QUEENSLAND COURTS

CORONERS COURT OF QUEENSLAND

FINDINGS OF INQUEST

CITATION:	**Inquest into the death of Andrew John Thwaites**
TITLE OF COURT:	Coroners Court
JURISDICTION:	Brisbane
FILE NO(s):	2016/3336
DELIVERED ON:	24 July 2018
DELIVERED AT:	Brisbane
HEARING DATE(s):	28 June 2017, 25 September 2017.
FINDINGS OF:	Christine Clements, Brisbane Coroner
CATCHWORDS:	CORONERS: Dive death investigation, recreational diving, carbon monoxide toxicity, drowning, contamination of breathing air from within electric air compressor, ignition of lubricating oil within over heated compressor, maintenance, filtration, ASA breathing air standards, testing for contamination

REPRESENTATION:

Counsel Assisting:	Ms Holly Ahern
Ms Kelly-Anne Masterman and Ms Deborah Monks:	Mr Angus Edwards I/B Jacobson Mahony Lawyers
Underwater Research Group QLD Inc:	Mr Damien Atkinson I/B Moray & Agnew Lawyers
Ms Sarah Williamson:	Ms Kristi Riedel I/B Gilchrist Connell Lawyers
Mr Shane Murphy:	Mr Andrew Lossberg, Crown Law, I/B Coronial Liaison Unit, Office of Industrial Relations
Mr Ian Leishman:	Mr Anthony Collins I/B Carter Newell Lawyers

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Introduction

1. On 10 August 2016, Andrew John Thwaites and his partner Kelly-Anne Masterman joined a group of recreational scuba divers for a day's excursion to Cherubs Cave at Henderson Rock on the eastern side of Moreton Island, Queensland. Both were experienced divers. Ms Masterman was a qualified Dive Master with 1,350 previous dives. When she met Mr Thwaites in 2011 he had completed 10 dives and by 2016 he was an Advanced Open Water Diver with 300 further dives.

2. Mr Thwaites and Ms Masterman were members of Underwater Research Group of Queensland Inc., (the Club), a not for profit scuba diving club.

3. The group of fourteen experienced divers set off on a 'bare boat' charter aboard 'Nemo', departing from Spinnaker Sound Marina on Bribie Island. The vessel had been chartered from Absolute Scuba.

4. When they arrived at the dive site it was considered to be perfect conditions for diving with a light current and calm surface conditions.

5. Mr Thwaites and Ms Masterman entered the water for their first dive at about 10:55 that morning and stayed under water for 50 minutes. They dived to a maximum depth of about 30 metres. They did not experience any problems.

6. After a rest period they commenced the second dive at 1:30 in the afternoon. About ten minutes into the dive, Mr Thwaites indicated with hand signals to Ms Masterman that he felt unwell and intended to surface. He made circular movements around his stomach. They commenced the ascent together. Ms Masterman estimated at about 15 metres below the surface she lost sight of Mr Thwaites. She thought she saw him hanging on to the anchor line of another boat anchored at the dive site because she recognised the 'yellow of his cap'.

7. Ms Masterman re-boarded Nemo alone and immediately told someone aboard that Andrew was on the other anchor line. There was a response that he had been seen and gone down again. There followed some discussion before it became apparent he was not aboard either vessel and there was a realisation that he was 'missing'.

8. Andrew Thwaites was not seen alive again. His body was retrieved from the floor of the sea-bed the following day. He died two weeks prior to his 45th birthday. He had no known previous medical conditions and did not take any regular medication, although he did suffer from occasional seasickness.

9. The inquest focused on the circumstances of how he came to die and what caused his death.

Organisation of the dive trip

10. Mr Thwaites and Ms Masterman were members of a closed Facebook group called 'Get Wet SCUBA Adventures'. Ms Sarah Williamson established the group to connect and enable communication between the diving community in South East Queensland. It is noted SCUBA diving in Queensland is regulated by the following legislation:

    (i) *Safety in Recreational Water Activities Act 2011* (Queensland), and Regulations
    (ii) Recreational Diving Recreational Technical Diving and Snorkelling Code of Practice 2011, (the Code), and
    (iii) *Work Health and Safety* A*ct 2011* (Queensland), and Regulations.

11. A group invitation for a proposed dive to Cherubs Cave on the Exhibition public holiday on 10 August 2016 was posted on the site. The cost of the day trip to participants was $120 including tanks and weights, or $105 if participants used their own tanks. Ms Williamson made the group booking with Absolute SCUBA to charter the vessel 'Nemo'. The charter included the skipper, Mr Arne Jorgenson, and a deckhand/lookout, Mr Ben Mohr. First aid, oxygen and some refreshments were also provided. The agreed charter price was $980. This was not paid until after the trip with the invoice issued on 24 August 2016.

12. In the course of the online communication exchange to establish the booking there was no reference by Absolute SCUBA or Ms Williamson to a dive supervisor.

13. The Recreational Diving, Recreational Technical Diving and Snorkelling Code of Practice 2011 (the Code) is directed to persons conducting a business or an undertaking that provides recreational diving. It is also directed to participants, and aims to make recreational diving a healthy and safe activity.

14. The Code states an appointed dive supervisor should manage the diving operation and remain at the surface of the dive site while diving is taking place.

15. This is an advisory code for those conducting business or an undertaking. It was a matter of contention in the inquest whether the activities of this day came within its ambit. However, the *Coroners Act 2003* is focused on death prevention and considers the Code for that purpose and how best to review the events on the day from that perspective. The issue of the legislative review required to improve SCUBA diving safety will be addressed later after review of factual matters.

16. On the information available the various roles and responsibilities described in the Code were assumed by different people during the course of the day, although not necessarily formally designated or acknowledged.

17. Ms Williamson confirmed all of the participants brought their own prefilled tanks. She recalled Ms Masterman and Mr Thwaites told her they would source their own gas for the tanks, and mentioned they would fill the tanks at the Club.

18. Details of the following matters are included to record events, prior to consideration of whether they are relevant to issues of how and what caused Mr Thwaites' death.

Events on 10 August 2016

19. Mr Mohr, was the volunteer deckhand/lookout aboard Nemo. He was qualified as a dive master in training and a qualified rescue SCUBA diver.

20. Mr Mohr thought the dive supervisor role was being performed by either Ms Williamson or Mr Ian Leishman. Ms Williamson thought Mr Leishman was performing the role and he thought Ms Williamson was.

21. Mr Leishman had agreed with Ms Williamson to provide dive master responsibilities to lead underwater. Mr Leishman provided the dive site briefing prior to both dives. This included the approximate location of the anchor, compass bearing to particular features of the dive and last known locations of sharks. The divers were advised of the maximum dive time and depth.

22. Mr Leishman did not include information about the diver recall protocol as he considered this was boat specific and would be provided by Mr Mohr.

23. On the evidence, Ms Williamson was also acting as dive master leading a group underwater on the first dive.

24. Prior to the first dive there was assessment and agreement of the environmental conditions before any of the divers entered the water. This involved Mr Mohr, Mr Leishman and Ms Williamson.

25. Mr Mohr provided a safety briefing for the boat which included information about life buoys and safety equipment, and entry and exit points from the boat. He referred to a checklist provided by Absolute SCUBA for that briefing. His understanding was the dive supervisor briefing would include maximum dive time, maximum depth, emergency procedure including lost bodies and safety, as well as identification of the dive site and marine life in the vicinity. He thought the diver recall protocol would be included in the dive supervisor's brief.

26. The evidence showed there was no clear understanding or agreement who was undertaking the varying roles of dive supervisor, dive master and deckhand / lookout. It is noted that the Code entertains the possibility of overlap between some of these roles.

27. The evidence established there was no briefing to the dive group identifying the diver recall protocol for that day's diving. Nor was there any specific reference to emergency procedures including lost buddies and dive safety. It is however noted this was a private group of very experienced divers.

Recollection of Ms Masterman

28. At the outset it is noted there was subsequent information about the air quality of tanks used by Ms Masterman and Mr Thwaites on 10 August and the impact of this upon physical and cognitive functioning. This will be referred to later but it is a relevant factor in considering Ms Masterman's actions on 10 August and her memory of that day.

29. Ms Masterman's first statement to police after Mr Thwaites' death was taken on the day he had gone missing and before his body was retrieved. They were the first divers to enter the water for the first dive. They dived together as buddies as they had dived regularly on many previous occasions.

    They dived with two identical computers each for redundancy and a manual gauge for air pressure. One computer reads the wearer's transmitter and the other reads the buddie's transmitter. This only worked when the divers were within 1-2 metres of each other. There were no issues during the first dive.

30. After this dive Ms Masterman recalled the Nemo had to pull anchor to collect two divers who had drifted away. The divers were doing their safety pause, but were not on the anchor line at the time and had drifted. They deployed their high visibility safety sausages.

31. They entered the water together for the second dive at 1.30pm. They had swapped to their smaller 12 litre tanks. About 10 minutes into the dive they were at around 20 metres depth. Mr Thwaites was about 2 metres away from Ms Masterman when he signalled to her by rubbing his stomach and making hand movements. She understood he intended to abandon the dive. He did not appear to be anxious or panicked. They started to ascend together and paused at a rock pinnacle that was a bit higher.

32. The dive profiles indicate they were together at around 11 minutes into the dive. They were at about 17 metres before there was separation.

33. Ms Masterman said she paused to get her bearings. She thought Mr Thwaites may have gone over a pinnacle while she went around it. This may

match up with the dive profile showing her descent for about 1 minute at the 12 minute point of the dive.

34. Ms Masterman recalled they were swimming fairly slowly and she had not inflated her buoyancy control device. She could not remember whether or not Mr Thwaites had deployed his. She saw some divers to her right and knew they were from the Nemo and were still entering the water.

35. She recognised the Nemo's anchor line and started to kick towards it. She turned to check after 5 or 10 kicks, but at that point could not see Mr Thwaites. She looked around and up and saw the University boat (the Downunder) and their anchor line. She saw what she thought was Mr Thwaites holding onto their anchor line with two other divers at about 5 metres. She thought she saw his yellow cap. She thought that although it was the wrong boat, he was safe. She could not get to the University dive boat because it was across the current. She proceeded slightly cross current to the Nemo. She was at about 15 metres depth. She said she could see them quite clearly at about 20 metres distance.

36. Ms Masterman had started to drift so she ascended without a safety stop. The current was quite strong and to return to the boat, she needed to swim immediately. She successfully grabbed the step on the port side of the boat. The time was approximately 1.45pm with reference to her dive profile times when she reboarded Nemo.

37. It is noted when Mr Leishman subsequently ascended at the completion of his second dive he noticed the current and surge was much stronger than when he had commenced the dive. His computer indicated a surge between 4.9 and 6.8 metres on his profile. He noted this whilst doing his safety stop which required him to hold onto the anchor chain with the crook of his elbow and with his right hand to avoid drifting.

The events aboard Nemo

38. After Ms Masterman re-boarded the Nemo, half an hour passed before the Captain, Mr Jorgensen, radioed Volunteer Marine Rescue and reported that a diver was missing at 2.15pm.

39. When Ms Masterman climbed aboard, she could not remember to whom she spoke. She immediately said that Andrew, (Mr Thwaites) was on the other anchor line. Mr Mohr confirmed he helped Ms Masterman aboard and she told him that Andrew had been feeling sick so they decided to come up. She told him he may have come up on the anchor line of the other boat which was about 30 metres away. Ms Masterman recalled either Mr Mohr or Ms Williamson said words to the effect:

> ‘No, he is not, he’s over there, he’s just gone down.’ They pointed to the south. She queried this and someone responded that he was on the surface and then actively deflated.

40. She asked if she should go back in and swim over to the other vessel but there was a negative response due to safety issues. They waited for 5 or 10 minutes watching the surface. Ms Williamson and her friend Mr Darren Marshall, and Mr Mohr were aboard, together with the captain. The rest of the group were still diving.

41. There was discussion between Ms Williamson, Mr Mohr and the captain about whether to do a diver recall but this protocol had not been talked about before the divers entered the water. They got a metal weight and banged it three times. There was no response and they repeated this on the side of the boat. They repeated signalling on other parts of the boat before revving the engine. During this period Ms Masterman recalled someone radioed to shore reporting that Mr Thwaites was missing.

42. The other divers started returning to the boat but not until the originally scheduled completion time at about 2.40pm. Most of them had not heard the signal, or asked what the banging was.

43. There was a degree of variation and uncertainty in the evidence about whether or not Mr Thwaites came to the surface before descending again. There was also some confusion about when this occurred with respect to Ms Masterman’s return to the vessel.

44. Mr Mohr recalled the Skipper of the other boat yelled out and pointed at the back of his boat. Mr Mohr looked out to a distance of about 40–50 metres. He saw a fluoro green colour just below the surface before it disappeared again. He was certain it was a diver, but he did not know whether it was the diver they (subsequently) were looking for. There were other divers from the other vessel surfacing at the time. He said Ms Masterman had surfaced but was still on the ladder when this occurred. Mr Mohr did not observe any signs of distress or signalling. He did not recognise the situation as an emergency at the time.

45. Ms Williamson was seated at the back of the boat with Mr Marshall when Ms Masterman surfaced. She had not dived the second time due to a suit failure and Mr Marshall decided to remain with her aboard Nemo. They heard Ms Masterman say Mr Thwaites had indicated he was unwell. She thought he was right behind her.

46. Ms Williamson said she saw Mr Thwaites surface approximately 75 metres from Nemo. He appeared to be face down and then dropped down below the surface. He was wearing a fluorescent green dive cap which she

recognised as he regularly wore this. She thought he might have dropped down below the surface due to the current to enable him to swim back to the Nemo.

47. The sequence of events is difficult to establish. Ms Williamson recalled someone from the University boat called out that Nemo had a diver at the back of the boat. Ms Williamson and Mr Marshall looked out and recognised Mr Thwaites' fluorescent green dive cap at the surface. Mr Marshall estimated it was a distance of 75 metres. They said very, very shortly thereafter Ms Masterman surfaced and said words to the effect:

    'Where is Andrew? He was right behind me.'

48. Ms Williamson also recorded her recollection in an incident report later that day. She stated the University boat had called them, asking if they wanted the diver picked up as they had lifted their anchor at this time. Ms Williamson and Mr Marshall agreed to this, but by the time the vessel got to the point where a diver was last seen, he had disappeared.

49. Mr Lachlan Pollard was the Skipper of the University boat, the Downunder, which at the time, was anchored close by Nemo.

50. His recollection was at about 1.40pm he saw a diver surface about 15 metres behind the two boats. He thought the diver was doing something with his equipment. He appeared to be moving and conscious. Mr Pollard did not think he was distressed and Mr Pollard did not see him signal. He said he observed him for about five minutes.

51. He recalled some form of communication with the other boat about the diver and an acknowledgement that they were watching him.

52. There is no common version from those aboard Nemo with the recollection of Mr Pollard about the timing and details of this sighting. Captain Jorgenson said there were no concerns at all aboard Nemo until Ms Masterman returned. Ms Williamson and Mr Marshall said there was agreement that the University boat would pick up the diver sighted by Mr Pollard. However, Mr Pollard was then diverted for about fifteen minutes with divers returning to his vessel before he pulled anchor and then commenced a search. This was prior to the return of the remainder of the diving group to the Nemo.

53. Mr Pollard trawled as far as Henderson Rock. It is noted on his return to the Nemo he retrieved two of the divers from Nemo who had drifted in the current and surfaced away from their vessel.

Discussion

54. Whilst there are some discrepancies between accounts, there is other information available on the most significant issue of whether Mr Thwaites surfaced, and if so, for how long. He was wearing a dive computer which was set to record his depth below the water's surface every 30 seconds. The dive profile report recorded at around 12 minutes into the dive, Mr Thwaites was at 1.7 metres for between 30–60 seconds before he subsequently descended. This is consistent with observations from those aboard Nemo, that a diver was seen at or near the surface. Three people remarked on the fluorescent cap, which was recognised by Ms Williamson as Mr Thwaites' distinctive dive cap

55. It is concluded Mr Thwaites was at or very near the surface for a very brief period. The period was potentially between 30 and 60 seconds, by reference to the intervals at which his dive computer recorded his depth. When sighted by three people aboard Nemo, he was between 40-50-75 metres astern the Nemo. There was no sign of distress and therefore no recognition by anyone at the time that there was an emergency situation.

56. Ms Masterman re-boarded the Nemo after 15 to 16 minutes in the water according to her two dive watches. They had entered the water together.

57. Accepting this evidence, Ms Masterman was still in the water from between two and a half and three and a half minutes after Mr Thwaites was seen at or near the surface.

58. At the twelve and a half minute of Mr Thwaites' dive he was recorded at 1.7 metres (and according to the sightings, very briefly reached the surface), before he descended within the next thirty seconds, to a depth of 11.9 metres. In the next thirty seconds he descended to 29.5 metres. From the fourteenth minute of the dive he remained at between 29.7 and 29.9 metres from where his body was subsequently recovered.

59. Information from Mr Thwaites' dive computer is inconsistent with the conclusion of Mr Pollard that he had watched Mr Thwaites on the surface for about 5 minutes, during which time he gave no sign of distress, nor signal to those on board. It is concluded Mr Pollard may have been watching another diver for some time before Mr Thwaites in fact ascended to, or very close to the surface.

60. The evidence from Mr Thwaite's dive watches and Ms Masterman's dive watches, together with the observations from those aboard Nemo establish the following:
    - Mr Thwaites did reach at or near the surface for a brief time (less than thirty seconds, being the interval at which the dive watch registers)

- This occurred between the twelve and a half and thirteenth minute of the dive.
- Ms Masterman surfaced between two and a half and three and a half minutes later, during which time Mr Thwaites had descended to more than 29 metres, where he remained.

Search and rescue

61. Volunteer Marine Rescue was notified by Captain Jorgenson at about 2.15pm on Marine Radio, channel 73 that a diver was missing from the Nemo.

62. Queensland Water Police were notified within five minutes and Sergeant Bairstow coordinated the search. On that first day, four helicopters, one fixed wing aircraft and twelve vessels were involved, co-ordinated by Joint Rescue Coordination. On Thursday 11 August there were twenty three vessels, three vehicles and a police dive team involved in the search. Joint Rescue Coordination had five helicopters and one fixed wing aircraft operating over a 186 square nautical miles of search area.

63. Mr Thwaites' body was found and retrieved by Queensland Water Police on the following day. His family were informed at about 11.30am on 11 August 2016. The dive team were operating a second drift line search of the area where Mr Thwaites had been diving. The area was tidal with large rocky out crops and was a maximum depth of 30 metres. His body was located in a short drop-off past a flat section of rock where there were some crevices descending a few metres deeper. His body was prevented from further drifting or rolling because of this position. The location was not far from the Nemo's last known swing coordinates from the anchorage point.

64. The police officer who found Mr Thwaites observed he was on his side in the crevice. It was considered possible that his buoyancy control device had been activated by his body position on the seabed, causing inflation of the device.

65. The search and retrieval of Mr Thwaites was well coordinated and effective and kept his family members informed.

Autopsy conclusions on the cause of death

66. Coronial autopsy examination was undertaken by forensic pathologist Dr Beng Ong on 13 August 2016. On 15 August 2016 the Coroner's Court was informed that Dr Ong was waiting on results of further tests and additional information to determine the cause of death. Initial observations revealed signs of drowning, but no underlying cause was identified.

67. Initial autopsy findings included a subarachnoid haemorrhage. No underlying pathology was observed and a naturally arising haemorrhage was therefore excluded. A traumatic haemorrhage might have occurred due to terminal seizures causing rapid movement of the head and minor trauma. Alternatively, the subarachnoid haemorrhage could be post-mortem artefact.

68. Air was noted in the vascular system. This could have been caused by post-mortem production. Alternatively it could be due to barotrauma with an air embolism. The pathologist was restricted in assessing this due to the period of time before Mr Thwaites' body was recovered. Dr Ong however noted the police dive officer had reviewed the dive profile which did not show the ascent was too quick. Therefore, barotrauma was unlikely. Decompression sickness was also considered but discounted in the circumstances of the dive.

69. Alternative explanation was a combination of physical off gassing and post-mortem gas production. No other natural disease process was identified that could have caused or contributed to death.

Information about elevated levels of carbon monoxide and carbon dioxide

70. On 29 August 2016 the coroner was informed by police of high levels of carbon monoxide and carbon dioxide detected in Mr Thwaites' dive cylinder. The pathologist was informed. The toxicology report was received on 30 September 2016 recording 56% carbon monoxide in haemoglobin from a femoral blood sample.

71. The completed autopsy report was finalised on 27 January 2017. Dr Ong considered it likely that Mr Thwaites had been impaired or incapacitated by the high levels of both carbon monoxide and carbon dioxide. He concluded Mr Thwaites died due to drowning. Carbon dioxide and carbon monoxide toxicity were identified as contributing factors.

Expert medical evidence relating to cause of death

72. The inquest was assisted by the expert evidence of Dr Ian Millar, a specialist in diving and hyperbaric medicine and an occupational physician. He is a consultant in prehospital emergency care based in the Alfred Hospital in Melbourne. He provided his report and gave evidence as an experienced diving and hyperbaric specialist. He has a particular interest in carbon monoxide toxicity and was therefore considered an appropriate expert on medical issues arising, including comment on the cause of death.

73. Most importantly, Dr Millar concluded the underlying root cause of Mr Thwaites' death was carbon monoxide toxicity. He identified the terminal

event as the situation when Mr Thwaites was submerged whilst unconscious, causing fatal drowning.

74. *In Dr Millar's expert opinion Mr Thwaites' death could only have been avoided had he been rescued and resuscitated at or before the point when he had nearly or just reached the surface of the water, just before his final descent to the seabed.*

75. I accept the critical importance Dr Millar assigns to the underlying root cause of death as carbon monoxide toxicity, which caused the fatal drowning.

76. I accept Dr Millar's expert opinion.

77. Dr Millar explained fatal carbon monoxide poisoning can include arrhythmic or asystolic cardiac arrest, respiratory obstruction and hypoxia secondary to loss of consciousness, and, in Mr Thwaites' case, drowning. Carbon monoxide poisoning caused loss of consciousness, airway obstruction and drowning.

78. Dr Millar considered the observed subarachnoid haemorrhage was a consequence of severe carbon monoxide poisoning. The body's response to such poisoning is a dramatic increase in brain blood flow as the brain tries to maintain oxygen delivery. Cerebral blood vessels dilate and stretch and haemorrhages are often reported. Dr Millar considered subarachnoid blood vessel leakage could also occur. Immersion distends brain blood vessels and could also contribute to distension, rupture and bleeding.

79. Dr Millar considered it unlikely that intravascular gas originated during life. Importantly he noted the dive profile from the diver recorder did not indicate the sort of uncontrolled rapid ascent that could induce pulmonary barotrauma and air embolism. Intravascular gas was not unexpected as a post-mortem phenomenon.

80. The finding of pulmonary trauma, as well as observations from police divers of blood in Mr Thwaites' mask suggested descent trauma. If he was not breathing and had an obstructed airway during his final descent, he probably still had some blood circulation to generate bleeding. Dr Millar explained in the absence of air supplied by a diver's regulator to a breathing diver, increasing compression with depth decreases the volume of gas in the driver's facial sinuses and lungs. This can lead to haemorrhage in the cavities unless there is open exchange of gas or fluid between the sinuses and airways and a functioning diving regulator to compensate for the pressure induced loss of gas volume in sinuses and lungs.

81. Dr Millar considered the impact of carbon dioxide, as distinct from carbon monoxide was only minor.

82. In comparison, the effect of carbon monoxide was critical. The gas is colourless and odourless. Although there is some debate about the level at which carbon monoxide becomes dangerous, most government regulatory authorities set the upper limit for safe work places at 35 or 50 parts per million (ppm) over an 8 hour working day.

83. For divers, the generally accepted safe level for carbon monoxide in compressed air is 5 parts per million to take into account the increase in partial pressure that occurs with breathing gases at depth.

84. Even low levels of carbon monoxide exposure have been shown to impair exercise capacity and probably predisposes to cardiac arrest in persons with ischaemic heart disease, heart failure or arrhythmias.

85. Carbon monoxide is rapidly absorbed into the blood stream when inhaled. It competes with oxygen to bind into haemoglobin which otherwise transports oxygen.

86. The immediate effects of acute high level carbon monoxide poisoning are probably a combination of a lack of oxygen delivery to tissues and direct tissue toxicity, predominantly to the brain and also to the heart muscle and cardiac arrhythmias. It also impacts on biochemical transmitters impacting on intracellular reactions.

87. Dr Millar noted there is variability between people of the impact of carbon monoxide, and also depending on the situation. For divers, the impact of increased pressure is critical.

88. Dr Millar analysed the information from Mr Thwaites' first dive and concluded the exposure to slightly elevated carbon monoxide was not an important contributor to his death.

89. He did not see any indicators in the information that oxygen toxicity, nitrogen narcosis or decompression illness played any part in Mr Thwaites' death.

Final conclusion on cause of death

90. The forensic anatomical and toxicology findings of the coronial autopsy have been considered, together with the expert review provided by Dr Millar.

91. *It is concluded that Andrew Thwaites died due to: Carbon monoxide toxicity, which caused fatal drowning.*

Investigation

92. Mr Thwaites death was investigated by:

- Queensland Police Service (QPS), including the Dive Unit;
- Workplace Health and Safety Queensland (WHSQ); and
- Maritime Safety Queensland.

93. A conjoint meeting was arranged to ensure communication and information sharing.

Police investigation

94. In accordance with the police protocol for investigation of dive related deaths, Mr Thwaites' equipment was seized, physically examined, tested and the contents of the cylinder were analysed. The equipment was generally considered to be in good condition.

95. Mr Thwaites' dive watch and dive computer were taken by police to a scuba dive business named 'Dive Dive Dive' (reportedly the oldest dive shop in Brisbane). The proprietor, Mr Blackwell downloaded information from the dive computers. Mr Thwaites' computers were incorrectly recording times and dates. Mr Blackwell was able to identify the dive on 10 August 2016 and generated a dive profile report.

96. The cylinder Mr Thwaites was using during his second dive was a Faber, serial #00/9628/103. It had most recently been hydrostatically tested in June 2016 and was compliant with the relevant Australian Standard which requires annual testing. The cylinder was in good condition and had 115 bar of air pressure remaining.

97. On the day following the recovery of Mr Thwaites' body, 14 August 2016, the Faber cylinder was delivered by Senior Constable Fenton to Safety in Mines Testing and Research Station ('SIMTARS') for an analysis of air quality. Results were supplied within the usual testing period and received by police on 26 August 2016, sixteen days after Mr Thwaite's death.

98. The following Australian Standards are relevant to the filling of scuba cylinders and stipulate the composition and purity of scuba air:

    - Australian Standard 3848.2 - 1999 Filling of portable gas cylinders - Part 2 Filling of portable cylinders for self-contained underwater breathing apparatus (SCUBA) and non-underwater self-contained breathing apparatus (SCBA) - Safe Procedures; 186 ('Australian Standard 3848'); and
    - Australian Standard 2299.1:2015 - Occupational diving operations. Part 1: Standard operational 187 ('Australian Standard 2299').

99. Collectively, the Australian Standards require that breathing air meet the following requirements in terms of composition and purity:

- Oxygen - 21-22 % by volume;
- Carbon dioxide - no greater than 600 parts per million;
- Carbon monoxide - no greater than 5 ppm; and
- Oil - no greater than 0.5 mg/m^3.

100. The results from testing the contents of Mr Thwaites' cylinder were formally reported on 9 September 2016 as follows:

    - Oxygen -19.8%
    - Carbon dioxide - 7,636 ppm;
    - Carbon monoxide - 2,366 ppm; and
    - Water -100 mg/m^3

101. The testing was repeated and confirmed the initial results. This led to Senior Constable Fenton obtaining and testing Mr Thwaites' and Ms Masterman's cylinders from the first dive, which also showed elevated levels of contaminants. (tank serial #11/0572 and tank serial #00/9524). The cylinders were taken to SIMTARS on 29 August.

102. In hindsight it would have been preferable if Ms Masterman's second cylinder was also tested at this time.

103. The SIMTARS report dated 9 September for Mr Thwaites first dive cylinder showed:

    - Carbon dioxide - 509 ppm; and
    - Carbon monoxide - 26 ppm.

104. Ms Masterman's first dive cylinder showed:

    - Oxygen–20.99%;
    - Carbon dioxide - 538 ppm; and
    - Carbon monoxide - 24 ppm.

105. Ms Masterman's second dive tank results were subsequently obtained from SIMTARS:

    - Oxygen 20.40%
    - Carbon dioxide - 2255ppm; and
    - Carbon monoxide - 820ppm.

106. The focus of investigation moved to identification of the source of contamination in the cylinders used by Mr Thwaites and Ms Masterman.

107. A search warrant was executed on 31 August 2016 on the premises of the Club. Mr Bill Hunt from Pressure Technologies (an expert in

compressors and breathing air systems) and Mr Shane Murphy from WHSQ were also in attendance. Mr Peter Harrison, an executive member of the Club, was present.

108. Mr Hunt inspected and sampled air from the Club's compressor which was an Ingersoll-Rand Type 15T4 ('the Compressor').There was also a large storage bank of cylinders. The system was split into one bank of two cylinders (numbered 7 and 8) and one bank of six cylinders (numbered 1-6.)

109. Five dive cylinders were seized from the Club and taken for testing by SIMTARS and delivered on 1 September. At this time Ms Masterman's second dive tank was also delivered for testing.

110. SIMTARS results for the cylinders from the Club as at 30 August 2016 were as follows:

- Slightly elevated levels of carbon monoxide in three of the Club's five dive cylinders (7 ppm, 20 ppm and 22 ppm);
- Elevated levels of carbon monoxide in all samples taken from the Club's bank of eight cylinders (from 68 ppm, 69 ppm, 86 ppm, 87 ppm, 109 ppm, to 1256 ppm (in cylinder 7) and 1485 ppm (in cylinder 8); and
- None of the Club cylinders or Compressor's samples had elevated levels of Carbon Dioxide, with the exception of cylinder 7 which was 1673ppm.

Other testing of cylinders separate from QPS arrangements

111. Following Mr Thwaites' death there was concern regarding the contents of diving cylinders which had been filled at the Club and individuals were arranging testing, independently of the police investigation. Dive Dive Dive was approached by members of the Club. It is noted that the dive 'community' within Brisbane is close knit and many members of the Club were known to the Dive Dive Dive business. The business is involved in performing the annual hydro static testing of cylinders for the Club.

112. Sometime before 2 September 2016, (which was before the SIMTARS test results were available) Mr Blackwell from Dive Dive Dive says he received a phone call from Underwater Research Group Inc. (the Club) member, Mr Peter Harrison asking him where he could get an air test undertaken. Mr Blackwell suggested several companies as his company did not provide an air quality test *report,* although he had equipment to test carbon monoxide, but no other contaminants.

113. During this phone call, Mr Harrison told Mr Blackwell that his club was having problems with contaminated air. As Mr Blackwell was aware of the recent death, possibly relating to contaminated air, he posted on Facebook

on 2 September that his company would test air and clean cylinders as required.

114. Mr Blackwell's motivation was concern of a risk of cross contamination from any other contaminated cylinders, which would place other divers at risk as well as the potential of cross contamination of his filling station.

115. He explained if multiple tanks are filled on a fill system together, normally the cylinders will equalise out, and then the fresh gas will be placed on top of the contents of existing cylinders. This would not feed air back into the compressor.

116. Mr Blackwell recalled the names of a couple of Club members who were known to him, who brought tanks in for testing including Ms Carla Jones and Mr Gary Davis.

117. Over several weeks, various members from the Club bought tanks into Dive Dive Dive for testing and cleaning. Mr Blackwell has no record of who bought their tanks in for testing and cleaning. His company tested approximately 20 tanks from the Club.

118. He could not recall whether any of the tanks came from places other than the Club.

119. Mr Blackwell found tanks tested from members of the Club had an oily odour and high levels of carbon monoxide. He could recall a particular Club member Mr Davis' tank had an oily, putrid smell coming from it.

120. The levels of carbon monoxide in the tanks his business tested and he could recall, ranged from about 20 - 670 PPM. A majority of the tanks were over the relevant Australian Standard for carbon monoxide (under 5 ppm).

121. Mr Blackwell took several photos of air quality testing of tanks from the Club which show the high levels of carbon monoxide. The handheld Analox carbon monoxide monitor used in his business costs between $350- $400.

122. Mr Blackwell estimated an inline carbon monoxide device detector fitted to an air compressor would cost about $2,500-$3,000.

123. His maintenance regime of the business' air compressor included:

- Three monthly independent testing for carbon monoxide;
- Oil changes as per manufacturer's specifications;
- Logging the information; and
- Involving an external third party for any major break downs.

Workplace Health and Safety Queensland investigation

124. Mr Shane Murphy led the WHSQ investigation into Mr Thwaites' death until it was determined the circumstances did not fall within the relevant jurisdiction. He was present at the execution of the search warrant at the Club in company with Mr Hunt and Senior Constable Fenton on 30 August 2016.

125. Mr Murphy contacted the club president, Ms Marie Cyprien and requested club members contact him to deliver cylinders filled at the Club so that these could be tested. An email issued from the Club on 1 September and subsequently between 6 and 9 September 2016, Mr Murphy seized 13 tanks from six club members which were delivered to SIMTARS for testing. These tanks belonged to:

- **Ms Carla Jones**: four tanks. Ms Jones was unsure of dates of fills but her husband Mr Hills gave evidence at the inquest that he had filled two of these tanks on 3 August 2016;
- **Mr Robin Aurisch:** one tank. The tank was filled 'approximately 3 months ago';
- **Mr Carsten Vang:** three tanks which had been filled on 3 August 2016;
- **Mr Ash Thomas:** two tanks filled 'around' 7 April. He was unsure who had filled them;
- **Mr Peter Harrison:** two tanks. He said bottles were filled at the Club on 1 August 2016. He said he had already had tanks independently tested; and
- **Ms Kerry Morgan:** one tank believed to have been filled on 3 August 2016.

126. Gas analysis was performed by SIMTARS on the first 5 tanks delivered by Mr Murphy, belonging to Ms Jones and Mr Aurisch.

127. Mr Aursich' tank showed:

- Carbon monoxide - 20ppm
- Carbon dioxide - 639 ppm

128. Ms Jones had four tanks tested. The readings were:
- Tank 1: carbon monoxide - 6 ppm; carbon dioxide - 427 ppm;
- Tank 2: carbon monoxide - 16 ppm; carbon dioxide - 486 ppm;

- Tank 3: carbon monoxide - 128 ppm; carbon dioxide - 609 ppm; and
- Tank 4: carbon monoxide 213 ppm; carbon dioxide 710 ppm.

129. On 15 September 2016 it was determined by WHSQ that they did not have jurisdiction to investigate either in relation to Absolute Scuba or the Club. The QPS was notified by Inspector Murphy that WHSQ was no longer investigating the matter. Mr Murphy informed Maritime Safety and SIMTARS, including that he would pick up the cylinders.

130. Queensland police were notified on 20 September of the results from the first five tanks tested.

131. Mr Murphy's information recorded cylinders from the following people were outstanding regarding testing, but remained with SIMTARS.

    - Two tanks belonged to Mr Harrison, who had told Mr Murphy they were filled on 1 August;

    - Three tanks belonged to Mr Vang who filled them on 3 August; and

    - Two tanks belonged to Mr Thomas who filled them on 7 April.

132. Mr Murphy concluded on advice he had no jurisdiction to retain the cylinders and was required to return the property to owners unless police advised otherwise.

133. There was a breakdown in communication and there was no response received from QPS and therefore on 23 September the Regional Investigations Manager of WHSQ advised Mr Murphy to proceed with return of cylinders to their owners.

134. Mr Murphy subsequently had phone conversations with the owners of the tanks that were returned. He advised that:
    - There was an issue with the compressor at the Club;
    - Do not breathe the air generated from the compressor;
    - He had no jurisdiction to continue with the investigation and have the tanks tested; and
    - They may wish to have the scuba tanks independently tested.

Discussion

135. It was unfortunate that there was a breakdown in communication between WHSQ and QPS relating to the seizure and testing of tanks from the Club. In particular the opportunity was lost for testing more cylinders that had been filled at the Club.

136. It is clear that WHSQ communicated with police but unfortunately a response was not received before cylinders were returned to their owners prior to testing.

137. What is however quite clear, is that all of the cylinders taken from the Club (and samples from the bank of cylinders at the Club) that were tested either by:

- Handheld carbon monoxide detector at Dive Dive Dive; or
- SIMTARS, as delivered by Queensland Police Service had elevated levels of carbon monoxide. The range was huge, between 6 ppm to 1,485ppm. (It is noted here that the storage bank cylinders had not been used for some years.)

138. Additionally, two individual Club members whose cylinders were filled at the Club and tested by SMITARS had elevated levels of carbon monoxide. The readings were between 6 ppm and 213 ppm.

139. Before moving on to examination of the Club and its compressor, the Maritime Safety investigation is considered.

Maritime Safety Queensland investigation

140. The Maritime authority was involved in the investigation of the business Absolute Scuba focusing on the vessel Nemo and compliance with the Federal requirement for a Safety Management System. An inspection of the vessel occurred on 12 August 2016. An Improvement Notice and a Prohibition Notice were issued and subsequently complied with.

141. On 19 August 2016, Investigators re-attended the vessel and conducted operational monitoring in relation to various emergency procedures (i.e. man overboard, engine room fire, anchor deployment). There were significant issues with the Safety Management System and the crew could not demonstrate that they could carry out the procedures within the requirements. However, the crew could demonstrate that they could safely operate the vessel and the investigator was confident that with changes put in place since the initial inspection and operational monitoring, there will be continued improvement.

142. The issues were resolved and the improvement notices and prohibition notices were subsequently lifted.

The Underwater Research Group of Queensland Inc. (the Club) and its compressor

143. The Club has been operating for many years with its constitution written in 1954.

144. In 1996 the Club purchased at auction a second hand Ingersoll-Rand Compressor for $4000. It was air cooled and oil lubricated with four stages of compression, driven by a three phase electric motor.

145. The Compressor's date of manufacture is not known however operating instructions located on line and provided by Mr Hunt are dated the year 1970.

146. No documents in relation to the Compressor's purchase were provided to the inquest.

147. The Compressor was fitted with the following:

- Primary oil and water separator fitted to the compressor block assembly and connected downstream of the final stage after cooler;
- A secondary oil and water separator; and
- A third stage oil and water separator of stainless steel construction mounted on the compressor frame (of unknown fabrication).

148. The compressor was housed in a separate ground level building. There was a rear section of concrete block construction housing the compressor. An internal door separated this area from the front section which contained a cylinder filling control panel with storage bank of cylinders.

149. A cylinder filling control panel was mounted on the wall between the two rooms of the compressor shed. The cylinder connection to the scuba cylinder was via two flexible high pressure hoses and yoke connectors. Supply to the panel was from the compressor line and two connections for storage bank cylinders. There were eight cylinders to store compressed air. The system was split into one bank of two cylinders and one bank of six cylinders.

150. An air filter was located on the outside of the compressor shed adjacent to a golf course.

151. At the Club's Annual General Meeting six compressor operators were nominated to fill tanks on a Wednesday night when the Club members meet socially.

152. The roles and responsibilities of these compressor operators were to:

- Know how to use the compressor and how to fill up members' tanks;

- Fill up members' tanks;
- Teach other club members how to fill up their tanks; and
- Encourage club members to learn how to fill up their tanks.

153. Club members would purchase a tag from the Club's canteen after a donation of $5.00 or the presentation of a pre-paid card. The member could purchase a card for $45 which allowed them to fill ten tanks.

154. The Club maintained a 'tank fill log'. The tank fill log records the date of fill; number of tanks filled; name of filler and space for a signature.

155. The tank fill log did not identify individual cylinders filled.

Evidence from the Club compressor operators

156. At the time of Mr Thwaites' death, the six appointed Compressor operators were:

- **Mr Peter Harrison**, a long standing member of the Club since 1981. Mr Harrison was a retired electrician and had 47 years of diving experience;

- **Mr Gary Broomfield** had been a member since 2013. He had previously worked as a dive instructor for a commercial diving operation for 7 years. Prior to that, he had been an electrician for 25 years. He was familiar with filling tanks from his previous experience at a dive shop (Nautilus);

- **Mr Gary Davis** had been diving since 1986 and had been a member since 2012. At the time of Mr Thwaites' death, he had been appointed as the vice president for approximately a week. He had a basic knowledge of compressors and motors but not much knowledge regarding maintenance;

- **Mr Alan Dodd** had been a member since 2004 and held the position of Club Captain from 2006 until 2010. He was responsible for maintenance of the club house and associated activities;

- **Mr Scott Bratton**; **and**

- **Mr Gary ('Ash') Thomas**. Mr Thomas was previously a self-employed electrical mechanic and refrigeration and air conditioning mechanic from 1970 to 2015. Mr Thomas has now retired. Between September 2002 and June 2005, his work included servicing, repairing and maintaining the air conditioning, fresh and exhaust air plant, air compressors, water and waste pumps, and all other

machinery at an entertainment facility in Brisbane. Those compressors were not used to fill scuba tanks. Mr Thomas had never been employed to provide breathing air from a compressor. He held current licences in:

(i) Electrical Workers Licence, Electrical Mechanic, Queensland;
(ii) Electrical Contractors Licence, Queensland; and
(iii) ARC Refrigeration and Air Conditioning Licence, Australia.

157. With the exception of Mr Bratton, five of the Compressor operators gave information to the coronial investigation and provided evidence at the inquest.

158. A formal claim of privilege was made in respect of evidence provided by Mr Thomas and was granted.

159. Their evidence was generally consistent and is summarised as follows: [1]

- The research involved in purchase of the second hand Ingersoll-Rand compressor was minimal. There was reliance on a history that it had previously been used in a dive business up north;

- According to the constitution, the 'Dive Captain' had the role to maintain the Club's compressor, but not everyone who filled that role over the years had expertise to oversee maintenance of the compressor. Other members from time to time volunteered with maintenance if they had experience and expertise to service and repair the compressor. No single person was designated but two members in particular had been involved over the years. These persons were Mr Lynton Holroyd (who had installed the Compressor) and most recently, Mr Thomas;

- The Compressor was completely submerged during the 2011 floods. Work was undertaken by Mr Thomas following the flood to restore the Compressor to operational service. It was raised 800mm above its previous position. It was thought this would improve circulation around the Compressor, although there was no indication of technical advice being sought. The internal area of the room was increased by 6 cubic metres. A commercial wall fan was installed which operated while the Compressor was working;

[1] A detailed account of the evidence can be found at Appendix 1

- The Club had a history of seeking voluntary assistance from members to repair the compressor as and when required. It was a matter of identifying who amongst the current members was best suited to the particular problem to be solved. There was no information of the Club paying for external technical expert service or repair of the compressor;

    - After 2011 when Mr Thomas rebuilt the Compressor following the flood, he fell into the voluntary role of performing maintenance on the Compressor;

    - Mr Thomas' maintenance regime included:

        (i) Check the belts once a month;
        (ii) Check the oil on the first Monday in every month;
        (iii) Change the filters every year or every 400 tanks, which ever came first; and
        (iv) Annual service

    - This annual service included rechecking the belts for wear and tear and realigning the belts. He gave everything a bit of a clean. He would drain the oil completely and then top the oil up. Mr Thomas would ensure the air valves were clean and check the air inlet filter;

    - The last service was carried out in September 2015 by Mr Thomas at which time he said the state of the oil was quite good, honey coloured and there was no smell. Mr Thomas was not aware however that oil can get old and gave evidence to the effect that if the can is sealed, the oil should be ok;

    - There had been instances in the past where there were issues with the Compressor's gaskets including in 2013 and 2014 when Mr Thomas had made his own gaskets;

    - There were no concerns regarding the maintenance of the Compressor and it was believed that Mr Thomas was qualified to deal with the Compressor due to his experience as an air conditioning mechanic;

    - The Compressor would usually be run for 2-3 hours each Wednesday night to fill tanks and it would take approximately 15 minutes to fill a tank;

    - The bank of eight cylinders had not been operational for a number of years due to faulty valves which were unable to be sourced to replace;

- It was the Club's practice that if anyone was interested in filling their own tank or in helping out, they would be shown how to use the Compressor so they could fill their own tanks;

- The 'rule' that appointed compressor operators were present and supervised other club members if they filled tanks was not applied once it was considered a member was competent to fill cylinders;

- Due to the noise of the Compressor whilst in operation, the internal door to the shed where it was housed, was ordinarily kept closed;

- The Compressor was not fitted with a temperature gauge and there was no way of knowing how hot the Compressor would be at any time;

- There was no schedule or record of maintenance activities kept in relation to the Compressor with the exception of a record of filter changes which Mr Thomas had implemented in 2015;

- There was no history of paying for external servicing to be performed;

- There was no operating manual available to the Club in relation to the Compressor's operation and Mr Thomas had never read a manual specific to *this* compressor (although he had read manuals for similar compressors in the past);

- In the time that the Club owned the Compressor, there were no previous concerns raised in relation to the quality of the air. However, there was no means of testing the air quality from the Compressor and it had not been tested at any time since 2011;

- No checks of the Australian Standards had occurred nor had any research been undertaken in relation to the possible dangers relevant to the Compressor and breathable air;

- There was no knowledge of the potential for internal combustion occurring within the Compressor giving rise to carbon monoxide, carbon dioxide and other contaminants;

- The members were generally very experienced and passionate divers, but there was no appreciation of potential risks arising from the state of the Compressor or the manner in which it was maintained and repaired. Ad hoc replacement parts were invented (such as gaskets of varying thickness and diameters), when it became difficult to source appropriate parts;

- Even after Mr Thwaites' death and subsequent discovery of contaminated cylinders taken from other Club members, there was a degree of denial from those most senior Club members on whose experience other members were reliant; and

- A number of the Compressor operators were unaware of a similar death having occurred in Australia and New Zealand from contaminated air from an air compressor.

Events leading to seizure of the compressor

160. There was uncertainty about events relating to the Club compressor in the months of July and August prior to its final seizure. Via correspondence from the Club's lawyers, Mr Broomfield says he operated the compressor on (Wednesday) 6 July 2016, stating he was the only operator on that day. He says that the Compressor had been operating for a period of approximately 20 minutes when Mr Bloomfield realised it was not running at its full capacity. He was filling two of his own tanks at the time and explained that it was not pressurising properly. He recalls leaving the tanks and going up to see Mr Thomas to bring him back down for a look. He says that they shut the compressor down and locked off the tanks and there were no further investigations at that stage.

161. Mr Broomfield's name appears in the tank fill log as having filled two tanks on an unknown day during 'July 2016'. Mr Thomas' club membership number appears in the Club attendance record for 6 July 2016 though Mr Broomfield's name does not.

162. In his statement, Mr Harrison said that on 13 July 2016, he was filling his cylinders when he could hear hot air escaping from the Compressor. It sounded to him as if a gasket had blown at the first stage. He could not recall whether anyone else was in the room but thinks someone made him aware of it. He thinks Mr Thomas went to check it. Mr Harrison was not noted in either the attendance log or tank fill log on 13 July 2016. His name does appear on the attendance log for 6 July 2016 but not in the tank fill log for this date. In his evidence, he confirmed that he had not been filling tanks but it was on this date that he recalls the Compressor blowing air out of the gasket.

163. Via correspondence from the Club's lawyers, Mr Thomas says that it was on 13 July 2016, he was informed by Mr Broomfield that the Compressor was not working to its full capacity. It is noted that Mr Thomas' name also appears in the attendance record for this date but Mr Broomfield's does not.

164. It is difficult to reconcile the evidence as to when the Compressor was not working to its full capacity and when Mr Thomas was informed of same. It could have been either on 6 or 13 July or on both occasions.

165. On 13 July 2016, Mr Thwaites' name appears in both the attendance log and the tank fill log. Mr Davis confirmed that Mr Thwaites was filling tanks on that night.

166. Following the gasket issue, Mr Thomas says that he rang the Brisbane branch of Atlas Copco (Atlas), about the leaking gasket. He says that the operator transferred his call to the service/spare parts department. He does not recall the name of the person he spoke with. He says he had never previously purchased parts from them but thought they might have the parts (gasket) for an Ingersoll Rand compressor or be able to direct him to someone who stocked the parts. He was told they do not stock Ingersoll- Rand parts nor did they know of anyone else who could help him.

167. Mr Thomas says that someone at Atlas told him 'when our guys are out in the field, we use a liquid gasket. Make sure it's a high temperature one'.

168. Atlas denied that there had ever been a call received from the Club in which advice was provided about using a high pressure liquid sealant.

169. On (Monday) 18 July 2016, Mr Thomas and Mr Harrison replaced the head on stage 1 and removed the old gasket, which was replaced with a high temperature liquid gasket. Mr Thomas checked the oil levels of the compressor and its fanbelts. No issues were discovered. Mr Thomas said that the level of the oil was near enough to full.

170. Mr Thomas did not think that there was potential for contamination due to the blown gasket. He says that it didn't enter his mind to inform the people who had filled their tanks on 13 July to dump the air.

171. On 3 August 2016, tanks 1 to 6 in the bank of cylinders were partly filled by Mr Thomas. On 8 August 2016, Mr Thomas finished filling tanks 1 and 6 and started to fill tanks 7 and 8. After two and a half hours of continuous running, the electrical circuit breaker on the club's switchboard tripped and the compressor stopped. Mr Thomas removed the belts from the electrical motor and tested the electrical motor, which was running correctly. He then rang Mr Dodd who said words to the effect of 'leave it and we'll check it on the night of 10 August 2016'.

172. On 10 August 2016, Mr Thomas and Mr Dodd removed the top of stage 1 and found that the compressor's rings had collapsed. No further work on the compressor was undertaken.

Discussion of evidence concerning when and where Ms Masterman and Mr Thwaites filled their tanks and the dive trips when tanks were used

173. Ms Masterman and Mr Thwaites owned 7 full sized scuba tanks. (two 15 litre tanks, four 12 litre tanks, and one 10 litre tank.) They also owned four small pony bottles for emergency use not relevant to his matter.

174. Their practice was to fill 4 or 6 of the large tanks at a time on the Wednesday night at club meetings. They generally matched their 15 Litre and 12 Litre tanks together for dives as their air consumption was very similar.

175. The Club meeting attendance log for 2016 records Mr Thwaites and Ms Masterman's attendances on 8 occasions. The most recent occasions were on 29 June 2016, 13 July 2016 and finally on 3 August 2016, which was the annual general meeting.

176. There were inconsistencies in the evidence provided by Ms Masterman.

177. Her first two statements reported the last time they filled their tanks was on 27 July 2016. She said Mr Thwaites filled all 6 tanks. However, she conceded their names did not appear on the attendance record for the club meeting on that date. It is noted the statement was taken on the day Mr Thwaites had gone missing.

178. The WHSQ inspector Mr Murphy recorded Ms Masterman told him she had last filled their tanks at the club on 3 August which was consistent with what she said to Senior Constable McIlvain

179. At the inquest she thought this might not have been the case because the compressor was really loud and she did not think it would have been running during the annual general meeting. (It is however noted the tank fill record indicates seven tanks were filled on that date.)

180. In the third statement provided to the inquest Ms Masterman set out a dive log taken from entries made by Mr Thwaites in his Facebook page. Based on that information she thought the tanks must have been filled between 10 and 24 July 2016.

181. Ms Masterman thought the last dive they had undertaken prior to 10 August was on 24 July when they did three mini dives each at Green Island, in Moreton Bay. At the inquest she corrected this information, accepting this dive occurred on 30 July.

182. Her final conclusion was that the last date they filled tanks at the club was 13 July 2016. Andrew Thwaites' name appears in the name column and there are initials in the signature column subsequently identified as Gary Davis. Seven tanks were documented as filled. Therefore, Ms Masterman considered this most likely included two pony bottles.

183. Later in evidence Mr Gary Davis confirmed Mr Thwaites was filling tanks on 13 July. Mr Davis left his tanks for Mr Thwaites to fill. When he returned, only some tanks had been filled. Mr Davis then filled his own 2 tanks and possibly, another member's as well. He crossed out the number of tanks filled in the tank filled column and entered the new total of '7'. Mr Thwaites had signed his name in the name column. Mr Davis signed his initial in the signature column.

184. This does not support Ms Masterman's assertion that seven of their tanks were filled by Mr Thwaites at the club on 13 July 2016, but it does confirm Mr Thwaites filled four or five tanks at the club on that date.

185. Significantly, 13 July was the date on which Mr Harrison said air was heard escaping from the compressor indicating a gasket had blown which was subsequently 'repaired' by means of a liquid sealant applied by Mr Thomas.

186. Problems had been noticed from 6 July when the compressor was taking a lot longer to fill cylinders.

187. Ms Masterman had told Ms Williamson they were going to fill their own tanks at Under Water Research Group Inc. prior to the dive. In her first statement provided on the day of the dive Ms Masterman told police 'Andrew and I always fill up our tanks at Underwater Research Group Qld.' It is noted there was some degree of scepticism on the part of the Club to Ms Masterman's statement that the tanks used by Mr Thwaites and Ms Masterman had been filled at the Club.

188. It is acknowledged there was confusion and variation in Ms Masterman's information about exactly when the tanks were filled at the Club, just as there was confusion and variation in the Club's information about when the compressor was leaking and when it was repaired.

189. However ultimately it is accepted on the balance of probability that the tanks were filled at the club having regard to the following:

- Ms Masterman and Mr Thwaites had told Ms Williamson prior to the 10 August trip they did not require pre-filled tanks as they had their own tanks which they filled at the Club, where they were members;

- The possibility they had filled their tanks from a compressor Mr Thwaites had recently purchased second hand from an overseas source was raised. Mr Hunt from Pressure Technologies was asked to inspect this compressor. Mr Hunt noted that the electrical supply cable was fitted with a European type electric plug. Mr Hunt tested the compressor with a universal adapter plug connected to a common power cable. The compressor could not be operated and there was no indication of power to the motor. He concluded that it could not be operated for filling scuba cylinders in its present condition. Mr Hunt's evidence in relation to this compressor is accepted. Accordingly, it is concluded that their tanks were not filled from this source.

- Ms Masterman's uncertainty and confusion over dates when the tanks were filled is unsurprising given the timing of the first statement whilst affected by grief and, unwittingly, from carbon monoxide toxicity, and the lack of access to the club records of tank fill and attendance logs.

- Ms Masterman narrowed the range of dates by reference to Mr Thwaites' own dive records to between 10 and 24 July 2016.

- By the time of her evidence at the inquest, when shown the tank fill log, she accepted it was Mr Thwaites' signature for last filling tanks at the Club on 13 July.

- Significantly, Mr Dodd confirmed he followed Mr Thwaites in filling two or three tanks on 13 July after an interval of 45-60 minutes and turned the compressor back on.

- Finally, and most importantly, there is the evidence of analysis of other Club member's tanks filled at the Club during this period which were subsequently tested. A number of tanks tested at Dive Dive Dive and at SIMTARS were contaminated to varying degrees by carbon monoxide.

Technical expert evidence provided to the inquest related to breathing air compressors and systems

190. Mr Bill Hunt owns and operates 'Sea-Lab Systems Pty Ltd' trading as Pressure Technologies. He is a qualified mechanic with 40 years' experience in breathing air systems. He acknowledged he was a member of the Club for approximately one year in the 70's.

191. Of particular pertinence to this investigation, Mr Hunt is a member of the Australian Standards Committee, ME2/5 which wrote Australian Standard 3848 for breathable air when filling portable cylinders.

192. Mr Hunt informed the police who investigate on behalf of the coroner that on 12 August 2016 (two days after Mr Thwaites' death) there was initial enquiry made with his company about a scuba dive compressor for a dive club. The inquiry was from Mr Ash Thomas, a member of the Underwater Research Group Queensland. There was no further follow up from the Club regarding a replacement compressor.

193. On 12 August 2016, Mr Hunt became aware of a dive related death when the Queensland Police Diving Squad requested his assistance to inspect a diver's regulator. Mr Hunt examined the regulator on 17 August concluding it was in good working order. He subsequently examined the compressor at the Underwater Research Group of Queensland on 31 August 2016 at the premises of the Club at Yeronga. The resulting assessment is contained in Mr Hunt's report headed 'Inspection and investigation of a breathing air

compressor', dated 18 October 2016.[2] The report attached a copy of the compressor product manual and compressor theory report.

194. Mr Hunt also disclosed that several days after his examination of the compressor he received an email from Kelly Anne Masterman. She was requesting support to improve Australian Standards relating to dive safety. He subsequently telephoned her and had a conversation. He informed her of his support on the issue but also that he could not discuss Mr Thwaites' death as he was involved in the investigation.

195. About a week later Mr Hunt became aware another business named Dive Dive Dive was testing and cleaning cylinders which were involved in the investigation. He therefore arranged to pick the cylinders up and conduct his own testing on the contents and informed the police accordingly.

196. This examination was initiated by Mr Hunt. He did not furnish a report regarding his findings but he found some of the tanks had elevated levels of carbon monoxide and carbon dioxide. This was consistent with what he understood Dive Dive Dive had determined. He returned the tanks to that business.

197. Mr Hunt explained the key standards applicable to SCUBA diving air quality. Australian Standard 2299 was written principally for the commercial diver to provide equipment and standards of operation in commercial diving operations.

198. Australian Standard 3848 was intended for the use of a filling station operators filling portable cylinders. This may apply to oxygen for medical purposes, or breathing air for scuba diving, or respiratory purposes such as firefighting.

199. There is also a Queensland Recreational Dive Code of Conduct under Workplace Health and Safety which refers to both of the two Australian standards. The diving code recommends people filling cylinders follow the Australian standard 3848 code and that air quality standards be maintained in accordance to standard 2299 (applicable to commercial divers) and standard 3848 (applicable to filling station operators.)

200. Mr Hunt pointed out that groups such as Underwater Research Group of Queensland are not required to comply with these standards or code of conduct.

[2] Exhibit E2 and E4

Examination of the compressor at the Club

201. Mr Hunt's examination of the compressor was limited by the circumstances. Essentially the compressor had failed and the first stage cylinder head and valves had been removed as well as stage two discharge valve assembly and housing. It could not be operated.

202. Mr Hunt advised the Compressor is air cooled and requires significant flow of air through the cooling coils and across the cylinder heads and barrels to remove the heat of compression and the drive energy. He observed the location of the compressor on a stand, well above floor height, may have contributed to heat looping of the cooling, recycling heated air through the compressor cooling coils. This could not be tested as the compressor did not operate.

203. In his oral evidence Mr Hunt stated the size of the space in which the compressor was situated and the small ventilation fan in the side wall was inadequate. The recommended air flow required for minimum cooling of the compressor had not been met.

204. The lubricating oil level was checked in the crank house and was at the minimum marking level. Mr Hunt said this impacts on both the capacity to lubricate moving parts within the compressor and the role of the oil in internally cooling the compressor.

205. Mr Hunt observed that the oil was dark in colour and had a strong odour. This indicated the oil had probably run a significant number of hours or had been operating under high temperatures. The oil degrades with use, picking up particles, which discolours it, as does operating at high temperature.

206. The Ingersoll-Rand manual recommends the oil level be checked daily before use. There were no records found of oil changes or topping up.

207. The particular type of oil (Shell Corena P 150) was appropriate. However, storage in a 20 litre drum was sub optimal. Oil should be kept in small sealed containers to reduce deterioration due to gassing off of the volatile additives. If older than five years, Mr Hunt considered it should be disposed of and replaced.

208. The condition of the compressor could only be assessed from visual inspection. There were significant carbon deposits of the barrel and piston. Seizure of the piston was evident by the deposits of aluminium on the cylinder walls. There were also significant deposits of carbon and lubricant which indicates significant overheating of the compressor.

209. The fact that the compressor had been immersed in the 2011 flood was not necessarily an issue provided it was subsequently correctly repaired. Essentially a thorough disassembly and cleaning was required.

210. Mr Hunt reviewed the filtration system which is essential in all lubricated breathing air compressors to remove contaminants that may be introduced into the air from the lubricating oil. He documented the following:

- Primary oil and water separator fitted to the compressor block assembly and connected downstream of the final stage after call. It appeared to be an original fitted to the compressor during manufacture'
- Secondary oil and water separator branded 'Domnick Hunter';
- Third stage of oil and water separator of stainless steel construction noted on the compressor frame. No fabrication details were indicated on the pressure vessel;
- A pressure maintaining valve was fitted downstream from the third separator; and
- A dual column filter was wall mounted in the corner of the room. Airflow is from the pressure maintaining valve and up to the cylinder filling panel. These filter columns were removed for further examination.

211. The filter columns were constructed from stainless steel pipe with a removable brass head at the top and a removable brass plug in the base and had no markings. There was no information of the fabricator, of the working pressure, of test pressure marks, of the date of manufacture or retesting marks. Therefore the pressure rating of the filter columns was not available to an operator for any markings or other available information. Mr Hunt compared the apparatus with standard industrial pipe charts and considered they may be suitable for use up to 25Mpa (a measure of pressure), but this could not be confirmed without further engineering investigation.

212. Significantly, Mr Hunt commented on the connection of the two columns by a link of stainless steel tube connected with twin ferrule compression fittings. He was concerned with the fitting. None of the tubing had been deburred. If properly assembled in accordance with manufacturer's instructions, 'Swagelok' fittings are high-strength and effective. If incorrectly applied it has the potential for the tubing to pull out from the ferrule with enormous force and potential for significant injury to the operator. As the filtration column takes the full operating pressure of the system, if it were to fail, it would be catastrophic.

213. In terms of the filtration, if air can escape to the atmosphere, the machine is simply pumping to atmosphere rather than producing air to fill the cylinder.

It will take longer to run to fill the cylinder and run harder. In an environment of poor ventilation it will be running hotter than it should.

214. This was confirmed by close examination and measurement of the fittings which were found to be outside operating tolerance and not in accordance with correct practice for this type of high-pressure connection.

215. The top heads of the columns were removed and found to have Teflon tape used to assist the O ring seal. The actual O ring seals were in poor condition.

216. Mr Hunt then explained his testing of the filter media within the columns of stainless steel. There were two components used in the filter media columns. The first was called molecular sieve, which principally removes moisture and some types of volatile organic compounds. That then enables the second component of activated carbon to work correctly. Mr Hunt tested the molecular sieve and found it to be completely inactive. This might be an explanation why the moisture content in the scuba cylinder was high.

217. There was no test available for evaluating the effectiveness of the activated carbon, but a 'very, very high odour' was evident indicating it was saturated. It adsorbs the hydrocarbons and contaminants in the air until it reaches a point called rollover. It then discharges and desorbs those elements back into the air stream.

218. There was a further problem with the size of the felt pad at the end of the column to prevent dust being carried through into the breathing air. The diameter of felt pads used was smaller than the diameter of the tubes, leaving an open path for dust and particles to pass through.

219. Mr Hunt provided a comparison between an ordinary industrial compressor in a factory pumping some service air around the factory with a breathing air compressor. If a piston ring is worn and it uses a bit of extra oil, it really might not be too significant. But in a breathing air compressor the oil control is really important to take the oil out of the breathing air. The oil control by the piston rings is critical to the process. If they are worn and they are passing too much oil, it impacts on the operation of the machine. If excessively worn, the piston rings are bypassed and do not seal correctly. This allows air back into the crankcase of the compressor. It reduces the efficiency, increases the run times, increases the heat, and deteriorates the oil.

220. There was evidence in the inquest referring to a 'brown mist' in the compressor room. (Its existence was denied by club executive members.) Mr Hunt agreed it was possible that the compressor was venting to the atmosphere and there was excess crank case pressure releasing crank case fumes into the atmosphere. Whilst this was not specifically tested the

description of the brown mist was consistent with the way the compressor was operating.

221. Mr Hunt noted some compressor filter systems use a catalyst to remove small quantities of carbon monoxide that may be ingested into the intake or generated by breakdown of the lubricant. No catalyst was found in either column. He also remarked on the absence of a reverse flow check valve to prevent reverse pressurisation infiltration system. A pressure maintaining valve to control the filter column pressures and the adsorption and desorption process that occurs in the filter media was also not fitted.

222. Mr Hunt's report then looked at the cylinder filling system. The age of manufacture and installation could not be determined. There were no current testing tags. The normal procedure for testing scuba diving cylinders in Australia is annually. The normal test interval of storage cylinders attached on a scuba compressor was every five years. He also observed the pressure relief valve fitted into the connecting line to the 6 cylinder bank was blanked off, thus making it non-functional as a safety valve.

223. Air samples were taken from all of the eight storage cylinders and analysed. All samples included carbon monoxide higher then permitted under Australian Standard 2299 for divers' air.

224. Samples of breathing air taken from Mr Thwaites' cylinder showed significant high levels of carbon monoxide and carbon dioxide. This raised the possible source of contamination as:

- Intake contamination, for example where exhaust of an internal combustion engine is close by. This possibility was discounted noting the air intake was external on the rear wall of the building which was adjacent to a golf course;
- Internal production of contaminants from operating temperatures outside of normal parameters and breakdown of the compressor lubricating oil;
- Ignition of the lubricating oil due to high operating temperatures; and
- All of the above circumstances**.**

225. Mr Hunt considered the visible damage to the compressor indicated overheating and lubricant breakdown during the operation of the compressor. This was consistent with the strong odour of burnt oil in the filter is. The remaining lubricant in the crank case also had a strong odour of overheated oil.

Mr Hunt's conclusions:

- The compressor was of unknown operating condition when last used to fill cylinders. The lack of available operating or servicing records indicated a lack of formal system of maintenance or monitoring. Whilst he said it was his belief that the maintenance of the club compressor was being handled by some probably well intentioned people, they were operating out of the area of required expertise;
- There was physical evidence in the stage I piston and barrel that the compressor had overheated and seized the piston in the barrel while operating;
- Likewise, the stage II discharge valve housing also indicated overheating;
- The high levels of contaminants in the sampled air were consistent with production from within an overheated compressor;
- The compressor room ventilation was limited, not within guidelines and inadequate for this type of compressor;
- The filter columns were exhausted and ineffective. The filter media indicated elevated levels of contamination evident by emission of volatile organic compounds and strong odours;
- The general condition of the compressor as well as the absence of maintenance records and the type of installation, demonstrated it was not appropriately maintained in accordance with:

  -recommendations from the manufacturer;

  -Australian Standards for filling dive cylinders as out lined in the Code of Practice; and

  -available information recommended from manufacturers of breathing air compressors.

226. Mr Hunt helpfully attached addendum to his report to assist readers of a non-technical background with respect to high pressure breathing air compressors and a research report on carbon monoxide in compressed air.

227. In his oral evidence Mr Hunt emphasised what was important for people using air compressors for breathing air. A mechanical qualification would be helpful. Significantly, there must be specific guidelines and sufficient mechanical aptitude to work on the machine.

228. The Australian Standard 3848 is the guideline for filling portable cylinders. It is a publically available document which should inform the practice of how breathing air cylinders are filled.

229. Mr Hunt was asked to comment on the high level of carbon monoxide identified in Mr Thwaites' second tank in comparison to lower levels in other tanks (filled on the same day.) He responded that the examination of the compressor showed there had been ignition occurring in the compression

process which generated high levels of carbon monoxide. It was unknown whether this was a short or long event. A short event could explain how one tank might have quite different levels of carbon monoxide to another. The process was similar to 'dieseling' which can occur in a diesel engine. The fuel is injected into the cylinder of the diesel engine and ignites, pushing the pistons up and down.

230. The same process occurs in a compressor if you have hot oil, high temperatures and the right compression. The oil will ignite creating the carbon monoxide and carbon dioxide gas within the compressor.

231. Essentially Mr Hunt stated the state of the compressor when he examined it, even though unable to operate it and in its disassembled state indicated a lack of proper maintenance over time. This resulted in seizure. He would not call the procedures in place good operating procedures.

232. The state of the oil observed in the compressor was consistent with being very, very hot in operation, and may have been running hot for some time.

233. In the context of the club's operations, proper practice would require checking the oil every time the compressor was about to be used, ensuring there is sufficient oil. This keeps the machine lubricated and with sufficient oil so that the compressor does not over heat.

234. The compressor room was inadequate in size and ventilation for the size of the machine.

235. The filtration was not working because the fittings were outside the operating tolerance and the O rings were in poor condition. The molecular sieve was exhausted and not functioning as filtration

236. All of these factors were part of the maintenance regime required to ensure the breathing air would meet the required specification.

237. The state of compressor was not the result of the final seizing event, it had developed over the operating time of the compressor.

238. There was no carbon monoxide catalyst fitted. In this respect Mr Hunt acknowledged there were differing practices in the industry. It was quite possible to have a compressor generating a safe breathable air product without a carbon monoxide catalyst.

239. Overall Mr Hunt's view was there was a low level of workmanship and skill on a very old machine. The conversion of the compressor to produce breathing air had been fairly poorly done and certainly not by industry standards. The maintenance levels were quite poor as well.

Findings required by s. 45

240. Section 45 of the *Coroners Act 2003* requires the coroner investigating a death to make findings, if possible, of who, how, when and where the person died, and what caused the person to die.

(a) The identity of the deceased person is Andrew John Thwaites.

(b) Mr Thwaites was participating in recreational scuba diving with his partner Ms Kelly-Anne Masterman on 10 August 2016 at Cherubs Cave, which is at Henderson Rock in Moreton Bay, Queensland. It was a privately arranged group of 14 experienced divers. Ms Masterman was a qualified Dive Master with 1,350 previous dives. When she met Mr Thwaites in 2011 he had completed 10 dives. By 2016 he was an Advanced Open Water Diver with 300 further dives.

He and his partner were using their own four cylinders which he had filled at the Underwater Research Group of Queensland Inc. on 13 July 2016. They were members of the group and regularly filled their cylinders from the club's compressor.

Their first dive was uneventful. They re-entered the water together at 1.30pm and planned to dive for 50 minutes. They descended to 27 metres and then remained around the 22–23 metre range until approximately the 10th minute of the dive. Mr Thwaites signalled to his dive partner by circular hand motions around his stomach that he was feeling unwell and indicated he was ending the dive. His partner did not perceive that he was seriously unwell or anxious or panicked.

They commenced the ascent together but at the 11 ½ minute of the dive they became separated as they took different paths round a rock pinnacle. Mr Thwaites' partner lost sight of him. The subsequent review of Mr Thwaites' dive computer showed the rate of his ascent increased rapidly from 6 to 7.5 metres per minute, to greater than 9 metres per minute during the 12th minute of the dive. He went from 12.5 metres to 1.7 metres during that period. He may have briefly reached the surface, as the recording by the dive computer watch is at 30 second intervals.

His partner continued the ascent and thought she recognised him from his distinctive fluorescent dive cap. He was above her, holding onto another boat's anchor line.

For the last 15 metres below the surface there was a strong current and Mr Thwaites' partner proceeded directly to the dive boat, without a safety stop, presuming he was safe. She re-boarded the vessel at 15 or 16 minutes from the commencement of the dive (according to her two dive watches.)

Those aboard the dive vessel Nemo had seen Mr Thwaites' fluorescent dive cap briefly at, or near, the surface of the water a couple of minutes before his partner climbed aboard. They were unaware of any problem and assumed Mr Thwaites actively descended, to continue his dive, or swim below the surface back to the boat. He was between 40-75 metres astern when his fluorescent cap was last seen.

It took some time before there was realisation that Mr Thwaites was not aboard the nearby vessel and was indeed 'missing.' A search was commenced by the second boat in the vicinity while divers from Mr Thwaites' group returned, unaware of these events.

There was no knowledge at the time that Mr Thwaites had become severely impaired and incapacitated and subsequently drowned due to contamination of the compressed air in his cylinder.

It was determined that his second dive cylinder had 2,366 parts per million of carbon monoxide. The recommended upper level is 5 ppm. Increased pressure at depth increases the partial pressure of both the toxic gas and other gases, including oxygen.[3] At 2,366 ppm of carbon monoxide, toxicity would be similar to that experienced from a surface exposure of 6-7,000 ppm.

As Mr Thwaites ascended his oxygen levels decreased and carbon monoxide poisoning effects continued. He lost consciousness at, or near the water's surface. He sank from 1.7 metres to 29.5 metres within around 60 seconds. From the 14th minute of the dive he remained at that level.

The expert evidence of Dr Ian Millar was accepted that Mr Thwaites' situation was irreversible from the point where he started to descend passively. It was not possible for him to be salvaged even if rescued from shortly after he commenced his final descent. The theoretical timeframe was as short as 10 seconds, maybe as long as 30–45 seconds.

Even if rescued prior to his final descent, Mr Thwaites would have been suffering severe carbon monoxide poisoning, and possibly water inhalation and subarachnoid haemorrhage. His survival would not have been guaranteed.

Mr Thwaites' body was recovered the following day on 11th of August 2016 by police divers.

The source of contamination of Mr Thwaites' air cylinder was the electrically powered air compressor owned, operated and maintained by the Underwater Research Group of Queensland Inc. Contamination occurred within the air compressor due to;

[3] Dr Millar Exhibit M2.1

(a) internal production of contaminants from operating temperatures outside the normal parameters and the breakdown of the compressor lubricating oil, coupled with
(b) the ignition of lubricating oil in overheated compressor cylinders.[4]

It was unknown whether the ignition event was of a short or long interval. A short event could explain how one tank might have quite different levels of carbon monoxide to another. The process was similar to 'dieseling.' In the context of an oil cooled electric compressor, if you have hot oil, high temperatures and the right compression, the oil can ignite, creating carbon monoxide and carbon dioxide gas within the compressor.

The expert review of the compressor undertaken by Mr William Hunt identified the following factors associated with the overheating causing production of carbon monoxide within the compressor:

(i) Lack of formal system of appropriate maintenance and monitoring,
(ii) Physical damage to the stage I piston and barrel and the stage II discharge valve housing, caused by overheating,
(iii) Inadequate ventilation of the compressor room,
(iv) Exhausted/inactive filter columns,
(v) Inappropriate fittings in filtration column non-compliant in size and composition,
(vi) Absence of temperature gauge,
(vii) Absence of compressor manuals to guide servicing and maintenance.

Some members of the Club were aware from about 6 August 2016 that the compressor was making an unusual noise, and was not efficiently filling tanks. A 'blown gasket' was presumed. The compressor remained in use on 13 July and was subsequently repaired on 18 July 2016. The compressor was used on 27 July, 1 August and 3 August but ultimately failed and the compressor seized on 8 August 2016.

The members of the club using the compressor to fill their diving tanks had no understanding or appreciation of the potential risk of contamination of air from the poorly maintained compressor.

The members of the club did not reference the Australian Standards applicable to production of breathing air for filling portable cylinders (Australian Standard 3848.)

The members of the Club did not have any mechanism on the premises to test for contamination of tanks filled from the compressor, nor did they pursue external testing.

[4] Mr W Hunt Ex E

The members of the Club undertook all maintenance and repairs of the compressor from within their own membership without independent external technical involvement.

(c) Mr Thwaites died on 10 August 2016.

(d) Mr Thwaites died at Cherubs Cave, Henderson Rock, Moreton Bay in Queensland.

(e) The cause of Mr Thwaites' death was carbon monoxide poisoning causing unconsciousness underwater and drowning.

Coroner's Comments s. 46 Coroners Act 2003

241. **Mr Thwaites' death was tragic and avoidable. It is to be hoped that knowledge of the circumstances of his death will help to prevent another similar tragedy.**

242. The inquest was greatly assisted by the expert advice and submissions provided by Dr Ian Millar, Mr John Lippmann and Mr William Hunt. I will read out some only f the comments relating to public health, and ways to prevent deaths occurring in similar circumstances in the future.

243. **Dr Ian Millar**'s expert evidence as a hyperbaric medicine and specialist in diving medicine was accepted[5]. He has researched and developed expertise in breathing air compressors installed at hyperbaric facilities around the world. Mr Thwaites died due to carbon monoxide toxicity which caused incapacitation and resultant drowning. The primary issue and root cause of his death was contamination of air within the compressor from which he filled his tanks.

244. Dr Millar put forward a number of recommendations aimed to improve safety for divers and reduce the likelihood of death caused by contamination of breathing air. The first was :

(i) **All Breathing air compressors be fitted with a carbon monoxide alarm.** (Handheld carbon monoxide gas analysers are available for between $200- $300. Single use carbon monoxide testing balloons that change colour cost between $10 and $20 each. These are best suited for divers who travel occasionally to locations where they are uncertain of compressed air quality.) Dr Millar suggested if a requirement for carbon monoxide alarms was established, the measurement instrument industry would respond with suitable

[5] Exhibit M2.2

products at reasonable cost. To save lives, carbon monoxide alarms do not need to have the same sensitivity to measure 5 ppm of carbon monoxide as required by periodic hydrostatic air testing of compressed air cylinders. An alarm threshold of 50, or even 100 ppm would be sufficient to prevent death.

(ii) The Australian Standards 3848 for breathing air from compressors should be promoted to inform appropriate selection of compressors fitted with filtration systems designed for breathing air production.

(iii) Compressor systems for production of breathing air should be maintained and repaired by competent persons, trained according to manufacturers' recommendations, and using approved parts.

(iv) There should be targeted information and education about safe use of breathing air compressors, including proper maintenance to prevent contamination. Education is necessary to improve understanding of the very real risks of carbon monoxide contamination. The importance of filling with air from properly installed and operated compressors with filtration equipment which has been properly maintained is paramount. It is suggested that government funding is provided to Divers Alert Network to deliver a targeted education and awareness campaign around the risks and how to improve safety for divers filling their tanks with 'breathable air' from compressors.

Dr Millar suggested –

245. **(v) Registration of all high pressure breathing air compressors. dependent only upon the intended or actual use of the compressor to supply humans with compressed breathing air.**

246. **Mr John Lippmann** is the Founder, Chairman and **Director of Research of Divers Alert Network Asia Pacific, (DAN)** which has 14,000 members, half of whom are based in Australia. Mr Lippmann has forty years of dive experience and is totally committed to improving safety for recreational divers.

247. Mr Lippmann identified many issues in common with Dr Millar, which I will not repeat. Some of the additional comments were :

(vi) Three monthly gas analysis of air from the compressor and also following any modification or repair. These requirements should apply to dive clubs as well as commercial operators and be encouraged for private users.

(v) Testing of at least one cylinder filled at each operation of a breathing air compressor

(vi) Creation of appropriate training/certification system for filling compressed breathing gas tanks for diving

248. Some of Mr Lippmann's comments to improve safety went beyond matters pertinent to establishing the cause or contributing factors in Mr Thwaites's death. It is not implied that these additional matters were causative or contributory to Mr Thwaites' death. They are however safety issues raised in the context of events around Mr Thwaites' death and are included for consideration for that purpose.

(vii) Inclusion of a diver recall procedure in a boat safety or pre-dive briefing

(viii) Encouraged use of written pre-dive briefing checklists to ensure coverage of important information

(ix) Bare boat charterers to provide checklist to hirers detailing what services are provided and what services are not provided, including diver recall procedure. Return of the document signed by the hirer confirms they have read and understood the services provided and they will provide other services necessary to provide safe conduct of the dive.

249. **Mr William Hunt**, provided invaluable technical expertise regarding breathing air compressors based on forty years' experience in the industry, and what can go wrong. He was a member of the Australian Standards Committee which wrote the standard for breathable air when filling portable cylinders. He did not specifically make recommendations.

250. His message was succinct :

(x) There is a longstanding Australian Standard (38348 and/or 2299) for breathing air produced by air compressors when filling portable cylinders. It does not say to whom it applies, it states the quality and standards which must be adhered to for air that is being produced for breathing by humans
……Comply with this standard.

He said-

(xi) Compressors such as the very old Ingersoll-Rand electrical compressor, which was designed to be cooled by air flow around it and lubricant oil within it, can overheat and ignite oil within the compressor, generating contaminants including odourless, tasteless, toxic carbon monoxide.

Finally, Mr Hunt said-

(xii) **If a compressor is not properly configured, filtered, operated, maintained and competently repaired with appropriate parts, there is a risk of such an internal ignition and combustion event. Contamination of the compressed air can occur**.

251. **There are some other issues**, questions and risks raised in the context of these events, **but again, I emphasize not directly relevant to Mr Thwaite's death.**

252. The events of 10 August 2016 occurred on a bare boat charter. On the evidence at the inquest this kind of arrangement appears to be an increasing practice with the decline of numbers of dive shops. There are potential risks to diver safety in such arrangements due to confusion over the applicability of the various legislation (*Safety in Recreational Water Activities Act 2011*, and Regulations; *Work Health and Safety Act 2011*, and Regulations; and Recreational Diving, Recreational Technical Diving and Snorkelling Code of practice 2011).

253. This particular arrangement was considered beyond the jurisdictional scope of Work Health and Safety.

254. On this particular day, there was confusion and ultimately no agreement about which individuals were performing the various roles of dive supervisor, dive master, lookout and associated responsibilities.

255. The diver recall protocol and what might be done if a diver was missing was not addressed.

256. There was no exchange of documentation (electronically) until after the event.

257. In this context it is recommended:

(xiii) that the legislation relating to recreational diving (*Safety in Recreational Water Activities Act 2011* and the *Work Health Safety Act* and Regulations together with the Recreational Diving, Recreational Technical Diving and Snorkelling Code of Practice 2011**) be reviewed.** (six points not read out)

258. **Maritime Safety Queensland reviewed the operations of the charter vessel.** What was not remarked upon in that review was the suitability of the dive vessel which was equipped with a full chain anchor but without a tender.

259. At the end of each of the two dives on 10 August 2016, two divers failed to ascend in accordance with instructions up the full anchor chain. They surfaced some distance from the vessel. On the first occasion, the divers deployed their high visibility buoyancy devices and continued drifting. They were among the last divers to surface and the vessel Nemo was therefore able to pull anchor and retrieve them.

260. Unlike other dive vessels, the chain did not stop at approximately 30 metres with a float attached and then a rope back to the winch. This allows the Skipper or deckhand to leave the site and retrieve divers whilst allowing a position of ascent on the float for divers who may still be in the water.

261. On the second dive, two divers from the charter vessel were retrieved by a second vessel in the vicinity which was already searching for Mr Thwaites while their vessel, Nemo, waited for the return of the rest of the dive group.

262. It is emphasised there is no suggestion that this limitation of the vessel being unable to immediately pull anchor and respond, had any bearing on the circumstances of Mr Thwaites' death. It is however an issue that should be reviewed from the perspective of diver safety. It is recommended that:

(xiv) Dive vessels' capacity to immediately respond to a diver / swimmer drifting on the surface be reviewed. The review should have regard to the availability of a tender and the capacity of the vessel to pull anchor immediately without stranding remaining divers underwater without a line to return to.

263. **Air testing**. It was noted that police testing of air quality from Mr Thwaites' cylinder took the usual turnaround time of about 10 days. It would be helpful if the Police Dive Squad had access to an immediate testing device. This would at least alert them to identify a possible risk promptly, which could be very important for other dovers who could also have contaminated air in their tanks.

(xv) The Police Dive Squad be equipped with suitable initial testing device / capability of air quality, prior to formal testing.

264. **In conclusion**, the most important issue identified following Mr Thwaites' tragic death was the need for education to alert divers of the risk of contamination when filling their cylinders. The risk of carbon monoxide contamination is a lethal risk, and a 'sniff' test will do nothing to alert a diver to the odourless gas. Divers can improve their own safety by informing themselves of the Australian standard for breathable air.

265. Divers should recognise that contamination can come from the external environment, but also from an internal ignition and combustion within an air compressor. This can occur if the compressor is not properly configured, filtered, cooled, and maintained and repaired. This risk can include electrical compressors.

266. A hand held testing device used every time a tank is filled should be part of every diver's equipment and routine. A diver's life depends on the reliability of their air supply underwater.

267. I thank all those who have participated in, and assisted with this inquest.

The inquest is closed.

Christine Clements
Brisbane Coroner
Brisbane
24 July 2018

Appendix 1 - Evidence of Compressor Operators

Evidence from Mr Peter Harrison

1. Mr Peter Harrison was a longstanding member of the Club since 1981. He is a retired electrician. He had 47 years of diving experience and was unaware of any other death having occurred from contaminated air from an air compressor. Over the 36 years he said he was unaware of any other occasion when there was concern regarding the air quality from the compressor.

2. He was president of the Club between 1993 and 1996 and again in the early 2000's for 3 years. He has been the boat captain for the past 21 years.

3. Mr Harrison was the club member directly involved in purchase of the Ingersoll – Rand compressor in 1996, which remained the Club compressor at the time of Mr Thwaites' death. The compressor was purchased at auction for $4000 and had previously been used in a commercial dive shop 'up north'. This influenced Mr Harrison in his decision to purchase the compressor for the club. Mr Harrison assessed it on that history and its construction from cast iron and its appearance. He assumed it was purpose built for breathing air compression as it was sold as a complete system including the filling stations/pipe works. Mr Harrison was not provided with log books or a manufacturer's manual. He made no other enquiry.

4. The Compressor was installed at the club by Mr Lynton Holroyd and another club member who has since passed away. In 2011 the Compressor went under water in the Brisbane River flood. Work was undertaken by Mr Ash Thomas to restore the Compressor to operational service. The Compressor was raised 800 mm above its previous position. It was thought this would improve air circulation around the Compressor. The internal area of the room was increased by 6m³. A high efficiency commercial wall fan was installed which operated while the compressor was working.

5. It was when Mr Thomas attempted to fill those banks that the compressor seized up on 8 August 2016 and did not work again.

6. Mr Harrison was not surprised that there were high carbon monoxide readings from samples taken from these banks after Mr Thwaites' death, given that the compressor had seized up while they were being filled.

7. Mr Harrison voiced the widely held but mistaken belief that there was no risk of carbon monoxide contamination from the compressor prior to it seizing. He said: 'As the compressor was electrically driven and

therefore free from carbon monoxide emissions, only contaminants in the surrounding ambient would be expected to be drawn into the compressor.' The air intake was drawn from outside the compressor shed on a wall backing onto a golf course.

8. Mr Harrison said the Club had a members' meeting each Wednesday during which they could fill their tanks. The compressor would run as required for up to two hours, but often for less than one hour. Mr Harrison explained the nominated compressor operators were members who other members could go to for guidance as to how to fill the cylinders from the compressor. He said it was not the case that member needed to be a nominated compressor operator to fill a tank. Knowledge was required how to start and shut down the compressor and bleed the filters.

9. There was an instruction card on filling procedures fixed to the wall next to the filling station. This was for filling the two cylinders off the 8-clamps. Mr Harrison wrote up that document in 1992 for the original two compressors prior to the purchase of the Ingersoll-Rand in 1996. The instructions remained on the wall as a step-by-step instruction for filling the tanks from the compressor as the procedure was the same. One of the original compresses was also an Ingersoll-Rand.

10. It would take 10-15 minutes to fill each cylinder depending on size, and if two cylinders were being filled together. The cylinders was placed in a barrel of water to keep them cool whilst filling.

11. Mr Harrison said he had very little to do with the maintenance of the compressor but would help on occasions.

12. On 13 July 2016 he said he was filling his cylinders when he heard air escaping from the compressor. He thought it was a gasket which had blown at the first stage of the compressor. The compressor could not be used after this date until it had been fixed. It is noted the tank fill log does not record Mr Harrison's name or signature on that date. Andrew Thwaites' name is written in the left hand column. The signature in the right hand column has been identified as Gary Davis. Nor does Mr Harrison's name appear in the attendance log for 13 July.

13. Mr Harrison said the following Monday, 18 July Ash Thomas rang him to ask him to go to the Club and help him fix it. Mr Thomas told him he had phoned a local business for advice on how to effect repairs. Mr Harrison understood advice had been given to use a high pressure gasket sealing substance in the absence of availability of a correctly sized gasket. Mr Harrison attended and helped Mr Thomas with the gasket repair. They cleaned out the old gasket, cleaned the surfaces up then put a special compound ('glue') in to replace the gasket. He said Mr Thomas had not

used that type of gasket before. (There is no record of either the attendance log on 18 July.)

14. Mr Harrisons' name does appear in the attendance log on 17 July 2016, which was a Sunday. It is the only entry on that day. There is no entry in the tank fill log on that date.

15. Mr Harrison said he was not present at the 20 July 2016 Wednesday meeting. He was in Tenterfield. As far as he is aware the compressor was working that night. (It is noted there are no entries in the tank fill log on 20 July.)

16. Mr Harrison said on 27 July he was present at the meeting. He said the compressor was being used and he did not recall any issues about the compressor that evening. (The tank fill log on 27 July records 5 tanks filled by Gary Davis.)

17. It is noted Mr Harrison's name next appears on the tank fill log on 1 August 2016, a Monday, and he recorded filling 2 tanks. There was no entry on the attendance log, presumably because it was only Mr Harrison in attendance. The next record of Mr Harrison on the attendance log was at the AGM on 3 August.

18. Mr Harrison subsequently stated (via his lawyers) that he used the cylinder filled at the compressor on 1 August when he went diving at Curtain Art Reef in Moreton Bay on 7 October. He suffered no ill effects.

19. Mr Harrison said at the time of Mr Thwaites' death one of Mr Harrison's cylinders still had the air in it from the Club compressor. He said he had another cylinder filled by another compressor, (his own compressor.) (T 4-84) He filled it just before he took the two tanks to be tested. He said he was interested to see how the two tanks compared. He had the air in both of these cylinders analysed at Dive Tech on 6 September 2016. Both results were within normal parameters. He identified the test results of the cylinder he claimed had been filled at the Club as PH1. The cylinder that had been filled elsewhere was tested with results marked P H 2.

20. Both test results had an identical comment:

> 'Distinct odour in sample cylinder Must be cleaned before use.' Mr Harrison said he could not detect the odour referred to.

21. The only variation in results was for carbon monoxide. PH 1, which was said to be the tank filled from the Club's compressor, had a carbon monoxide level of 2 ppm which is within the allowable range. The tank

said to be filled from his home compressor had 0 ppm of carbon monoxide.

22. The levels of carbon dioxide, oxygen and water vapour were identical.

23. Subsequently, on 8 August the compressor seized and stopped working and has not been used since. The club has used a portable compressor and a carbon monoxide analyser to test for carbon monoxide.

24. Mr Harrison said he was not advised of test results of any of the sampling from the Club on 30 August when the search warrant was executed, - only what he had heard from people talking.

25. Mr Harrison confirmed the door between the two sections in the compressor room was usually closed when compressor was being operated due to noise. There was no temperature gauge to enable monitoring.

26. The reliability of Mr Harrison's statement, information to his lawyers and evidence at the inquest were challenged. (This is prefaced by the comment that Mr Harrison had a serious health issue around this time and thought his memory may have been impaired, as well as the passage of time. He had however relied on a personal diary to assist him, as well as a personal dive log.)

27. In the course of further questions Mr Harrison conceded although he usually filled his two tanks at the Club, he also had a home compressor which he sometimes used.

28. He had dates recorded when he filled tanks from his home compressor.

29. His two tanks, which he said he had last filled at the Club on 1 August, had previously been filled at home on an unknown date in July for 60 minutes to 200 bar pressure.

30. The next documented fill from his home compressor was fill number 21 on 5 September 2016. But this referred to his third tank, described as the white one, which was not hydrostatically tested and was reserved for use solely on Mr Harrison's boat.

31. Fill number 22 occurred on 11 October of Mr Harrison's two tanks, described as red / silver. This however was after he said he had used the tank he had filled at the Club on a dive on 6 September.

32. There was therefore no record made by Mr Harrison of what he said occurred, namely between 30 August and 6 September when his two

tanks were tested at Dive Tek , he emptied and refilled one tank at home before taking both tanks for testing. No explanation was provided.

33. Mr Harrison said every time he filled his cylinders at the Club he made a record in the tank fill log. Therefore the only times he filled at the Club between 30 March 2016 and 3 August was on 11 May (road trip) and 1 August.

34. He stated the day to day maintenance of the compressor was generally undertaken by Ash Thomas, checking oil and belts. With respect to any repairs required it was Mr Thomas who would investigate from the Club members who was best skilled to undertake the job. He could recall Alan Dodd, Lynton and Ash Thomas being involved in repairs over the last 12 months

35. After the most recent blown gasket, which he thought occurred on 13 July, he said he helped Mr Thomas with repairs on the following Monday, 18 July. He was not noted in the attendance log or tank fill log on that date, and acknowledged therefore he may have been mistaken with the date. He can recall being asked by Mr Thomas to have a look and thinks it was 13 July by reference to a trip to Tenterfield around that time.

36. His first evidence was they moved the head by a number of millimetres to gain access. Then he said they removed the head, but not the barrel. Then he conceded he could see the top of the pistons, and yes, he could see inside the cylinder and felt the rim. There were no gouges or anything. The information was hard to extract.

37. Mr Harrison was also quite unhelpful with evidence about his two cylinders, which he said he had filled at the Club on 1 August. (That is, after the blown gasket had been repaired, after Mr Thwaites' last entry of filling tanks on 13 July and before the compressor seized on 3, or 8 August 2016).

38. Mr Harrison finally explained that:

- He had been present on 30 August when the police and Workplace Health and Safety attended with a search warrant and inspected the compressor. The police / workplace health and safety specifically raised the possibility the compressor was the problem and Mr Thwaite's had contamination in his tanks;

- He could not remember in the week following the search warrant, first talking with Mr Blackwell from Dive Dive Dive about testing, and being advised to go elsewhere where specific measures could be provided;

- He finally acknowledged , as a member of executive, they sent an email to club members warning them of a potential problem with contaminated air and to cooperate with WHS investigation;

- He emptied one of his two tanks he had filled at the Club on 1 August and refilled it from his home compressor. (There is no entry in his own records reflecting this); and

- He took both tanks to Dive Tek on 6 September to have them tested to make a comparison with the tank he had emptied and re-filled from his home compressor.

39. He denied emptying both, re-filling them and then getting them tested.

40. He could identify which tank had been filled and was re-assured that both tanks had less than the allowable level of carbon monoxide. He said in the tank he identified as filled at the Club, there was 2 ppm of CO, in comparison to none in the tank he had re-filled at his home compressor. All other test results between the two tanks were identical, including the comment by the test company:

> 'Distinct odour in sample cylinder. Must be cleaned before use.'

41. Mr Harrison said he could not detect any odour and so he used the tank that he said had been filled at the Club on 1 August and dived on 6 September with it, reporting no ill effects.

42. He also agreed he had estimated the compressor hours at a guess of 1000 hours when he submitted a charcoal sample for testing from the filter medium. (There was no record of compressor hours he could refer to, only of tank fills.)

43. Mr Harrison steadfastly maintained his personal view that there was no contamination of air from the Club compressor. Even at the time of the inquest he said:

> 'I do not think there was (contaminated air). …My personal view.

44. He was asked:

> 'And you are still of that view?'

45. Mr Harrison said:

> 'Well, it is looking very doubtful, but, you know, we did use that compressor for 20 years, never had a problem. Obviously things

do breakdown, and, you know, I hope it is not–I hope its–but there is no alternative, I do not know.'

46. The impression Mr Harrison gave was that he could not entertain the possibility that the compressor was the source of contamination, because they had never had such a problem before and he had never heard of such contamination from a compressor in forty years. This was despite acknowledging there was:

- No schedule or record of maintenance undertaken (apart from a record of filter change);
- No manual to refer to;
- No testing of air from the compressor for contamination, including carbon monoxide;
- No outside expert servicing of the compressor; and
- Knowledge after the event that Ms Masterman's tanks also had elevated levels of carbon monoxide.

47. The good news from Mr Harrisons' evidence was that the Club had moved forward responsibly and:

- Purchased a hand held carbon monoxide analyser;
- Purchased a portable compressor;
- Undertaken research and development of safety schedules around maintenance and testing of the proposed replacement compressor, including; and
- External testing of compressor sample every 6 months, and compulsory testing of every tank filled at the compressor.

Evidence from Mr Gary Broomfield

48. Mr Broomfield joined the Club in 2013. He provided a statement in September 2017 and consequently stated he had little memory of events. He had not held a committee position at the club. He previously worked as a dive instructor for a commercial diving operator for 7 years. Prior to that he was an electrician for approximately 25 years.

49. He was familiar with filling tanks from his previous work at Nautilus.

50. He was unaware of any diving deaths as a result of carbon monoxide poisoning until Mister Thwaites death.

51. He expressed no concerns regarding the maintenance of the Club's compressor. He said he had thought it was properly maintained and had no reason to be alerted to any issues. However he also stated he had no knowledge how to maintain the compressor.

52. He was a nominated compressor filler because of his previous experience working at Nautilus (dive business). He said the compressor would usually run for an hour or two on the Wednesday Club nights. He confirmed that the temperature was not monitored and you were not able to tell if towards the end of the two hours, the Compressor was getting hot. Mr Broomfield said he would empty the oil and water drains every two tanks. The Club's process on how to use the compressor was very similar to what he knew at Nautilus.

53. He confirmed during his time at the club the storage cylinder banks had not worked.

54. He recalled in 2014 or 15 there was an issue with the gasket.

55. He also recalled an occasion he thought on 6 July 2016 when the compressor was not working to full capacity. It was taking longer than usual to fill his 2 tanks and he notified Ash Thomas who identified a leak. The compressor was shut down and he had not filled tanks subsequently at the club.

56. In his evidence at the inquest of interest it was noted:

- He was unaware of any Australian or New Zealand standards that apply in relation to purity of the air for gas cylinders;
- He confirmed the temperature was not monitored on the Club Compressor;
- He only completed the attendance log 'on and off';
- He always filled in the tank fill log including on 6 July 2016 when he filled 2 tanks, although the entry only records 'July 16';
- He used a cylinder which had been filled at the club on 6 July 2016 for a dive on 17 July at Gold Coast Sea Way. He did not experience any unusual symptoms;
- He had cylinders hydro- statically tested and cleaned in September 2016 at Dive Dive Dive, but was not given the carbon monoxide reading. He presumed the reading was okay. He had his tanks cleaned as well;
- However he acknowledged being told there was an oily smell at the time his tanks were cleaned but he could not detect it;
- He said he stumbled across information on Facebook indicating his tank (pictured) had been analysed for carbon monoxide. He recognised his tanks but was not absolutely certain. He recalled the reading was 63. He thinks that was filled elsewhere but could not say where; and
- He had not provided that information to Work Health and Safety or his solicitors. He said he could not be certain it was his tank.

57. On further examination Mr Broomfield confirmed he was aware there was some suspicion at least surrounding the compressor at the Club.

58. He was aware there was a person who came from the police and Workplace Health and Safety and did a search and had a look at the compressor at the club.

59. He subsequently accepted that he knew about 3 weeks after Mr Thwaites' death that there might be some issues surrounding air from the Compressor. He denied this issue was a specific focus of talk around the Club.

60. The extent of his role in maintenance was changing the filter about 4 years earlier and helping change the gasket the first time it failed in 2014/15. He confirmed any maintenance of the compressor was performed by members of the Club. Ash Thomas had a leading role and he was assisted by other senior members like Linton Holroyd, Peter Harrison, Alan Dodd.

61. He and Gary Davis were probably the more experienced compressor operators.

62. He filled tanks at the club on only 2 occasions between 30 March and 3 August 2016. He said it was a rule that a compressor operator be present when non-authorised people filled. He considered the tank fill record was entirely accurate.

63. He could not describe a maintenance regime for the compressor. He was not involved in maintenance. He did not know whether there were any records of maintenance. He was involved in changing the filter with guidance from Ash. He was unaware of the existence of a manual for the compressor. He was unaware of anyone having a role to check the air quality of the compressor and there was no equipment to do so at the Club.

64. He denied awareness of a brown mist in the compressor room at any time. He confirmed the big 8 cylinders described as the bank were never used whilst he was a member.

65. He said he was involved with the replacement of the gasket, which required taking the head off the compressor. He said he did not look at the cylinders as he is not mechanically inclined.

66. On 6 July he did notice the compressor was not working to its full capacity and told Mr Thomas. There is some uncertainty with the solicitor letter indicating this to Mr Thomas was not told until 13 July.

Evidence from Mr Gary Davis

67. Mr Gary Davis was another of the nominated compressor operators. He works as a manager within the Queensland Police Service. He had previously worked at the Nautilus Dive Centre alongside Mr Broomfield. He had been diving since 1986 and was a member of the club since approximately 2012. At the time of Mr Thwaites' death he had been the vice president for about 1 week and continued until August 2017. He attended most club meetings on Wednesday evenings.

68. He had basic knowledge of compresses and motors but not much knowledge regarding maintenance. He had no previous knowledge of a diver dying from carbon monoxide poisoning. He had been shown by more senior members of the club how to fill tanks.

69. He recalled Mr Thwaites had been shown by a number of people over some weeks how to use the compressor. He had shown an interest in how it operated.

70. He recalled filling his tank on the same evening as Mr Thwaites (13 July 2016). The tank fill log required members to record the total number of tanks they filled. This count was recorded to dictate when the compressor needed to be serviced.

71. Mr Davis had no concerns regarding the compressor and believed Ash Thomas was qualified to deal with the compressor due to his experience as an air conditioning mechanic.

72. He recalled an air leak some time ago which was identified as a blown gasket. He assisted in pulling the head off the compressor. He thought Ash Tomas and Alan Dodd most likely fitted the gasket. There was an earlier similar air leak which had not involved him.

73. He was unaware of any external party maintaining or attending to the compressor. He confirmed the Banks had not been used while he was a member. He filled directly from the compressor.

74. He confirmed he filled tanks on 13 July and 27 July 2016. On 13 July he filled his two tanks after Mr Thwaites. He confirmed the compressor had been shut down and he restarted it. Possibly, the compressor could have been off for up to an hour. He also filled 3 other tanks belonging to other club members.

75. He then dived on 17 July, using 1 tank he had filled on 13 July. That tank was then filled again on 27 July.

76. He used his two tanks (which had been filled, one on 13 July and one on 27 July), on 31 July at Flat Rock and Shag Rock. He understood subsequently that this was before Mr Thwaites' death and before he was aware there was a potential issue about the air from the club compressor.

77. He did not experience any unusual symptoms after these dives. He confirmed he had some air remaining in the cylinders used in these dives. He agreed he became aware at some point of the investigation into the contents of cylinders filled at the club. He was aware of the email sent out by the club to get tanks tested and to assist workplace health and safety with the investigation. (He was a member of the executive at the time.)

78. In his evidence to the inquest Mr Davis disclosed his tanks were taken to Dive Dive Dive. He conceded in his evidence and apologised confirming that if he had asked Dive Dive Dive to test his tanks it would have been due to the carbon monoxide issue, but he could not recall the conversation.

79. He clarified as follows - I dropped them off to get an air fill at some stage when the compressor had broken down. They advised me that one of the cylinders was out of test and I argued with them because it had been tested but had not then stamped. So I dropped them off to be filled before I was aware of the incident. He found out that one needed to be hydrostatically tested. He could not provide the date which would have subsequently been stamped on to his tank at that time. He stated he would send a photo into the Coroner's Court. There is no record that such photo was received.

80. Therefore, he said, he was unable to assist workplace health and safety or the investigation because one of the tanks had been completely emptied and hydrostatically tested. The other had been filled by another compressor.

81. All he could say for sure regarding the number of cylinders filled on 13 July was:

> 'I had 2 of my own cylinders and I ended up with 7. But it is possible that I ended up filling four on that night…… or three, it is likely that I filled more than two'.

82. It was probably 45 minutes to an hour after Mr Thwaites had finished filling when Mr Davis filled tanks.

83. Mr Dodd was a nominated Compressor operator for 2016. He said essentially that Club members (who were not Compressor operators)

were trained to use the compressor and once they were confident in filing the tanks, 'were left to their own devices'. He said that they all knew that if they had any problems, to shut it off and come up and see someone.

84. To the best of his knowledge, since 2011, no one else had ever worked on the Compressor alone without Mr Thomas being present. Mr Dodd knew of one instance (before the 2011 floods) where they had the air quality from the Compressor tested. He confirmed though that there was no testing done after 2011.

Evidence from Mr Alan Dodd

85. Mr Dodd recalled discussing his preference for how the tanks should be filled with Mr Thwaites a long time before his death. His preference was to fill the tanks one at a time, continually changing tanks once they reached a certain temperature. He said this minimised the heat and in this way, the pressure was not dropping. He referred to this as the 'sequential method'. This involved both tanks being connected to the whips, one tank being turned on and the other turned off. He did not see Mr Thwaites filling tanks after that conversation and did not know whether Mr Thwaites had accepted his recommendation.

86. Mr Dodd said that said there was no temperature gauge on the compressor. He said that there was no instruction given about how many hours the compressor should be run because it 'never ran that long'. He said that it rarely ran for up to two hours at a time.

Mr Thomas' evidence in relation to the Compressor

87. A formal claim of privilege was made in respect of evidence provided by Mr Thomas and was granted.

88. Mr Gary Thomas was previously a self-employed electrical mechanic and refrigeration and air conditioning mechanic from 1970 to 2015.

89. Mr Thomas has now retired. Between September 2002 and June 2005, his work included servicing, repairing and maintaining the air conditioning, fresh and exhaust air plant, air compressors, water and waste pumps, and all other machinery at an entertainment facility in Brisbane. Those compressors were not used to fill scuba tanks. Mr Thomas had never been employed to provide breathing air from a compressor.

90. He held current licences in:

- Electrical Workers Licence, Electrical Mechanic, Queensland.
- Electrical Contractors Licence, Queensland
- ARC Refrigeration and Air Conditioning Licence, Australia

91. During 1995-2005 and again between2011-2016 Mr Thomas was a compressor operator for the Club and assisted with the maintenance of the Compressor. He undertook this work in a volunteer capacity for the Club.

92. Mr Thomas did not install the Compressor. He thought this was done by Mr Holroyd, Mr Harrison and another person who was not a Club member. He had very little to do with the maintenance of the compressor prior to an extended holiday commencing in 2005.

93. Mr Thomas denied being in charge of maintenance, he just helped out. He did however take on a leading role with respect to the repairs of the compressor after the 2011 flood. He said that there was no rule that a person could not work on the compressor without his permission.

94. There was no log kept of when there were problems with the Compressor. Mr Thomas described gaskets in the Compressor failing in 2013 and 2014 and making his own gaskets.

95. Mr Thomas said that the people who filled tanks were not only those people who were nominated as Compressor operators. He said there was no rule that there should be one of the Compressor operators in the shed at all times when filling was occurring.

96. Mr Thomas said that the Compressor would commonly run for an hour but this depended on how many tanks were filled. He conceded that the tank fill log indicated that 16 tanks were filled and that the Compressor could have been run for about two hours.

97. Mr Thomas had never read a manual for the compressor prior to Mr Thwaites' death. Mr Thomas said that he had read manuals for an Ingersoll Rand compressor whilst at his previous employment, (which was not running a compressor for breathing air production).

98. Mr Thomas described his maintenance routine with respect to the compressor. He said he would:

    - Check the belts once a month;
    - Check the oil on the first Monday in every month;
    - Change the filters every year or every 400 tanks, which ever came first.

99. Mr Thomas said that he implemented a log of when the filters were to be changed in 2015.

100. He carried out a full service every year. This included rechecking the belts for wear and tear and realigning the belts. He gave everything a bit

of a clean. He would drain the oil completely and then top the oil up. He would ensure the air valves were clean and check the air inlet filter.

101. Mr Thomas states the last service was carried out in September 2015 at which time state of the oil was quite good, honey coloured and there was no smell. He was not aware however that oil can get old and gave evidence to the effect that if the can is sealed, the oil should be ok. Mr Thomas said there was nothing on the Compressor room wall about other people checking the oil levels or checking that it wasn't running too hot. There was no temperature gauge on the Compressor and no way of checking if it was running too hot.

102. The door internal door in the Compressor room was supposed to be kept open at all times [to assist with air flow to the Compressor]. He conceded however, there was no sign on the wall telling Club members to keep the door open, nor did he recall a discussion within the Club's committee to the effect that people should told to keep the door open.

103. Mr Thomas gave evidence that the Compressor:

- Was fitted with four pressure gauges to indicate the discharge pressure;
- Had pressure relief vales on every stage;
- Did not have a pressure maintaining valve, but it had an electric cut out switch, which would shut down the Compressor if the pressure levels were too high;
- Was not fitted with a non-return valve;
- Was not was fitted with a final return valve; and
- Was not fitted with a catalyst (to detect carbon monoxide).

104. Mr Thomas had never tested the air quality from the Compressor. He did not check the Australian Standards or undertake any research on possible dangers relevant to the compressor and breathable air.

105. He had no appreciation of the potential that carbon monoxide could be generated from within a compressor.

106. He said he was led to believe from general conversation within the Club, that carbon monoxide comes from car exhaust fumes. He said that the air intake was from an external wall facing onto the golf course. He was unaware that over time if a compressor gets too hot, there can be a combustion event inside the compressor, causing generation of carbon monoxide within the compressor and contamination of compressed 'air' filling cylinders.