with water and then add compressed air) in two stages. Firstly the pressure is raised to 21.6 bar. If there is a failure in the integrity of the canister before that pressure is reached then that is deemed a failure. All canisters produced between that failed sample and the last one which passed a test are removed from the production line and placed in quarantine. More samples are then taken and as necessary the production line is reset. During all of his time with Polypag this witness has never known a canister to fail this part of the burst test. Once the canisters have reached the 21.6 bar standard they are then further pressurised until they are destroyed and do not then re-enter the production process.

98. This witness' evidence about these safety tests differed slightly from his colleague's as Mr Kellner described a stage in the bursting test where "we fill the can with pressure at 18 bars, hold this pressure for 25 seconds" before the pressure is raised until it bursts, which must be over 21.6 bar or it is a failure. I do not consider that much turns on this difference in descriptions. Mr Kellner's just seems slightly more detailed.

99. The testing system does not therefore appear to offer any opportunity for water contaminated canisters to re-enter the production line to be filled with the products. Indeed, when asked, Mr Eugster could not envisage how water could enter a canister after the production process because the contents remain under pressure.
100. Mr Eugster also told the court that during the manufacturing process, when the constituent chemicals in the formulation are brought together, heat is produced reaching about 45°C. Bearing in mind that he is not a chemist, he could not envisage how any other internal reaction could produce a higher temperature. He considered that if any canisters had been subject to a higher temperature that could only be as a result of the application of an external heat source. Mr Eugster was aware that his colleague, Mr Kellner had carried out some testing to try to replicate the accident.
101. Mr Eugster was only aware of reports of two other incidents of ‘exploding canisters’ of a similar type to that involved in Shetland. The first incident was in Switzerland, the second in Denmark in 2004. He advised the court that Polypag had seen the canisters involved and that there were colour changes on the label on one of the canisters (the Swiss one) indicating an exposure to heat; and on the other (the Danish one) the label was missing suggesting to the witness that it had been heated up in water. He had no personal knowledge of the failure mechanism of the canister involved in either incident. He had seen a photograph of the canister involved in the Danish incident and described the failure mechanism as similar to that involved in the case of Mr Thomson, that is with the canister top having separated from the body. I did not hear any other detail of any investigations into the reasons for the failures in these cases.
102. The witness was asked about Doctor White’s theory that if moisture entered the filled container a reaction could have been set off which would have caused the container to fail. He could not envisage how that could happen. For water to enter there would have to be a leak at one of the seals in the cans. If there was, because of the internal pressure, he would expect foam to seep out of rather than water enter in. He could not envisage any situation where water could enter a canister on the production line as water is not used even to clean the production lines between process. As already indicated his description of the testing process, although water is involved, it is only at the stage where a canister is being tested to destruction.

103. Mr Eugster confirmed that Polypag had never been asked by any enforcement agency to alter the wording on the labelling of their canisters. He was able to advise that the instructions on the canister about use between 5 and 25°C are intended to improve the operation of the foam. If it is too cold the foam will not form a regular structure and if too warm then it can be ‘dangerous’.
104. He could offer no explanation for the ‘explosion’ of the Shetland canister, other than over-pressurisation through external heating. He was invited by Mrs Gregory, for the widow, to speculate on possible explanations for the ‘explosion’ in Shetland which would have linked it to a manufacturing defect in which the integrity of the canister had been breached leading to a release of stored energy with an explosive like effect. He was not willing to agree with any such explanation.
105. The witness drew attention to what was obvious from the photographs provided by the Crown and the reports prepared by the Health & Safety Executive experts namely that not only did the Inquiry require to be concerned with the physical integrity of the canister which caused Mr Thomson’s fatal injury but also with those others recovered from the locus which showed signs of over-pressurisation. I discuss this issue in more detail in the context of the Health & Safety Executive’s witness’s evidence. Suffice to say this witness noted that the top section of some of those cans was shaped differently from the manufactured state. Photograph 24 shows a collection of fourteen cans situated between the photographer and the fan heater. Three of these are obviously missing the plastic caps (which normally fitted over the top metal section of the can) covering the aerosol valve. One of these, located to the photographer’s far left, showed clear evidence of the top metal section having deformed by rising up in such a way that the witness concluded that the internal pressure within the canister had been raised to a level which he suggested would be close to 18 bars.

### *The Polypag tests*

106. The other Polypag witness was **Mr Torsten Kellner** who is an employee of a sister company of Polypag known as Rathor. There he is responsible for research and development of the packaging of aerosol cans which, he said, means everything about

those products other than the formulation of the contents. He is a certificated chemical technician. In the main his evidence related to investigations carried out in an attempt by Polypag to explain the Shetland incident.

107. I have already noted that his description of the way the bursting tests are carried out was fuller than that of Mr Eugster, in that he referred to a pressure test to 18 bar with that pressure being held for 25 seconds.

108. He had prepared a report in English (Production No. 8) which described the tests he carried out as follows:

*“A can of R567 size WN64 x 206Z shall be heated with a heating fan or a hot air blower and the pressure and temperature of the can (to be precise of the pre polymer, the gas phase, the can jackets lower part, where the pre polymer is situated and the can jackets higher part where the gas phase is situated) shall be measured and recorded”.*

109. His report referred only to two tests being carried out, the first involving heating only the lower third of the can (that is where the pre polymer would normally be situated) and in the second with the top third being heated (that is where the gas phase is situated). In both cases the tests were discontinued once a measured maximum pressure of 18 bars had been achieved. When the witness gave evidence at the Inquiry it transpired that before these tests were carried out another test had been carried out involving placing a canister in a tank of water which was heated. This had resulted in an explosion of the canister once it reached a temperature of 93°C.

110. The conclusion as set out in his report, was that before the Shetland canister could have ‘exploded’ it must have been exposed to a heat source of more than 90°C; but that the position of the heating fan and canisters found at the locus could not correspond with the position at the time of that heating as, on the one hand the heating fan is too far away from the canisters and on the other the four other deformed canisters (he referred to them as ‘bossed’ a reference to the raised or ‘popped up’ ‘cone’ or top section) were positioned in such a way that air was not being blown directly at them. In other words, these canisters were being protected from the direct effect of the hot air blown from the heater by other cans which did not all show signs of over-pressurisation.

111. He painted a picture of the accident as follows:

*“The heater fan was placed directly before the three bossed cans [shown in photograph 24] at an angle of 90°, whereas can 4 [the one involved in the incident] was the one positioned closest to the heater fan. When the cones of one or several cans deformed, which was accompanied by a loud sound, the craftsman [deceased] went to look at the cans that were placed before the heater fan. Either he turned off the heater fan or positioned the device in a way so that the cans were not heated any more. When the craftsman leaned over the cans and picked one of the bossed cans up in order to check it he let it fall immediately as at the top of the gas phase the can had a temperature of at least 90°C. By this sudden movement, heated pre polymer was transported to the boundary layer and there mixed with the gas phase which resulted in an immediate rise in pressure and in the bursting of the can”.*

Mr Kellner’s evidence under cross-examination by Mr Dowle was that for his hypothesis both the heating and the sudden movement of the pre polymer were involved and that he thought even if the canister had not been moved it might have exploded a moment or so later.

112. This description was, in my view, highly speculative, however it is clear that the witness accepted that the canister exploded due to over-pressurisation. I accept that as the only sensible explanation for the explosion I do not, however, accept that his (the Polypag explanation) explanation of the way in which over-pressurisation was caused is likely. Whilst I do not exclude it as one of a number of possible explanations there are a number of independent facts which cause me to question how likely it would be. Not least of these is the capacity of the domestic heater involved in this case to generate such a high source of heat. Whilst the tests carried out by HSE cannot exclude this (because they did not let the fan involved in the incident heat up to its maximum) it seems unlikely given the other tests that they carried out on that heater and also on another one similar capacity.

113. This issue was particularly relevant when it became apparent that Mr Kellner’s experiments had made use not of a domestic fan heater such as that involved in the incident but rather of a directional industrial heater which I understand was much more

akin to a heated air gun/blow torch, that is it had a nozzle with a diameter of some 5cm which was able to generate an air temperature of up to 200°C.

114. During my own intervention with the witness, to clarify his evidence, he made the following points:

- a. In the actual test he carried out to replicate Mr Thomson's accident, measurement of pressure stopped at 16 bar because the plastic material forming part of the valve melted causing a leak of foam from the valve. The leaking foam then expanded. His hypothesis was that in the fatal incident the pressure had continued to increase above the pressure they were able to demonstrate in their test, to at least 18 bar because there is deformation noted to the top of the can (similar to that noted in the ones recovered from the locus) "since we know that deformation would only happen above ....18 bar". This latter conclusion is based on the normal performance found in the standard safety tests "because we have so many tested during the normal burst pressure test that we knew... the can deformed at more than 18 bar".
- b. When the earlier test was carried out in a water tank the container failed not by leaking but by the top section separating from the body, just as in the case of Mr Thomson's fatal incident. In their test the force was so great that a pallet with a 50kg of weight placed on it, which had been placed over the water tank for safety reasons, was moved. This demonstrates the significant amount of energy released by such a failure.
- c. The behaviour of gasses within a defined volume follow certain well recognised laws of physics, with pressure increasing as temperature increases. However the presence of a solid material such as the pre polymer in these canisters affects these 'laws'.
- d. Initially his evidence had been that the only way to increase the pressure inside the canister was to heat up the contents. He did, however, concede that water being introduced to the mixture could cause a reaction which would increase the pressure. He excluded this as a likely explanation in Mr Thomson's accident because he said the reaction between the water and the contents would be immediate. Moreover he thought it unlikely that four canisters, not all from the same batch, would have become contaminated with water through an error during

production; or indeed later because of the difficulty of it overcoming the normal internal pressure (around 5 to 6 bar).

- e. It would not be possible for the Health & Safety Executive to have found a container with contents heated to 130° which only had an internal pressure at 7 bar. The witness suggested that such results showed a failure of the measuring device. He told me that he had personal experience of such problems associated with contamination by foam or other problems. When he had carried out his tests, four thermocouples has been used, two on placed inside and two on the outside of the container. This was possible for them as manufacturers. HSE had to improvise.
- f. He had more experience with Polypag than his colleague (who could not think of any occasions when canisters had failed at the pressure test stage of the safety testing process). This witness could only think of that happening on two or three occasions in the past 20 years.

115. Although he had agreed in cross-examination by Mrs Gregory that the pressure of 21.6 atmospheres, which cans would require to withstand in the standard pressure test, equated to a temperature of 68°C he subsequently clarified this evidence saying that 21.6 atmospheres would be associated with a temperature of 86°C.

116. He said that the warning on the canisters not to use them at a temperature of greater than 50°C is derived from the relevant German safety standards. He would not expect any canister to fail at such a temperature. Indeed he would not expect one to fail at a temperature of less than 86°C. According to his evidence, the German standard (TRG 300) requires there to be a safety margin of at least 50% above the specified maximum. He said that a temperature of 50°C would normally be expected to equate to an internal pressure of 12 bar. Adding a 50% margin gives a pressure of 18 bar. That I the pressure to which samples are tested for 25 seconds and well within the 21.6 bar which samples require to survive to pass the standard bursting pressure tests. As I understood it the sample therefore requires to be able to sustain a pressure of 18 bar for 25 seconds and then survive the pressure being raised to 21.6 bar before it passed. At around 18 bars of pressure it would be expected that the top section would deform, just as was found to be the case with the recovered deformed canisters from the Shetland site, but not separate. When the canister completely fails or bursts the top and body section of the canister

separate at the crimped fold. It is from these tests that the witness was able to suggest that 86° of temperature is the equivalent of 21.6 bars of internal pressure and 93°C the equivalent of 22.5 bars. This is based on information derived from the standard testing of 3 cans per hour or 3 in 6,000.

117. It is also worthy of noting with regard to the suggestion that Mr Thomson's accident might have been attributable to a leak in one of the joints of the canister due to defective manufacture, that Mr Kellner found that when in the second test heating in air that when the nozzle mechanism started to melt and the canister was no longer sealed that they "had foam everywhere". This is what he would expect if there was a leak in the integrity of the canister at a seam, and does not seem consistent with what was found in the Levenwick house.

118. Mr Kellner also confirmed that the expiry dates stamped on the canisters related to the performance of the formulation of the foam – that is that performance of the foam or the volume produced diminishes over time – and that out of date canisters do not present any additional safety hazards.

*Additional comments on Dr White's criticisms*

119. As I have said the Polypag witnesses were given an opportunity to comment on the witness Doctor White's evidence to the extent that it had not been canvassed with them when they gave evidence. Unfortunately it was not possible to easily reorganise a video-link immediately and it was thought that the mechanism opted for, which I have described, would be relatively straightforward. As it turned out it became a somewhat extended process.

120. Polypag ultimately produced a report dated 3<sup>rd</sup> April 2009 which was then translated. Rather than simply commenting on Doctor White's evidence they reported on a test of the impact of water being present in a can; and attempted to explain diagrammatically the theory put forward in their earlier report and covered in their evidence. In the test for the effects of water, canisters were manufactured containing 0.25, 0.5, 0.75 and 1 millilitre of water added to the standard constituents. This produced an increase in pressure but of limited magnitude. The pressure increase which the witnesses ascribed to the addition of

water was a maximum of 2 bar when 1 millilitre of water was added. Their hypothesis was that if there is a linear relationship between the quantity of water added and the increase in pressure then the quantity of water required to reach the critical failure point at 21.6 bar would be in the order of 5 to 6 millilitres. However if such a quantity of water had been present in the Shetland canister then the pre polymer constituents would have reacted with the water in such a way that there would be solid foam in the container which would have been unusable. Moreover their position was that any such reaction and increase in pressure would have taken effect within 24 hours of the introduction of the water.

121. I am not satisfied that it is safe to rely upon the hypothesis that the relationship between volume of water and increase in pressure is linear given that only four relatively small quantities of water were tested and these tests were not repeated. The observations of the effect of the water on the contents and the fact that the reaction was complete within 24 hours did appear to be more significant and is another factor leading to my disinclination to accept as a likely explanation for Mr Thomson's death water contamination when the canister was filled or the subsequent breach of integrity of the canister by water from some external source. Particularly as other canisters found at the locus with evidence of increased pressure and there was no evidence led that any of them had water contamination of their contents.
122. Although parties were not able to cross-examine the witness on this report, submissions were invited. As Mrs Gregory pointed out, there was no evidence before the Inquiry which would allow me to conclude that water was able to enter the canisters on the production line. The possibility of that occurring was rejected by the Polypag witnesses whose description of how the line was cleaned after each production run I accepted.
123. I have already commented on the evidence of the difficulty water would have entering a pressurised canister. I find that quite compelling. Even Doctor McCullough, who was called for the widow, thought that water entering the canisters during the production process was unlikely. Nor could he envisage it getting into a canister during normal usage or storage.

124. For all of these reasons I consider it appropriate to exclude water contamination as a likely explanation for the explosion implicated in Mr Thomson's death.

125. As a footnote to the evidence of the Polypag witnesses as I have already noted the April report submitted by them also contained additional material attempting to explain their theory that heating of the canister by an external source combined with movement of the pre-polymer had led to the explosion. This was not an area of evidence covered by Dr White that I invited them to comment on. I have not given any additional consideration to that aspect of the report.

### **Health & Safety Laboratory Experts**

126. Three specialists from the Health & Safety Laboratory at Buxton gave evidence at the Inquiry. **Jan Joel** a 'Higher Scientist' with 19 years experience who holds a B.Sc. in metallurgy and is a specialist in metallurgy and materials spoke to her detailed report dated 21<sup>st</sup> April 2008 on the examination of the failed canister implicated in Mr Thomson's death and on the other recovered canisters. **Darrell John Bennett**, who is also a Higher Scientist; who holds a BA from the Open University and an HNC in Electrical Engineering; and has been with the Health & Safety Executive for some 35 years, with 10 years experience as a Higher Scientist, specialises in the ignition of gasses, dusts and vapours. He spoke to a detailed report compiled with a colleague, Mr Tony Melton. These two witnesses carried out the bulk of the scientific investigations into this tragic accident. The third witness was **Doctor John White** is a Senior Scientist (a position held since 2000) holding a B.Sc. in chemistry; an M.Sc. in analytical chemistry; a Ph.D in mass spectrometry; and is a member of the Royal Society of Chemists with the grade Chartered Chemist. He has worked with the Health & Safety Executive for 18 years. Although not involved in the main inspection and testing of the recovered canisters, he was asked by Mrs Joel to assist her understanding of the incident based on his knowledge of the properties of Isocyanate (he described himself as "the Isocyanate person at work). He was asked if, with that background, he could suggest any mechanism for a canister of Isocyanate failing. His evidence took on a particular significance primarily because the Polypag witnesses, who had given their evidence before him, had not been asked to comment on his evidence particularly in relation to the possible effect of water 'contamination'. Because of this the conclusion of the Inquiry was delayed.

127. It was clear from their evidence that the three specialists were frustrated that they could not provide what they would consider a clear conclusion as to the cause of the canister failure. In reviewing their evidence for the purpose of this Determination I will focus upon the evidence of Mrs Joel and Mr Bennett. That of Doctor White was more hypothetical and not based on any experimental data.

### **The Metallurgical Examination**

128. Mrs Joel had been asked by the Health & Safety inspector, Mr Todd, to examine the failed can; the recovered cans; and other specially purchased cans to determine the cause of can failure. In particular she was asked to carry out a metallurgical examination of the failed can and any cans which failed during subsequent examination.

129. The laboratory had received the failed can in its post-accident condition, that is in two parts. These were described as a “failed can body” and “a failed can top”. The laboratory also received the electric fan heater recovered from the locus and three bags containing 15 cans of filler. Later Mr Bennett purchased a number of ‘new’ cans of ‘Evostik’ foam filler for testing. It was not in dispute that these were also produced by Polypag.

130. Mrs Joel’s report (Production 3) is very detailed and she gave evidence over an extensive period in court. I am satisfied that her examination was very thorough but I intend only to highlight matters that are of particular significance to my conclusion.

131. Firstly it was noted that not all of the canisters recovered from the locus were from the same production batch. The failed can had a batch number 425241/10L1 with a best before date (of the contents) of 10.01.2007. Eleven of the fourteen other (intact) canisters recovered from the site bore the same batch number and best before date. Four had a batch number 425037/10L3 with an earlier best before date of 15.12.2006. Mrs Joel subsequently removed and examined three cans from the purchased test batch with all three having best before dates of 07.06.2008 and a batch number of 4300089162/10L3. Two of these had been tested to destruction and one had been discharged and punctured. Mr Bennett had also discharged the contents and punctured two of the cans from the locus, from each of the two batches found at the locus.

132. Mrs Joel carried out a visual inspection; weighed the cans; carried out thickness measurements of the materials; and subjected samples from the three discharged cans, the failed cans and the 'tested' can to detailed metallography; and also carried out hardness tests. Her assessment was that the failure was not a materials issue but rather the operation of the effects of over-pressurisation. There were no indications on the failed can or on any others from the locus of heat markings or of any mechanical damage. The only damage noted to the failed can which was not exhibited by the other recovered cans, even those with the popped tops, was a missing instruction label, a concertina effect at the bottom of the failed can body and a dent in the failed can top.
133. Mrs Joel's evidence was that as far as heat markings were concerned she would not expect to see visible evidence of heat damage on the metal of the canisters unless exposed to a heat of 220°C. At that temperature it would start to show what she referred to as 'temper colours'. These would start with a pale yellow moving to a dark blue (at a temperature of around 310°C).
134. Whilst carrying out her tests this witness noted some differences between those from the newly purchased batch and those from the locus. The newly purchased batch appeared to be made of a thinner sheet metal than those at the locus (including the can implicated in Mr Thomson's death). When being tested to destruction it was noted that when over-pressurised some longitudinal failures occurred within the material of these 'new' (thinner) canisters. Whereas in the tests of the recovered canisters the failure found through over-pressurisation was a failure of the longitudinal joint, rather than within the material.
135. The witness confirmed the description of the construction of these canisters given by the Polypag witnesses that is a bottom section, a body, a top metal section and a valve. The body was constructed of rolled metal joined with a longitudinal weld. The top and bottom sections were joined to the body by circumferential crimping.
136. The witness gave evidence about the damage noted to the canister implicated in Mr Thomson's death other, that is, than the separation of the top from the body. There was damage to the bottom of the failed can which she described as a compression change,

producing wrinkling the metal (like a concertina). This lead to a reduction in the height of the can by some 18mm on one side and 30mm on the other. The witness suggested that this was consistent with it striking something solid. The witness could not comment on the likelihood of this being a human body or a domestic floor. There was also deformation (denting) of the can top which also indicated a collision with a solid object, but not with as much force as was involved with the bottom section. The witness suggested it had might have been “flung off and had hit a wall perhaps...”

137. Her conclusions were that:

- a. The failure of the incident can appears to be consistent with an over-pressurisation that caused the top of the can to separate from the body at the interlock seam between those two sections.
- b. There was no discolouration on the failed can that indicated that it had been heated.
- c. The top of the failed can had expanded and the curve adjacent to the interlock seam had straightened.
- d. One of the other recovered cans from the site which she examined had also expanded in the same way as the failed can in that the interlock seam had straightened and the top expanded but it had not failed at the interlocking seam in the way the failed can had.
- e. The top had expanded on all the tested cans and the curve adjacent to the interlock seam had straightened.

138. These conclusions seem to me to be very significant not only in explaining the mechanism (if not the cause) of the failure of the canister implicated in Mr Thomson’s death, but also as a touchtone for some of the hypotheses suggested as explanations for the accident which led to Mr Thomson’s death.

139. The finding of a number of cans having the curves of the top section straightened suggests that they were all subject to some source of energy which caused an increase in internal pressure. The increase within these was sufficient to cause the top to ‘pop’ but not sufficient to cause the interlocking seam to completely straighten and fail.

140. Taken with all the other evidence this suggests to me that suggests to me a significant rise in internal pressure and not a failure at modest pressure. The fact that four recovered canisters had these defects and the failed can also had the same defect in addition to a complete separation of the interlocking seam and the fact that these events clearly affected two different batch numbers indicates that it is extremely unlikely that these failures are in any way linked to manufacturing or production error. In any event a manufacturing or production error seems highly improbably given the number of cans produced by Polypag and the dearth of reports of other similar failures.

141. Mrs Joel was satisfied that the failure of the canister implicated in Mr Thomson's death was not a materials issue.

### **The Explosives examination**

142. Mr Bennett (and his colleague Mr Mellor who did not give evidence) provided a detailed report of their examination and testing of the items recovered from the locus and of the canisters bought for comparison purposes. Their examination had been prompted by being asked if they could answer a number of questions, namely:

- a. Is it possible to raise the temperature of the canisters above 50°C using the recovered fan heater placed at a distance of 2 feet; and if so by how much?
- b. Given the configuration of the canisters seen in the photographs taken following Mr Thomson's death, would there be much of a difference in temperature between those at the front (i.e. closest to the fan heater) and those at the back?
- c. Is it possible to determine if the canister which failed appeared to be faulty or damaged in some way which might cause it to fail?
- d. Is it possible to determine the criteria which would cause a canister to fail explosively? And what temperature would be required?
- e. Would agitation of the contents cause a significant increase in pressure within the canister?
- f. What pressure are the contents of the canister under?
- g. What propellant is used?
- h. What does agitation of the canister achieve?
- i. Do any of the used or sealed canisters exhibit any mechanical damage which might weaken the sealed end?

j. Does it appear that any of the used canisters have been exposed to heat?

143. The witnesses carried out a number of tests intended to answer these queries. They carried out pressure measurements using a transducer connected to an adaptor constructed to connect to the valve on the tested canisters, held in place with a clamping jig. They carried out temperature and pressure rise tests using the fan heater recovered from the locus, placed about 24 inches away from cans positioned similar to those seen in the police photographs post-incident; they carried out shake tests using a pneumatic ram; they carried out temperature tests to can failure stage using newly purchased cans and some of those recovered from the incident scene. For these latter tests they initially used a water bath but then an oil bath as they had been unable to produce a sufficient temperature/pressure change in water to replicate the failure of the can in the incident. As I have already said, Mrs Joel was provided with some of the cans for further examination.
144. Mr Bennett and Mr Mellor's report (Production 4) summarises their conclusions and Mr Bennett gave oral evidence about the tests and conclusions.
145. They concluded that with the fan heater recovered from the locus placed 2 feet away from the cans it was not possible to raise a can temperature to the 50°C warned against on the canister labelling. The maximum temperature they recorded was 36.6°C, although they considered that it would have been possible to have raised the temperature above 50°C if the fan heater had been closer. A temperature of 60°C (with a measured pressure of 12.47 bar) was recorded with that heater as close as possible, "with a little bit more to come" had the test been continued. It was, however, never established what the maximum temperature was that the fan could have produced if left running for a significant period in close proximity to the cans replicating a scenario of the fan being left running overnight as Mr Sandison suggested was common practice (albeit he did not accept that the fan would be placed against canisters). The witnesses had not wished to test the recovered fan in that way in case it was destroyed. I would have invited the Crown to make arrangements for that to be done, however that was not possible because it transpired that the original heater could not be found by HSE, as confirmed in a report from the Health & Safety Laboratory Investigations dated 12<sup>th</sup> February 2009 produced by the Crown.

146. A maximum temperature of 84°C was recorded with a similar output heater which HSE had procured for testing (whilst avoiding potential damage to the incident heater). This temperature was only obtained after a thermal cut-out fitted to that particular heater had been disabled. Whether the incident heater could have produced a similar temperature or even a higher temperature must remain unknown and it is not appropriate to speculate. The witness Bennett was not even able to say whether the incident fan heater was equipped with a thermal cut-out device such as in the purchased heater.
147. The witnesses also concluded that the way the canisters were placed when found after the deceased's accident was not a significant factor in shielding individual canisters from the effects of heating from the fan heater. What was more significant than the way they were set up was the directional effect of the fan. There was a relatively narrow band of heat output. The heat gun described by the Swiss witness as being used in their experiments was even more directional.
148. When the witnesses tested to the stage of can failure the lowest temperature and pressure measured for can failure in any of the four tests carried out (that is on the two cans from the purchased test batch and two undamaged canisters from the locus) was 123°C and 7.6 bar respectively, although not in the same test. I consider that it is unsafe to rely upon those tests which showed can failure at 7.6 bar for reasons I explain. Excluding the test which returned that low pressure result, the lowest temperature and lowest pressure for can failure are 123°C and 20.5 bars respectively. Some considerable time was spent at the Inquiry exploring the circumstances of the tests where there was can failure recorded at 7.6 bars of pressure. This was in the context of suggestions made to witnesses that this could indicate a defect in the production and/or filling of the canister. The results of the tests are detailed on a table contained at page 7 of the witnesses' report (Production 4).
149. As I have already noted, these tests were carried out with the cans being placed in a bath of oil which then had its temperature increased until the cans failed. Two of these tests involved canisters taken from the Shetland site and two from the newly purchased 'test batch'. (According to Mrs Joel these newly purchased canisters were made with slightly thinner plate metal and those tested to failure showed evidence of failure in the material whereas those from the site showed failure at the welded seam). One of the 'test

batch' canisters had half its contents by weight removed before the experiment. The authors of the report observed the tests from a remote site.

150. The first indication of failure of the cans was said to be that part of the crimped top seam suddenly unfolded with an audible noise but the rest of the joint appeared to remain intact with no loss of pressure (except possibly in the one case where failure occurred at an apparent pressure of 7.6 bar) until the temperature and pressure increased a little further resulting in complete failure. All the cans failed with a loud bang and a pressure wave sufficient to damage the door of the blast cell in which the experiment was carried out and to cause damage to adjacent equipment. Unfortunately, attempts to record the failures were unsuccessful because the speed and violence of the event did not make it susceptible to recording on the video equipment used.

151. Three of the cans failed at measured pressures of between 20.5 and 21.2 bar. As indicated the other appeared to fail at 7.6 bar. Mr Kellner from Polypag raised questions about the accuracy of the measurements carried out by HSE and it seems to me that inaccurate recording must be a real possibility despite the care which HSE took to avoid contamination of their measuring equipment. All parties who expressed an opinion seemed to accept that it was over-pressurisation not temperature itself that caused the failure of the incident canister and there is no other credible evidence available to suggest that a pressure of only 7.6 bar could lead to a complete failure. The HSE measurement technique involved an adaptor fitted and sealed over the top of the canister. A clamping jig was utilised and as I understand it the valve was then depressed, allowing the internal pressure to be measured using a pressure transducer. This system relied on the integrity of the clamped adaptor. Mr Bennett accepted that the particularly low pressure result might be attributable to a leak at the valve or an ineffective connection with his measuring equipment. He accepted that if a test was being performed on a can which contained a leak of some sort whether at the valve or elsewhere, the contents would not then follow the simple directly proportional law of a constant temperature/pressure ratio as the volume would not be constant. His final view was that because the other results obtained appeared reliable it was unlikely that there was a measurement error. This is the one aspect of his evidence I did not find convincing. I find it much more likely that there was

some sort of leak or other malfunction as otherwise this result is extremely difficult to explain.

152. Even if the low pressure reading was accurate in neither the HSE nor the Polypag tests did any failure occur without a significant temperature increase.
153. The observations of the HSE witnesses that the circumferential joint (between the body section and the top section) unfolded before the stage of a canister failure was considered significant because of the recovery of other canisters from the Shetland site that showed evidence of this effect. The witnesses considered that this indicated that these ‘popped’ cans from the Shetland site had also been subject to over-pressurisation (as had the failed can) albeit not sufficient in their case as to cause complete failure.
154. The temperatures of the canisters in the HSE tests were determined by placing 2 thermocouples on the exterior of the cans, one inch below the top seam and one inch below the level of the liquid in which they were suspended (each being immersed to half the canister height only). The method of temperature measurement may be significant in explaining another significant variation found in the experiments in that of the four cans tested to destruction the maximum temperatures recorded were 130°C and 148°C for the cans from the incident and 140°C and 178.2°C for the new cans. The significance of these discrepancies was not explored in detail at the Inquiry and it would be wrong for me to speculate, although I cannot help but note that the higher temperatures were obtained with the newer cans which according to Mrs Joel were constructed of thinner metal; and the highest temperature (but not pressure) was obtained for the can which had been emptied of half its contents before the test.
155. Mr Bennett and Mr Mellor observed that heating of the canisters to 82°C and 84°C (with pressures obtained of 13.5 and 13.4 bar) even combined with shaking of the can did not lead to failure. Accordingly they concluded that shaking of the canisters had little effect irrespective of the temperatures and pressures to which they had been exposed. Shaking of the canister is considered good practice and is intended to agitate the contents to produce mixing of the pre-polymer. This enables the contents to foam more effectively when released through the valve and the expelled contents react with air (or more

accurately water vapour in the air). The propellant used was said to be dimethyl ether but there was no evidence that the nature of propellant was significant in the accident.

156. Whilst over-pressurisation due to heating was considered to be the most likely explanation for the failure of the incident canister and the changes noted in the others at the Levenwick site, there was no evidence that either the failed canister or any of the three ‘popped’ canisters recovered from the locus had been exposed to excessive heating in that there was no discolouration of the labels on the popped cans (that on the failed can had been lost during the incident) and no visible colour changes in the metal (but according to Mrs Joel such changes would only start to occur at 220°C). These witnesses considered that heating a canister on a hot plate would be unlikely to be detectable. That was therefore suggested by them as a possible explanation for the canisters having been over-pressurised by heating without any evidence being left. There was, however, in my view no evidence from which I could conclude that that is what in fact happened. There was no evidence of any facilities with a hot-plate at the Levenwick house.

157. Although he did not notice the plastic caps of the canisters being displaced in his tests, because the plastic caps on the tops of the cans which were being tested by HSE had been removed to allow measuring devices to be attached, Mr Bennett was aware from the recovered popped canisters from the site that once the top had popped the plastic cap would not fit on. Whether they would actually be forced off as the top expanded is not clear.

158. The witness’ evidence was that an indication that over-pressurisation of a canister had occurred was the popping up of this section such that the plastic caps would no longer fit. Where such evidence is discovered it would make sense for users to be cautious and it seems to me that it may be that the manufacturers/retailers should consider including wording to this effect on the warning label and data sheet.

159. Mr Bennett also explained to the Inquiry that during their tests he and his colleague noticed that when a can was tested to failure, before complete failure the body of the can expanded to such an extent that the surrounding label split. This appears consistent with the discovery that the canister implicated in Mr Thomson’s death was missing its

labelling, some of which was found spread around the room and on the ceiling where there was also contamination by foam.

160. The witnesses hypotheses is that at some point before the complete failure of the incident can which led to the fatality it and, it is likely, the three others recovered from the locus had been subjected to over-pressurisation to the extent that the top seam had started to unfold and the top had ‘popped’. This could have been by heat but also by some other chemical reaction inside the canister. However, the witness could not identify any scientific explanation based on the tests carried out by him as to why this particular can had failed completely and explosively whilst the others had not. From his tests all the cans seemed to perform as expected according to the safety parameters described by the Polypag witnesses. A maximum working temperature of 50°C was said to equate to a pressure of just over 12 bar; and the can should not start to fail (‘pop up’) until a pressure at least 50% higher than that (18 bar) had been reached; and it should not fail completely until a pressure of about 21 bars had been reached. With the exception of the one aberrant result all the canisters in his tests failed at measured pressures of between 20.5 and 21.2 bar; and all failed at high temperatures (between 123°C and 178°C).

161. Mr Bennett suggested that a temperature of 60°C or more would make a can uncomfortable for holding, depending of course on the temperature tolerance of an individual. There is no evidence that the deceased was using gloves which would protect him from heat.

### **The Chemistry**

162. I have already mentioned that Doctor John White gave evidence to the Inquiry. I have already set out his qualifications. He had not initially been involved in the investigations into this incident and had not produced a formal report. He had, however, provided a short statement (Production 7) which detailed some of his experience working with the International Safety Organisation Committee on Air Quality (Workplace Atmospheres and Organic Vapours). This lead to his writing one of the International Safety Organisation Standards (ISO/16702) titled “Determination of Total Organic Isocyanate Groups in Air using 1-(2 – Methoxyphenyl) Piperazine 2007” and a paper on the Methods

for the Determination of Hazardous Substances (MDHS) 25/3 titled “Organic Isocyanates in Air” in 1999.

163. He became involved in this matter after Mrs Joel had sought an opinion as to whether he could suggest any mechanism whereby a canister of Isocyanate could fail. He suggested one possibility was a chemical reaction between water and the Isocyanate. In his statement he says that the isocyanate “is stated 4, 4-methylenebis phenyl isocyanate, MDI”. I note that in the Bostik data sheet it is described as diphenylmethane-4, 4’-di-isocyanate. Nothing was made of this difference in description at the Inquiry and I do not do so now. The mechanism he postulated was that if there was water in the container along with the isocyanate an initial reaction would cause the production of an Amine, Carbon Dioxide and heat. The Amine would then react with further Isocyanate to produce an insoluble Urethane. The Carbon Dioxide produced during this reaction would cause the Urethane to foam and would increase the pressure in the can. The heat caused during the reaction would cause the (dimethyl ether) propellant to vaporise causing an increase in pressure in the can. Moreover the foam released would expand and this expansion could breach the integrity of the can. A combination of these effects could lead to the failure of the can. He explained in evidence that the Isocyanate would require to be mixed for the hydrolysis (mixing with water) reaction to start. He was not able to say how much mixing would be necessary. He conceded that his work, upon which this hypothesis was based, was with a different formulation.
164. Dr White considered that Mr Kellner was wrong when he said that there would be an instantaneous reaction with any water. That was not put to the Polypag witness when he was giving evidence by video-link, hence the continuation of the proceedings to allow this failure to be rectified. The information subsequently provided to the Inquiry by Mr Kellner was that the reaction would not be as instantaneous as he had first suggested. It is not clear whether in the additional tests carried out by him Mr Kellner “mixed” the water and pre-polymer but his findings seem to me significant in two respects. Firstly the pressure increase attributed to the introduction of water was complete within 24 hours; and secondly the foam produced was substantially changed. There was no suggestion in the evidence presented to me that the foam produced in the explosion which led to Mr Thomson’s death was different from that which would normally be expected to be extruded from the canister.

165. For Doctor White's hypothesis to be relevant to Mr Thomson's death it is essential that water entered the canister in some way. Doctor White could not postulate any mechanism which would allow water enter a pressurised canister. Nor did he think it likely that it would have entered during the production process and he agreed that the finding of 3 cans from 2 different production batches at the locus showing evidence of over-pressurisation made that even less likely. As I have already explained I can find no evidence from which I consider it would be safe to conclude that water did enter the canister involved in this fatality, either at the time of production or later by overcoming the internal pressure within the canister to penetrate a defect in a crimped or welded seal.
166. Moreover there is the issue of timing. According to Dr White's hypothesis the reaction between the water and the Isocyanate would have occurred when they were mixed.
167. If I accept that the mechanism which caused the popping of the 3 recovered canisters was the same as that involved in the over-pressurisation of the canister which exploded, it seems to me that it is necessary to exclude this water penetration theory. Accordingly, scientifically sound as this hypothesis might be, I do not consider that in the circumstances of Mr Thomson's fatality this proposition assists in explaining the cause of the accident leading to his death. Even Doctor White thought it was at most a possibility not a probability. He conceded that that hypothesis was based on general principles rather than the specific circumstances that could be established in this case.
168. He was asked about a number of other possible scenarios. He said that even if the constituent chemicals had been added to the can in proportions different from that intended it was unlikely that they would react in such a way that there would be over-pressurisation. This was in response to Mr Dowle's suggestion of this as another explanation for "over-pressurisation". Doctor White's evidence seems to me to effectively discount that.
169. Nor did Doctor White think that overfilling with gas at the filling stage would lead to an explosion in the circumstances of the type experienced by the deceased, as 'overfilling' would not alter the nature of the constituent chemicals.

170. Nor did the witness accept the theory postulated by Mr Kellner that there had been an energy transfer from cooler pre-polymer to warmer gas with external heating concentrated on the top of the can. Rather than that leading to an increase in pressure he thought the reverse would happen with the energy in the hotter gas being transferred to the cooler pre-polymer. He could see such a transfer from the pre-polymer to the gas if heating was concentrated on the base of the can where the pre-polymer would be expected to be found. Such a transfer of energy could lead to an increase in heat in the gas stage causing it to expand. However this evidence was not explored further by parties and there was no evidence available to allow me to conclude that had happened
171. It was interesting to note that this witness could not understand what witness Kellner was meaning when he said that when the pre-polymer constituents are first added to the canisters on the production line there is a reaction which produces heat (exothermic reaction). He could not understand why, given his knowledge of the chemicals involved that would happen. He had not, however, carried out any work to test this evidence.
172. Doctor White also raised doubts about the reliability of the results produced by Mr Kellner during the tests which involved heating the canisters with a directional heat gun. In particular he queried the results which showed the temperature in the pre-polymer area inside the canister as hotter than the immediately adjacent area outside. The only explanation he could think of for that was that in addition to heat transfer some other reaction was taking place within the container. As indicated in the preceding paragraph he could not envisage such a reaction producing heat given the declared constituent chemicals.
173. Although he did not consider that he was an expert on the behaviour of canisters when pierced, in response to a question about a possibility of the canister having developed a leak which led to an explosion, Dr White was able to comment on how Isocyanate would behave in those circumstances. He suggested that the propellant gas would leak out and the Isocyanate would dribble out of any hole the latter leaving foam around the edge of the breach. As far as I am aware no such evidence was seen on the recovered canister.

174. Doctor White provided a working description of how one of these canisters is intended to operate. Within the canister there is a pre-polymer mix in solid form together with a propellant in liquid form. When the nozzle of the valve on the top of the canister is depressed, pressure is released. The liquid gas (or at least some of it) turns into gas and as it does so it exits the valve through the plastic tube which has been inserted in to the nozzle. In the process it sucks the pre-polymer product through with it into the atmosphere where it reacts with the moisture in the air and the foam forms. The liquid gas acts as a propellant but also turns the pre-polymer product into an aerosol, that is particles of the product are dispersed in a gas.
175. This witness agreed that the explosion of this canister was due to over-pressurisation and that the most likely cause of that was exposure to heat.

### **The Expert for the Widow**

176. The final witness was Doctor McCullough, who was called by Mrs Gregory and gave evidence on 21<sup>st</sup> January 2009. He had produced a report (Production No. 9) which was available to the Inquiry.
177. Doctor McCullough is 59 years old and describes himself as a Consulting Engineer and Scientist. He holds the degrees of Master of Science and Doctor of Philosophy. He is a Chartered Engineer and Chartered Scientist. He is a Fellow of the Institution of Mechanical Engineers and a Fellow of the Energy Institute. He holds the title European Engineer (awarded by the European Federation of National Associations of Engineers). He is also a member of the Academy of Experts and the Expert Witness Institute. He is Chairman of a firm of Consulting Engineers based in Glasgow. There is no doubt that he is well qualified.
178. He had been asked by Mrs Thomson's solicitors to consider the circumstances that may have caused Mr Thomson's death and to review the reports prepared by the Health & Safety Executive witnesses. He had been provided with copies of various witness statements, photographs and productions. He was also present when factual evidence was given to the Inquiry.

179. His conclusion was that there were a number of competing possibilities to explain the accident suffered by the deceased. In his report and in evidence to the Inquiry he reviewed six of those possibilities accepting that all had their difficulties and that none were compelling. They were:

- a. Overheating of the canister by the fan heater recovered from the locus;
- b. The suggestion by HSE that the canister implicated and the other popped cans had been heated on a hot plate;
- c. Overheating by ambient air or solar radiation (such as may have happened in the incident referred to by the witness Laurenson);
- d. Overheating by use of a blow torch (the only evidence for which came as hearsay evidence obtained during what I considered to be a superficial investigation by Bostik);
- e. Lighting or smoking a cigarette leading to ignition of the propellant (for which no supporting evidence was presented to me); and
- f. Defective canister manufacture.

180. In his report and also in his evidence he suggested that the first five scenarios could be discounted for positive reasons. Whilst he accepted that there was no positive evidence to support the sixth scenario, that the explosion was due to a manufacturing defect at the upper joint (the joint between the top section and the body section of the canister), his opinion was that “It cannot be discounted. Therefore, on the balance of probabilities” that was the most “robust explanation”.

181. Whilst I accept that might be one possible explanation I am not persuaded that there was material before me that would allow me to conclude that it was the most likely explanation. I am not persuaded that the witness’ reasoning is sound and I reject his conclusion.

182. Doctor McCullough was the only witness with any claim to expertise who did not think that the explosion of the canister was due to over-pressurisation. He did eventually concede that heating of the recovered ‘popped’ canisters to reach an internal pressure of at least 18 bar was more likely than his manufacturing defect as an explanation for their popped condition.

183. When assessing expert testimony it is helpful to remember that the role of an expert is not to usurp the function of the court by expressing an opinion as to the issue in dispute. Rather it is to act independently (irrespective of the means by which he became involved in the case, for example was he employed a party who might have an interest in a particular conclusion, and to provide evidence which can be tested by the tribunal charged with the responsibility of decision making. In *McTear v Imperial Tobacco Ltd*. [2005] 2 SC 1 Lord Nimmo Smith reviewed the law anent expert evidence in Scotland. He was particularly concerned with suggestions that conflicting expert testimony might be tainted by the motivation of the expert; and also the appropriate approach to epidemiological evidence. However his comments and the earlier cases he refers to have a more general application. For example at page 141, Paragraph 5.16 he discusses the case of *Main v Andrew Wormwald Ltd* 1988 S.L.T. 141 which had been referred to by the pursuer's counsel in support of his suggestion as to how his Lordship should deal with the epidemiological evidence. Lord Nimmo Smith says this:

“ in a passage in the Lord Justice-Clerk's opinion which is not reported in the published report, but is on pp.73-74 of the version provided to me from the reclaiming print, the Lord Justice-Clerk held that the reasoning of the Lord Ordinary in that case was flawed in respect that he appeared to have accepted what the pursuer's medical witnesses said about a report of the Industrial Injuries Advisory Council without himself applying any critical analysis to the passages in that document which were relied upon. The Lord Ordinary was not obliged to accept a passage referred to by one of the witnesses as the expression of reliable opinion, nor was he obliged to accept the witness's view that what was stated in the passage was correct: the Lord Ordinary was entitled and indeed bound to consider whether what was stated in it was convincing. In the Lord Justice-Clerk's opinion, the proper conclusion was that reliance could not be placed upon it in the context of that case. Among other reasons, one reason was that the authors of the report put forward, as a ground for believing that an association was likely to exist between asbestos exposure and lung cancer in the absence of intervening asbestosis, that research had shown that the incidence of lung cancer deaths among asbestos workers was directly related to total asbestos dust exposure. No detail was given regarding this research, and the result must be, the Lord Justice-Clerk said, that the basis upon which the conclusion of the report was based had not been established before the court. This of course was a view expressed in relation to the evidence in that case, but I have quoted it because it is a clear demonstration of the application to that evidence of the general principles relating to the evidence of expert witnesses.

I accept [pursuer's counsel'] submissions on this matter. Having regard to all the authorities referred to above, I conclude that it is necessary to consider with care, in respect of each of the expert witnesses, to what extent he was aware of and observed his function. I must decide what did or did not lie within his field of expertise, and not have regard to any expression of opinion on a matter which lay outwith that field.....

Above all, the purpose of leading the evidence of any of the expert witnesses should have been to impart to me special knowledge of subject-matter, including published material, lying within the witness's field of expertise, so as to enable me to form my own judgment about that subject-matter and the conclusions to be drawn from it. ....

Another matter which I propose to mention at this stage, and to which I shall also return, is the need for expert witnesses to be independent. I must decide in relation to each of the expert witnesses whether, and if so to what extent, he may have been acting as an advocate rather than providing independent assistance to the court....

184. In *Davie v Magistrates of Edinburgh* 1953 S.C. 34 a number of issues arose in relation to the expert evidence which had been led in that case. At p.40 the Lord President (Lord Cooper) rejected a submission that, where no counter evidence on the science in question had been adduced for the pursuer, the Court was bound to accept the conclusions of an expert witness for the defenders, saying that this view was "contrary to the principles in accordance with which expert opinion evidence is admitted". He went on to explain these principles, as follows:

"Expert witnesses, however skilled or eminent, can give no more than evidence. They cannot usurp the functions of the jury or Judge sitting as a jury, any more than a technical assessor can substitute his advice for the judgment of the Court [...]. Their duty is to furnish the Judge or jury with the necessary scientific criteria for testing the accuracy of their conclusions, so as to enable the Judge or jury to form their own independent judgment by the application of these criteria to the facts proved in evidence. The scientific opinion evidence, if intelligible, convincing and tested, becomes a factor (and often an important factor) for consideration along with the whole other evidence in the case, but the decision is for the Judge or jury. In particular the bare ipse dixit of a scientist, however eminent, upon the issue in controversy, will normally carry little weight, for it cannot be tested by cross-examination nor independently appraised, and the parties have invoked the decision of a judicial tribunal and not an oracular pronouncement by an expert."

185. I am afraid that Doctor McCullough was unable to persuade me that he has been able to exclude all other possible explanations and the assertion that his sixth possibility is the most robust on the balance of probabilities is not persuasive. When there is no positive evidence to support a theory it just does not do to baldly state "I cannot think of any other explanation therefore that one must be the most probable". I was not satisfied that the

witness was able, on the basis of his expertise to catalogue a closed list of possible explanations and exclude each of the others. Not only is his theory not susceptible to testing, it must also be borne in mind that Doctor McCullough's principal area of expertise is engineering not chemistry nor indeed explosions or the behaviour of gasses.

186. I spent some time exploring with Doctor McCullough the basis for his conclusion, particularly in the context of the recovery from the locus of other canisters from mixed batches which had 'popped' through some mechanism which I consider it is reasonable to conclude is likely to have also to have been involved the canister responsible for the fatal injury. His evidence he did raise some questions about the accuracy of the measurements carried out by the Polypag witnesses. For example although the canister body was presumed to have high thermal conductivity, when Polypag heated the top of the canister there seemed to be very poor conductivity to the bottom. When the Polypag tests were concentrated on heating the bottom of the canister the results did suggest that there was good conductivity. This could not be explained by this witness other than to say that perhaps their measurements were not reliable. This was not, however, explored with the Polypag witnesses. When I asked him about possible explanations he said (page 213 on 21<sup>st</sup> January 2009) "I would be speculating as to what happens inside the can when it is heated". Because, of course, it is not his area of expertise.

187. When asked about the relevance of the three other 'popped' canisters, he said that obviously something had happened but he could not think what it was. He did eventually accept that heating of the three recovered canisters and the incident canister to at least 18 bars pressure was a more likely explanation than a manufacturing defect.

### **Submissions**

188. Mr Mackenzie invited me to limit my determination to the matter set out in section 6 (a) and (b) of the 1976 Act only. He invited me to find that the accident and death were "contemporaneous" having occurred on 10 February 2007 at about 10.00hrs at Upperton, Levenwick, Shetland; that the cause of death was haemopericardium consequent upon a laceration of the right ventricular failure, a necessarily and rapidly fatal consequence of blunt force trauma to the chest sustained in an accident in the workplace. As to the cause of that accident he conceded that a determination was more problematic, and that the evidence fell short of providing a definite answer to that question. He invited me to limit

my determination to finding that the accident occurred when the deceased was handling a canister of expanding foam filler when, as a result of an internal over-pressurisation suffered a catastrophic failure in consequence of which the top of the canister became detached from the body of the canister at the interlocking seam joining the two, thereby propelling the body into the deceased's chest. Moreover he submitted that the evidence allowed me to conclude that the over-pressurisation was due to an increase in temperature of the canister and contents attributable to either a mechanical or chemical means prior to 10 March 2007.

189. Except for the final submission I accepted the Crown's position. For the reasons I have set out I consider that it is likely that the over-pressurisation was due to exposure to excess temperature rather than mechanical or chemical processes.

190. As I understand the submissions by Ms Knarston on behalf of Bostik she associated herself with Mr MacKenzie's submissions but invited me to conclude that the over-pressurisation was due to an increase in temperature. She invited me to reject the suggestion that a defect in the manufacture of the canister led to its failure. For the reasons I have set out I do consider that I must reject that as an explanation.

191. Mr Dowle adopted Mr MacKenzie's submissions with regard to the formal findings in terms of Section 6 (1) (a) of the 1976 Act. Thereafter, he disagreed and suggested that it was not appropriate to conclude that the explosion was due to internal over-pressurisation. If I understood his submissions properly, although he did not go as far as to invite me to conclude that there had been a manufacturing defect, Mr Dowle placed reliance on Dr McCulloch's conclusions, particularly in relation to the probability that a leak at low pressure caused the explosion and further that a canister could explode without being exposed to extreme heat. I have already set out the reasons why I reject Dr McCulloch's conclusion. I do not exclude the possibility that a canister could explode for a reason other than its being subjected to extreme heat. However in the context of this death that is not relevant and does not justify my making such a finding. Mr Dowle did subsequently agree that it was likely that at some point the failed canister and the 3 recovered canisters which showed evidence of having popped had at one stage been exposed to excess heat. He invited me to hold that there was, however, no evidence from

which it would be safe to conclude that this had been caused by them being placed in front of the fan heater recovered from the locus.

192. Ms Gregory for the widow indicated that she largely concurred with Mr MacKenzie's submissions and adopted Mr Dowle's submission in relation to a possible finding that the failure of the canister involved had been caused by internal over-pressurisation. Mrs Gregory covered the evidence in great detail and was at pains to point to evidence which pointed away from any finding that the ambient temperature in the house was particularly high at the time of the death and in particular that the fan heater had been on for any extended period at its maximum output. As she herself accepted much of her submission on this point was speculative, but for what it is worth I agree that I cannot make any positive finding in relation to the fan heater being the cause of any overheating of the canisters.

193. I was invited to conclude that there was no evidence that the deceased had done anything on the morning to lead to an over-pressurisation of the order needed to cause a canister to explode; that there was no evidence that he had contravened any instructions or guidance; and in short that he was not the author of his own misfortune. She accepted the difficulties in identifying a specific reason for the canister failure. However she invited me to conclude that there were only 2 explanations with scientific validity. Either over-pressurisation or a breach of integrity either at increased pressure or at ambient pressure. In her submission, in what she described as "the absence of evidence to support over-pressurisation" I should rely on the opinion evidence of Dr. McCulloch that the canister failed due to a breach in its integrity as a result of a manufacturing defect and that the breach occurred at ambient pressure. Careful and detailed as Ms Gregory's submissions were I cannot accept that I am entitled to make any such finding.

## **Conclusion**

194. Despite extensive investigation by a number of well qualified scientists I regret that at the end of this long and frustrating Inquiry I am unable to conclude that there is a clear explanation of the circumstances which led to the over-pressurisation of the canister which I accept was involved in an explosion whereby the top and body separated. One of these parts, which on the evidence I consider it most likely to be have been the body

section, was propelled into the deceased's chest with such force that it caused a necessarily fatal injury. The most likely explanation for that over-pressurisation is that the canister was heated to a very high temperature. When and how that occurred has not been unascertained. I cannot exclude the possibility that the fan heater recovered from the locus was in some way implicated. The existence of the other popped cans in the vicinity points to some such connection. However, I am not satisfied that the evidence is such that it would be safe for me to come to any conclusion as to what that connection was. It is, however abundantly clear that no naked flame such as one might expect from a blow torch was involved.

195. During the course of the Inquiry I expressed my sympathy to the family of the deceased over their sad loss. In concluding this note I wish to pay tribute to the courteous and dignified way the family members conducted themselves during what was for them a difficult, extended and frustrating court procedure.