IN THE MATTER of the Coroners Act 1988

AND

IN THE MATTER of Inquest into the death of ROBERT KENNEY DAVIDSON

DATE OF HEARING: 10 & 11 April 2006

DATE OF DELIVERY OF FINDINGS:

PRESENT:
- Mr. M.J. Hunt for the Davidson family
- Mr. M. R. Bott for Divers World, Picton
- Detective Sergeant Hamilton for the Police

FINDINGS OF CORONER

INTRODUCTION

1. ROBERT KENNEY DAVIDSON of 55 Kennedys Bush Road, Christchurch died in the sea at Port Underwood in Marlborough on 10 July 2004. Mr. Davidson was a senior manager employed by the rail and transport operator Toll New Zealand Limited and his principal place of work was at Christchurch. Mr. Davidson and his wife Justine Davidson had three children Laura, Sam and Madeleine. Mr. Davidson's mother and her partner DONALD FREDERICK STANNERS had a property at Haka Haka Bay, Port Underwood. As well, Mrs. Davidson, was originally from Blenheim. These family links to Marlborough meant that the family regularly visited Marlborough for recreation and family interaction.

2. Mr. Davidson liked fishing and underwater diving. He had been a recreational underwater diver since about 1983 and the property of his mother and her partner at Haka Haka Bay was a good base for fishing and diving.

3. In July 2004 at the time of the school holidays Mr. Davidson decided to come to Marlborough with two of his children, Sam and Madeline, and have some rest and do some fishing and diving.

ARRANGEMENTS MADE

4. Mr. Davidson had a friendly relationship with Mr. Stanners for ten or eleven years. They would often go out together fishing or diving. Mr. Stanners was not a diver but would help Mr. Davidson. They owned a runabout boat together and they used this for fishing and diving.

5. In early July 2004 Mr. Davidson called Mr. Stanners to make arrangements to go to and stay at Haka Haka Bay. Mr. Davidson asked Mr. Stanners to get two dive tanks owned by Mr. Davidson filled with air. Mr. Davidson's diving equipment including his air tanks were always stored at Haka Haka Bay as the only diving Mr. Davidson did was

out of Haka Haka Bay. The tanks were believed to be empty and to be in need of being filled.

6. On Wednesday 7 July 2004 Mr. Stanners took the air tanks to Divers World Picton and had them filled. He returned to Haka Haka Bay with the tanks and put the dive bottles in the locked shed where they were usually kept and locked the shed.

7. The following day, Thursday 8 July 2004, Mr. Davidson arrived at Haka Haka with Sam and Madeline. They were intending to stay at Haka Haka until early the following week. Mrs. Davidson did not come and remained at home in Christchurch with Laura.

8. On Friday 9 July 2004 Mr. Stanners and Mr. Davidson went out and set nets and put out a cray pot. No diving was done on Friday but it was arranged that Mr. Davidson would dive on Saturday.

DIVING ON 10 JULY 2004,

9. Mr. Stanners and Mr. Davidson left to go diving together mid morning. They took the boat to the water with tractor and trailer. All of the required gear was thought to be in the boat. They launched the boat and Mr. Davidson drove it off. They checked nets and the Cray pot and collected a flounder and a crayfish. Mr. Davidson then decided to dive at a regular and favoured spot. He realised that he did not have his wet suit jacket so he and Mr. Stanners had to go back to the Bay where they found it lying in the drive. By the time they returned to the dive spot a swell of about two metres was running. They went to the dive spot but by the time they got there it was getting later in the day than they had intended and they were becoming pressed for time. It was decided that Mr. Davidson would go down for a short dive only. He put on his gear in what seemed to be the normal way taking with him the single dive tank that had been taken onto the boat. Mr. Davidson appears to have checked his gear and Mr. Stanners looked at it as well but he was not an experienced diver. Mr. Davidson entered the water and Mr. Stanners manoeuvred the boat to keep it in approximately the same position. The developing swell meant that Mr. Stanners had to concentrate on working the boat.

10. Mr. Stanners thought that there was something unusual about the way in which Mr. Davidson entered the water on this day. Normally he would go into the water head first and come back up and give an okay signal. This time he went in feet first, rolled up and went down again without any signal. Usually Mr. Stanners would see continuing bubbles but on this day he did not.

11. Mr. Davidson and Mr. Stanners had agreed that Mr. Davidson would go down for fifteen minutes. After fifteen minutes he had not surfaced and after thirty minutes Mr. Stanners was becoming worried. He knew that Mr. Davidson's air supply would be near exhaustion and it was also getting rougher and it was very cold. Mr. Stanners tried to find Mr. Davidson using a bathyscope but could not see anything. The boat was running low on petrol and the concerns of Mr. Stanners were developing. After an hour he knew that Mr. Davidson would have run out of air so he went back to shore. He hoped that Mr.

Davidson would be on the surface perhaps clinging to a rock. Mr. Stanners raced home and arranged for the Police to be notified and for other help to be gathered. It was not possible to locate Mr. Davidson on Saturday 10 July 2004.

12. On Sunday 11 July 2004 the Police Dive Squad located Mr. Davidson's body at a depth of nine metres. He was found in the immediate area where Mr. Stanners indicated he had entered the water. Mr. Davidson's body was not entangled and was lying on the bottom.

13. Senior Sergeant Bruce Robert Adams, the officer in charge of Police National Dive Squad gave evidence as to the location of Mr. Davidson's body and the inspection of his dive equipment. When the dive equipment was first inspected by a Police diver it was found that the cylinder valve was turned on 90 degrees only. Normally it takes three or four complete turns to fully open or close a dive cylinder valve. As it turned out this was not a causative influence on the death of Mr. Davidson. It was also found by Police Dive Squad that the dive cylinder had been incorrectly fitted to the Buoyancy Compensator Device but there had been some adjustment to the equipment to compensate for this.

14. Senior Sergeant Adams noted the breach of safe diving practice in that Mr. Davidson dived alone. Again however it is not known whether a buddy would have been able to save Mr. Davidson.

15. Police Dive Squad undertook a comprehensive analysis of Mr. Davidson's equipment and of the circumstances in which he died and the conclusion reached was that the cause of death was air contamination.

CAUSE OF DEATH

16. When Mr. Davidson's body was recovered it had been in the water overnight and by the time it was recovered it had been seriously affected by sea lice degradation. Doctor Malcolm McKellar, a very experienced specialist pathologist, examined Mr. Davidson's body but it was not possible to obtain suitable blood specimens or other tissues for useful examination. Doctor McKellar concluded that the cause of Mr. Davidson's death was consistent with asphyxia and having seen other toxicological analysis he concluded that the asphyxia was due to the inhalation of toxic levels of carbon monoxide in the underwater breathing cylinder which was being used by Mr. Davidson during his last dive.

17. Police National Dive Squad had, after Mr. Davidson's death, taken possession of two yellow dive cylinders. One serial number P888845 was the cylinder which Mr. Davidson had been using when he had died. The other cylinder, SA8749 was the cylinder which had been filled at Divers World at the same time as P888845 but which had remained in the shed at Haka Haka Bay unused.

18. Police Dive Squad sent both cylinders to Institute of Environmental Science and Research Limited (ESR). ESR found in summary:

The contents of both cylinders P888845 and SA 8749 do not conform to NZS 2299.1:1999 or to BS 4001 for compressed breathing air, having failed with respect to carbon monoxide, methane, carbon dioxide and oxygen.

In a table in Ellenhorn and Barceloux (reference 1) a level of 1950 ppm carbon monoxide (0.195%) in breathing air is described as "rapidly fatal". The air in the cylinder the deceased was using contains nearly seven times this limit and is some 1360 times higher than the recommended limit of 10 ppm.

UNDERWATER BREATHING

19. In the absence of air lines connecting an underwater diver with the surface, an underwater diver is required to carry his or her own breathing apparatus. Self contained underwater breathing apparatus (scuba) utilising compressed air carried by divers in cylinders is in very common use throughout the world.

20. To maintain his or her life under water a scuba diver is required to carry a tank of compressed air. Put very simply, the volume of air at ordinary air pressures as would sustain life in a person for a particular time period (for example 30 minutes) is compressed into a cylinder at pressures well above ordinary air pressures and is progressively released into breathing apparatus to enable life to be sustained under water for approximately the same period.

21. The process of taking a large volume of air at ordinary pressures and compressing it into a small tank at high pressure is achieved by the use of mechanical air compressors. It is not safe to use pure oxygen for prolonged periods nor is it safe to use pure oxygen beyond a certain depth and thus it is necessary for ordinary air to be compressed for scuba use.

22. To achieve the air pressures ultimately required it is necessary for the mechanical compressor to compress air in stages. In the first stage, the compressor sucks air in through an intake filter and compresses it as it pushes the air onwards. As we know from the heat of a bicycle pump, when air is compressed it produces heat. This heat has to be dissipated in the compression process. Within an air compressor as each stage of compression of the air occurs there is a requirement for heat to be dissipated. Additionally, as the process of compression and cooling proceeds, dew (moisture) is produced and needs to be separated out. Ultimately in what is usually a three stage process air is compressed to the desired pressure. Usually in high volume commercial operations, this air is taken to banks of large tanks where it is stored under pressure and bled off as required into small scuba tanks. It is however possible in certain circumstances to take air directly from the compressing unit and into scuba tanks and this is more often done in small scale non commercial units.

23. Air is compressed for scuba purposes in many different situations. They range from high volume commercially operated operations through to small scale backyard operations. The operators range from trained personnel with an understanding of the

requirements through to those who in a private situation may have an understanding at a practical level but may not have any professional training or qualifications.

24. Compressor units can be driven by internal combustion engines or by electric motors.

AIR CONTAMINATION

25. It is critically important that the air which is compressed into scuba tanks is pure and free from contamination. There are various contaminants which can get into compressed air in scuba tanks but the contaminant which is properly feared most is carbon monoxide (CO). Carbon monoxide is toxic to all creatures which breathe air and it produces its effects due to starving the tissues of oxygen. It is odourless, invisible and quickly fatal. A victim can quickly lose consciousness without noticing any symptoms. Carbon monoxide is produced by the incomplete burning of carbon in fuel.

26. It is possible for carbon monoxide to contaminate scuba tanks through being within the air which is drawn in by the compressor, progressively compressed, and then injected into the scuba tanks. Thus if the air intake to the compressor were to be in the same area as an internal combustion engine were discharging exhaust fumes it is easy to see that the air ultimately compressed could contain carbon monoxide.

27. In addition, it is well known that air compressors themselves can in certain circumstances produce carbon monoxide and thereby contaminate, as part of the process, the air which is being compressed for delivery to scuba tanks.

28. Air compressors are not internal combustion motors but in certain circumstances internal combustion can occur within an air compressor. As an example, oil deposits at the interface between the piston and the cylinder can build up to a point where the heat from compression causes burning which can release the toxic carbon monoxide. The air being drawn into the piston becomes contaminated by the carbon monoxide which is being produced in a pulse in the cylinder above the piston head and that contaminated air is driven into the next stage of the compression process. As a further example, in certain circumstances, an ignition can occur within an activated charcoal air filter causing carbon monoxide to be produced at the final stage of the compression process. The danger of there being an unintended pulse of production of carbon monoxide in the air compression process through the faulty performance of the air compressor is a danger which is well recorded in the scientific and operational literature relating to air compressors. There are known precautions and procedures which can be taken to eliminate or reduce the risk of inadvertent carbon monoxide production during the air compression process.

CYLINDERS P888845 AND SA8749

29. It is known with certainty that the air in each of these cylinders was grossly contaminated with carbon monoxide. It is obvious that Mr. Davidson who died shortly after beginning breathing air from cylinder P888845 died as a consequence of breathing

carbon monoxide. What became an issue during the Inquest and in the period leading up to the Inquest was when did the contaminated air get into the cylinders.

WHEN DID THE CONTAMINATED AIR ENTER THE CYLINDERS

30. The evidence of Mr. Stanners was that he took tanks P888845 and SA8749 to Divers World, Picton on 7 July 2004. He took the tanks to Divers World believing them to be empty or at least in need of replenishment. Mr. Stanners was able to verify through an EFTPOS transaction that he paid to Divers World on 7 July 2004 the sum of $12.00 being the cost of recharging the two tanks. Mr. Stanners stated that he took the two tanks home and put them in a locked shed where they remained until on 10 July 2004 tank P888845 was taken by Mr. Davidson down into Haka Haka Bay.

31. The time period between the known visit to Divers World on 7 July 2004 and Mr. Davidson's death on 10 July 2004 was very short. In this time interval, the air tanks in question were kept in a locked shed.

32. The possibility that some person could have entered the locked shed and had then maliciously introduced carbon monoxide into the tanks was addressed and was thoroughly investigated by the Police. The outcome of that investigation was that there can be no basis for any such suspicion. No known motivation for such an action could be found and no realistic opportunity existed to enable interference with the tanks to take place. Furthermore, and importantly, the mechanics of injecting carbon monoxide into both tanks to produce the analyses made demonstrated that such a thing was as good as impossible. Specialist equipment would have been required and a source of pure carbon monoxide would also have been required. I am satisfied on the evidence before me and beyond any doubt, that the last injection of air or any gaseous substance into the tanks took place on 7 July 2004. That finding, does not however, answer the question of when the contaminated air entered the cylinders.

THE TECHNICAL INVESTIGATIONS

33. Shortly after Mr. Davidson's death the Occupational Safety & Health Service of Department of Labour undertook an investigation. The investigator was GEOFFREY LEONARD COOPER. Mr. Cooper (who at the Inquest gave evidence before me) has more than forty years experience as a diver. His expertise is that of a very experienced diver who is very experienced in the systems surrounding diving. His present position with the Department of Labour is that of a Health and Safety Inspector who also holds the title of National Diving Co-ordinator.

34. In his report of 8 September 2004 Mr. Cooper addressed the factual background to Mr. Davidson's death and he also reported on his inspection of the equipment at Divers World. At the stage of his report, Mr. Cooper was aware of the outcome of ESR analysis of the Davidson tanks.

35. Amongst the conclusions in Mr. Cooper's report were the following:

8.1 At the time of compiling this report, it is not known exactly what caused the death of Robert Davidson.

8.6 In my opinion, the contamination of the "Davidson cylinders" did not occur at Divers World Picton.

36. In reaching his conclusions Mr. Cooper recognised that the cause of death was carbon monoxide poisoning but he could not account for how the carbon monoxide got into the tanks although he was satisfied that it did not get into the tanks at Divers World Picton.

37. There were a number of reasons for Mr. Cooper's conclusions exculpating Divers World in the contamination including:

- Cylinders filled for other users at about the same time were not contaminated.

- Regular testing of air supplied by Divers World Picton by New Zealand Underwater Association (an approved testing agency) in accordance with the required Standard showed Divers World air when tested to meet the required Standard.

- The records maintained at Divers World showed that the Davidson tanks had been filled from the storage bank of compressed air not directly from the compressor and if that were the case it was inconceivable that the levels of contamination could have been achieved and that no other tanks could have been contaminated.

38. If Mr. Cooper's first report was correct then somewhere, which place could not be identified, serious and fatal contamination of scuba tanks had occurred. If such a thing had occurred in the case of Mr. Davidson then it could well occur again. In these circumstances I requested the Police to commission a further report from the Departments of Mechanical Engineering and Chemical and Process Engineering at the University of Canterbury.

39. That report dated 9 November 2005 was duly received. The principal contributors to the report were SHAYNE DOUGLAS GOOCH, a Lecturer in Mechanical Engineering at University of Canterbury, IAN ALEXANDER GILMOUR, a Senior Lecturer in the Chemical and Process Engineering Department at University of Canterbury and CRISPIN HALES of Hales and Gooch Limited in Chicago. Doctor Gooch started his working life as an apprentice fitter and turner and progressed to his present position. He has a PhD in Mechanical Engineering, is a member of the American Society of Mechanical Engineers and has responsibilities in that Society. Mr. Gilmour has a Masters Degree in Engineering and has some 33 years experience in research in the field of Chemical Engineering. Doctor Hales is a consultant in relation to mechanical systems, safety and accident reconstruction; he is a Chartered Engineer in the United Kingdom and is a Fellow of the

Institution of Mechanical Engineers (UK) and the American Society of Mechanical Engineers (USA).

40. Amongst the preliminary conclusions in the Gooch Gilmour and Hales report of 9 November 2005 were the following:

1. The dive tank filling station at Divers World Picton was a likely source of the air tank contaminants resulting in the death of Robert Kenney DAVIDSON.

2. The scenario most consistent with the available evidence is that a combustible contaminant was introduced inadvertently into the filter assembly at some time prior to the filling of the air tanks used by Mr. Davidson. The evidence that only Mr. Davidson's tanks were filled with highly contaminated air is consistent with his tanks being filled directly from the compressor, bypassing the storage tanks.

3. The coating of fine brown/orange dust in the compressor room indicates abnormal compressor operating conditions and the equipment does not appear to be in good running order.

4. Operating and maintenance procedures do not comply with current accepted practice. The air supply circuit and function of all system components needs to be reviewed. If the filling station continues to operate in its current state it is likely that a similar air contamination event will occur in the future.

41. In reaching their conclusions Doctor Gooch, Mr. Gilmour and Doctor Hales addressed the mechanisms for CO formation. They identified five possible mechanisms and they addressed each of them in the following way:

MI. Deliberate contamination with CO

M2. Introduction from an external source such as an internal combustion engine exhaust entering with the air through the compressor intake

M3. Generation of CO from oil vapor in the last stage of the compressor under conditions of adiabatic recompression

M4. Generation from carbon deposits in the 3rd stage of the compressor under conditions of overheating (often referred to as `dieseling)

M5. Generation of CO within the filters

A discussion of each of the five possible mechanisms is as follows:

M1. Deliberate contamination with CO is most unlikely. To achieve a final concentration of CO of 13,600 pm would require the tank to be emptied and then refilled with pure CO to a pressure of 4 atm followed by topping up with pure air to the full pressure of 238 atm

(3500 psig). This would require the possession of a pressurized tank of pure CO and special couplings

M2. This level of contamination could not be achieved even if the tank was filled directly from the exhaust of an internal combustion engine

M3. This is a likely mechanism and could occur by partial combustion of oil vapor in the cylinder head. This requires additional heat and the presence of oil vapor. Oil vapor can enter the cylinder head by leaking past the piston rings. Additional heat can be generated by recycling of air in the third compression stage. The recycling could be a consequence of a mechanical fault such as a faulty exhaust valve

M4. This is a commonly reported phenomenon but the high level of CO rules this out as a likely scenario.

M5. The presence of a combustible contaminant (such as a piece of paper) if accidentally introduced into the filter will spontaneously ignite in the atmosphere of pressurized air due to the high partial pressure of oxygen. This could initiate ignition and start a gasification reaction between the charcoal and oxygen to produce carbon monoxide. On inspection of the site the temperature of the air entering the filters was measured to be more than 10 deg C above atmospheric which will increase the likelihood of this occurrence. Any carbon dioxide generated by complete combustion would be expected to be adsorbed by the molecular sieve. This would explain the high ratio of CO/Co2 in the tank (13, 600/1890)

42. After the Gooch Gilmour Hales report was received, the Police at my direction referred the report back to Mr. Cooper. Mr. Cooper, by a further report of 20 January 2006 confirmed his belief in the correctness of his first report. He said:

7. 1 agree with some of the recommendations by Gooch & Gilmour to improve the performance of the Williams & James compressor at Divers World Picton. However, the set up at Divers World did not cause the contamination of the Davidson cylinders.

(a) The compressor operates in a confined space and would perform better if the cooling system was moved outside the building. The cooler the compressor, the cooler the air. This makes for dryer air and less moisture in the filters. However, this is a business decision for Divers World to consider.

(b) The theory of hot oil is just that - a theory. There is no evidence of the compressor using oil, or getting excessively hot.

(c) The burning of charcoal in the filters is also not likely to have happened. The operators would have noticed smoke. The filters were repacked on 8 July 2004. The re-packers of the filter would have noticed the charcoal was burnt. The lifetime of the filters is currently about 30 hours. After this time, the filter is quite damp and not likely to burn.

(d) The Gooch & Gilmour report does not provide any evidence of where the high levels of methane came from, nor does the report touch on the percentage of carbon dioxide ratio with the carbon monoxide. (Detected in the Davidson cylinders).

(e) The Davidson cylinders were most certainly attached to the SCUBA filling system at Divers World on 7 July 2004, sometime between 09:00 and 14:00 hours. According to the compressor log book, the compressor was run on Monday 5th July from 16:45 until 17:30. It was next run on Wednesday 7th July at 16:30. (Appendix E).

Between 17:30 on Monday 5th July and 16:30 on Wednesday 7th July 2004, when the Davidson cylinders were filled, Mr. Reay had two cylinders filled. New Zealand King Salmon had 17 cylinders filled. That is 21 cylinders filled off the compressor bank which was last run, on Monday 5th July. Only the Davidson cylinders appeared to have been contaminated.

(f) The Reay cylinders were not contaminated (Appendix F).

(g) It is not feasible that the operator would start the compressor at 09:00 on Wednesday 7th July to fill the two Davidson cylinders and the air be contaminated. The Compressor would have been cold as would the filter bank. This rules out the hot oil, or filter fire.

8. Taking all the evidence I have into account, the Davidson cylinders were 'not contaminated at Divers World Picton. The contamination occurred after the last use by Davidson and prior to 7th July 2004.

9. Carbon monoxide can be purchased from BOC Gases, however it is not an "off the shelf" product and questions would be asked.

10. Carbon monoxide is used by hospitals, universities and laboratories.

11. The Davidson cylinders contained a large proportion of methane as well as carbon dioxide and monoxide. I understand the proportions and percentages are not consistent with gases from an internal combustion engine. (Appendix F).

12. I am unable to provide details of where or how the Davidson cylinders were contaminated. I am able to say, on the evidence I have at my disposal, the Davidson cylinders were NOT contaminated at Divers World Picton and I stand by my report dated September 2004.

EVIDENCE AT INQUEST

43. At the Inquest Mr. Cooper, Doctor Gooch and Mr. Gilmour presented their various reports and confirmed the positions which they had taken.

44. Further, at the Inquest evidence was given by the then Manager of Divers World, TAMMY LYNNE WARD, and the then Dive Master employed by Divers World, CHRISTOPHER JOHN BAILEY.

45. Ms. Ward and Mr. Bailey rejected the possibility that the compressor would have been started for a one off fill of the Davidson tanks. Their written records showed no such use of the compressor and, they stated that it would have been quite contrary to usual practice to have done so.

46. Some reliance was placed by Mr. Cooper and Ms. Ward on the written records of compressor use. However the police officer in charge, Detective Richard Rolton, had done some analysis of those records and was able to demonstrate that they were inaccurate in some significant respects. Mr. Hunt, Counsel for the Davidson family was able to demonstrate in his cross examination of Ms. Ward that the written records were not a solid foundation for the proposition that there could not, in the case of the Davidson cylinders, have been a direct injection of air into the cylinders from the compressor.

47. The expert witnesses, Mr. Cooper, Doctor Gooch and Mr. Gilmour all generally maintained the positions that they had taken in their respective reports with one exception. Mr. Gilmour, in the light of new evidence and when pressed on the theory of there having been a spontaneous ignition of a combustible contaminant in the air filter became less confident about that and ultimately agreed that it probably had not taken place. In his evidence Mr. Gilmour noted that when pure carbon is burnt it does not produce smoke and the significance of this is that there could have been a malfunction in the equipment without the production of smoke or indeed odor.

48. DAVID BRUCE CARTER, the Technical Programmes Manager for NZUA gave evidence at the Inquest. He referred to the ongoing testing programmes undertaken by NZUA and he referred in particular to his regular visits to Divers World. In the opinion of Mr. Carter and based on his extensive technical experience, his conclusion was:

I cannot see how the contaminants in the cylinders in question came from the air filling system at Divers World Picton.

From my experience and in cases where higher than acceptable levels of monoxide have been found at other air filling stations, this is usually contributed to by an almost ground level air intake position on the compressor, exhaust fumes picked up from traffic, or parked cars with engines left running close by the compressor air intake.

He said further –

Although I find monoxide in sampled air at the odd times, it is rare to find carbon monoxide in New Zealand air filling stations that we complete air checks on and hardly ever above the NZ Standards prescribed limit of 10 ppm.

Never at the levels of [the Davidson tanks] as earlier indicated.

ANALYSIS OF COMPETING VIEWS

49. It is not possible on the evidence before me to reach a point of certainty on the cause of the contamination of the cylinders. Nor is it possible for me to reach a point where I am satisfied beyond reasonable doubt precisely what happened. A process of elimination can however get to a point where some likelihoods emerge.

50. The theory of Mr. Cooper was based on the proposition that on some occasion prior to 7 July 2004 the cylinders of Mr. Davidson had been filled with air which was heavily contaminated with carbon monoxide. The cylinder or cylinders contaminated on that occasion could not have been used as if they had been used Mr. Davidson would have died on an earlier occasion. Rather, the theory goes, the contaminated tank latently lay with its poisonous contents unused until 7 July 2004, then, on 7 July 2004 the contaminated tank and the other tank were taken to Divers World. There, they were filled together from the storage bank of cylinders. In the process of filling the contents went through a pressure equalization process so that the contaminated air ended up (albeit in different concentrations) in both tanks. Then, on 10 July 2004 Mr. Davidson used one of these tanks and was poisoned.

51. I believe that the credibility of the theory breaks down at more than one point. There is no evidence whatsoever to suggest that Mr. Davidson had his tanks filled by a backyard operator as was suggested by Mr. Cooper and by Mr. Bott, Counsel for Divers World. There was no evidence of the existence of any such backyard operator. On the contrary, the available evidence indicated that Mr. Davidson followed normal practices in having his tanks filled and used commercial tank filling operations. If there were a backyard operator who filled one of the tanks it remains unclear how such an operator could have achieved the very high concentrations of carbon monoxide in one tank so that when, as the theory goes, they were diluted by passing into the second tank they nevertheless remained exceptionally high. I am satisfied that Mr. Davidson was a recreational diver who had no need to and did not go to unconventional suppliers of air.

52. I am also satisfied that the remote possibility of some person having deliberately introduced pure carbon monoxide into Mr. Davidson's tanks for malicious purposes has been eliminated.

53. The evidence of Mr. Carter indicated that his experience had been with carbon monoxide picked up from an air intake. He had not had any experience of or familiarity with the possibility of carbon monoxide being produced from the air compression process itself. His evidence and his conclusions have to be viewed against that background.

54. Taking all these matters into account and applying a process of elimination it is evident that the Divers World air compressor was the most likely source of the contaminant.

55. By the time Doctor Gooch and Mr. Gilmour were able to get to the Divers World equipment more than a year had gone by. Even if they had been able to get to the

equipment immediately after 7 July 2004 the examination of the kind which they did prior to their 9 November 2005 report is unlikely to have given definitive results. More definitive results may have been achievable if immediately after 7 July 2004, the compressor and its accessory equipment were dismantled and internally examined and evaluated. This of course, was not possible.

SOME CONCLUSIONS

56. It is not possible for me to determine by precisely what mechanism the carbon monoxide which ended up in the Davidson tanks was produced. It is however possible for me to find and I do find, that it is likely that the carbon monoxide which was found in the Davidson tanks was produced by an idiosyncratic malfunction of the Divers World air compression equipment.

57. In summary I make this finding for the following reasons:

•As already indicated, and importantly, a process of elimination drives attention towards the Divers World equipment.

• The danger of the production of carbon monoxide in the process of air compression using air compressors of the kind used here is recognised and well recorded in scientific and operational literature relating to diving and the needs of divers.

• There were some features of the equipment which gave Doctor Gooch uncertainty about the efficiency and safety of the equipment and I will now refer to these.

58. I believe that I can fairly describe Doctor Gooch as having been uneasy about the Divers World equipment and the way in which it was maintained. He pointed to a modification in the form of an automatic condensate drain. He also pointed to a peculiarity of the cooling system where on the water radiator which formed part of that system it was necessary to remove the cap to prevent operational problems with the equipment. Doctor Gooch pointed to red brown coloured dust venting from the condensate drain and categorized it as being abnormal. A seemingly recurrent fault with the compressor was that valve springs would break. While the reason for the breakage of valve springs at abnormally frequent intervals could not be finally determined Doctor Gooch pointed out that valve springs are tempered steel designed to operate in a particular temperature range. An overheating problem with the machine could cause a recurrence of spring failures. There remains a suspicion that the Divers World equipment was prone to overheating. This suspicion can be linked back to factors including the problems with the cooling system and the need to keep the radiator cap off and the recurrent failure of valve springs.

59. In all of the circumstances it is in my view likely that at some point of the process there was a pulse of carbon monoxide which ended up in the Davidson tanks. I am conscious that this could only have happened if the tanks were directly filled from the compressor and I have thought carefully about the evidence of Ms. Ward and Mr. Bailey

that this would not have happened. I am nevertheless left with the view that it must have happened.

REGULATORY REGIME

60. At the time of Mr. Davidson's death, the regulatory regime was in transition. There was however (and this remains the case) a requirement for all operators of compressed air filling systems to be certified after having qualified for such certification. Additionally, then as now there was a requirement for the regular inspection of premises and the regular taking of random air samples. The New Zealand Underwater Association was accredited by the Minister of Labour to conduct a testing programme in relation to scuba equipment and air filling stations. A programme was initiated and pursuant to that programme NZUA would undertake nationwide checks of air produced from filling stations at a frequency of intervals which was initially annual, then twice yearly and now four times a year. The testing programme was against the required standards for air purity found in the relevant New Zealand Standard. The standard for air quality in relation to carbon monoxide was 10 ppm.

61. If the Gooch Gilmour theory is correct and if the carbon monoxide was produced within the air compressor system at Divers World Picton, then the testing regimes were unlikely to detect the potential dangers in the system.

62. It seems apparent that the hazards that can be created from air compressors internally, and as part of the process, producing carbon monoxide are not sufficiently understood or appreciated. Nor are they likely to be identified in the course of previous or current monitoring regimes.

63. It appears that the internal production of carbon monoxide by air compressors is a rare event. Nevertheless it is, an event which can have catastrophic outcomes as it appears, occurred here.

SAFETY MEASURES

64. The internal production of carbon monoxide by air compressors is preventable or at least the risks of it can be minimized. The evidence suggested that scrupulous maintenance regimes, the avoidance of modifications to manufacturers equipment, the correct choice of lubricating oils, the avoidance of overheating (and therefore combustion) in the process and scrupulous attention to the packing of filter materials and filters will all go some considerable way to reducing the risk. Furthermore, none of these disciplines is likely to be effective in the absence of proper training in relation to the risk to ensure that operators understand the purpose of these disciplines.

65. These procedures and disciplines alone cannot completely eliminate the risk. Ultimately, there needs, wherever possible, to be certainty that the gaseous substance injected into scuba tanks by air compressors is free of carbon monoxide. Doctor Gooch in his evidence indicated that it is possible at relatively low cost to install a carbon

monoxide monitoring device with an alarm in the outlet lines from air compressors. The presence of such a device here would have saved Mr. Davidson's life.

OVERALL CONCLUSIONS

66. In summary my conclusions are these:

(a) Mr. Davidson died on 10 July 2004 in the sea at Port Underwood.

(b) The cause of Mr. Davidson's death was asphyxia which arose as a consequence of the inhalation by him of a scuba air supply heavily contaminated with carbon monoxide.

(c) The likelihood is that the concentrations of carbon monoxide in Mr. Davidson's air tanks entered the tanks on 7 July 2004 at Divers World Picton.

(d) It is unlikely (and is eliminated as a possibility) that there had been a deliberate injection of carbon monoxide into Mr. Davidson's air tanks prior to 7 July 2004 and away from Divers World.

(e) It is unlikely and improbable that there had been an accidental injection of carbon monoxide into Mr. Davidson's air tanks prior to 7 July 2004 and away from Divers World Picton.
(g) The accidental and unintentional production of carbon monoxide from the internal processes of air compressors is a known but unusual hazard.

(h) Within relevant industry and diving circles there appears to be insufficient knowledge and understanding about the potential hazard.

(i) The training monitoring and testing regimes are not adequate to deal with the potential hazard.
(f) The most likely explanation for the presence of the very high levels of carbon monoxide in Mr. Davidson's air tanks is that it was brought about by an idiosyncratic malfunction of the air compressing equipment at Divers World Picton on 7 July 2004 but of a nature which was such that the subsequent reconstruction of events is not possible.

67. There will inevitably continue to be debate about the mechanisms which produced the carbon monoxide in Mr. Davidson's air tank and brought about his death. Genuinely held views of experts some with long reaching experience have differed. I repeat that the findings which I have made have not been made at levels of certainty but have been made at varying levels of likelihood and probability based on the

RECOMMENDATIONS

68. It became clear that if there had been a pulse of carbon monoxide produced by the Divers World Picton air compressor at a time when direct tank filling was being undertaken, then this pulse of carbon monoxide would have ended up in the tanks being

directly filled. If the concentrations of carbon monoxide were sufficiently high, any diver using the air while under water would likely have died. It was also clear that such an outcome (were it to have happened) could have been preventable and should have been avoided. The recommendations which I am about to make are made against the background of the complex and difficult facts of this case and against my belief that it should be and is possible to substantially reduce or virtually eliminate the risk of carbon monoxide poisoning of scuba divers.

69. My recommendations are these:

(a) That the Police make available to:

- Environmental Risk Management Authority
- Department of Labour
- New Zealand Underwater Association

a copy of these Findings with the request that each recipient should forthwith review all matters relating to health and safety procedures which have arisen out of this Inquest.

(a) (a) Without reducing the scope of the general review, consideration should be given to the imposition of a mandatory requirement that new and existing commercial air breathing compressor systems, and subsequent modifications to these systems, be certified by a suitably qualified professional engineer. Further, as part of the regime for the regular inspection of premises and the regular taking of random air samples there should be greater emphasis on the regular examination of compressor systems to ensure that maintenance regimes are being properly observed and to ensure that there are no uncertified modifications to such systems.

(c) That, as an interim measure, consideration should be given to the imposition of a mandatory requirement that carbon monoxide monitoring and alarm devices be installed on, at least, all commercial filling station equipment.
(d) That the adequacy of the Hazardous Substances (Compressed Gases) Regulations which came into force on 1 October 2005 be reviewed.

TO THE FAMILY OF MR. DAVIDSON

70. The sympathy of this Court and those associated with it is respectfully extended to the family of Mr. Davidson. It is to be hoped that the loss which you have suffered will lead to the avoidance of other families suffering a similar loss in the future.
P.J. RADICH

CORONER

7 August 2006
coroner.davidson findings.pjr.sas 7 August 2006