



# Report on Compressor Failure

Sam Walder - Equipment Officer 2017/18

## Outline

On the 10<sup>th</sup> December 2017 the compressor was left running unattended after a club trip – this being standard practice. On the evening of Wednesday the 13<sup>th</sup> I paid a visit to stores as a fire alarm activation had been caused by the compressor. On arrival it was ascertained that the fire alarm had been triggered by atomised oil in the air.

Some time during pumping, an O ring in one of the filling whips had blown out. This meant that the compressor did not reach final pressure and was not shut down. In total it ran for around 85 hours, not far off our typical annual usage.

Appendix 1 of this document contains the text of an email that was sent to the building manager of the SU to explain why our stores had caused an evacuation.

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## Damage

Having run for so long continuously, the filter had become saturated and water and oil from the compressor entered the pipework, manifolds, filling whips and cylinders.

Additionally, the compressor oil was deemed to be unserviceable, the oil filter required changing, and most of the valves in the condensate separator system needed servicing.

## Action taken

Cylinders:



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- The 12 cylinders connected to the system were deemed contaminated and were taken for visual inspection with Bristol Channel Divers. This uncovered an issue with the servicing that was received from DM scuba.

#### Pipework/filling whips/manifolds:

- The pipework and manifolds were disassembled and taken to Bristol Channel Diving Services to be cleaned. The disassembly is surprisingly easy to perform.
- The filling whips were a concern as we were initially unsure whether the oil would have damaged one. Appendix 2 contains the emails with BCD that establish that this is not the case. The whips were cleaned by Bristol Channel Diving Services.
- The filling valves were stripped down, cleaned and serviced with help from Bristol Channel Diving Services

#### Compressor:

- The compressor oil was changed
- The filter was changed
- The condensate separator system was disassembled, cleaned and serviced
- An electronic timer was added that will turn off the compressor after around 2 hours of continuous running

#### Paperwork/signage:

- Fire search plans were affixed to the doors of both stores to indicate the contents of the rooms (Appendix 3)
- A safe system of work was written for the compressor (Appendix 4)
- A log sheet for compressor use was introduced (Appendix 5)
- All operators are now required to have been trained on the BSAC compressor operator SDC

### Costs incurred

Date	Item	Value
15/01/2018	Gift to Bristol Channel	£ 28.00
	Greg's Fuel	£ 20.00
	Bristol Channel	£ 408.79
04/01/2018	Bauer parts (not spare filters)	£ 213.42
09/01/2018	Midland Diving Equipment	£ 44.99
	O rings	£ 18.00
	More O rings	
02/01/2018	Timer	£ 26.19
	Reduced lifetime (transferred to pot 2)*	£ 674.55
		<b>£ 1,433.94</b>

#### Calculation of lifetime cost

According to the [pot 2 calculations](#), we need to put £565.57 a year into pot 2 to pay for the compressor.

The compressor was installed on 2015-09-15. The first logged filter change was on 2017-10-11 with 179.8 hours used on the compressor timer. This is 2.07 years, so 86.69 hours of use a year.



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After the incident, the unit had 307.2 hours of use on it, an increase of 127.4 hours. Some training was conducted, so around 3 hours use a week for the 8 weeks preceding this would be expected. This is 103.4 hours used during the incident – which corresponds to 1.19 years of normal use, or £674.55.

## Linked Files

[www.ubuc.org/maintenance/LogResources/2018/Compressor%20Issue/2018-01-04%20-%20Bauer%20Quotation.pdf](http://www.ubuc.org/maintenance/LogResources/2018/Compressor%20Issue/2018-01-04%20-%20Bauer%20Quotation.pdf)

[www.ubuc.org/maintenance/LogResources/2018/Compressor%20Issue/2018-01-08%20-%20Polymax%20Order.pdf](http://www.ubuc.org/maintenance/LogResources/2018/Compressor%20Issue/2018-01-08%20-%20Polymax%20Order.pdf)

[www.ubuc.org/maintenance/LogResources/2018/Compressor%20Issue/2018-01-09%20-%20MDE%20Invoice.pdf](http://www.ubuc.org/maintenance/LogResources/2018/Compressor%20Issue/2018-01-09%20-%20MDE%20Invoice.pdf)

[www.ubuc.org/maintenance/LogResources/2018/Compressor%20Issue/2018-02-15%20-%20Bristol%20Channel%20Diving%20Invoice.pdf](http://www.ubuc.org/maintenance/LogResources/2018/Compressor%20Issue/2018-02-15%20-%20Bristol%20Channel%20Diving%20Invoice.pdf)

[www.ubuc.org/maintenance/LogResources/2018/Compressor%20Issue/MDE%20Air%20Filter%20Instructions.pdf](http://www.ubuc.org/maintenance/LogResources/2018/Compressor%20Issue/MDE%20Air%20Filter%20Instructions.pdf)

[www.ubuc.org/maintenance/LogResources/2018/Compressor%20Issue/O-rings%20in%20the%20filling%20whips.pdf](http://www.ubuc.org/maintenance/LogResources/2018/Compressor%20Issue/O-rings%20in%20the%20filling%20whips.pdf)



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## Appendices

### Appendix 1 – Email to SU building managers

From: [sam.walder@bristol.ac.uk](mailto:sam.walder@bristol.ac.uk)

To: [nicola.kerry@bristol.ac.uk](mailto:nicola.kerry@bristol.ac.uk), [andrew.williams@bristol.ac.uk](mailto:andrew.williams@bristol.ac.uk)

CC: [committee@ubuc.org](mailto:committee@ubuc.org), [committee@bristolsta.com](mailto:committee@bristolsta.com), [henry.bromell@bristol.ac.uk](mailto:henry.bromell@bristol.ac.uk)

Subject: Fire alarm activation 13/12/2017 Richmond Building

Body text:

Hi Both

We just wanted to feedback on the fire alarm in the Richmond Building last night.

Henry was present in the Winston Theatre and became aware of a pre-alarm activation, and began the fire searching process. On confirming the location of the activation as the UBUC diving stores he phoned myself and Greg, aware that we had more knowledge of this area. He also advised us that the compressor was running.

I advised that we were both on our way, and that he should ensure that the evacuation was complete due to the presence of pure oxygen and compressed air in the store, in addition to fuel in the adjoining boat store. En route I phoned the security services emergency number to ensure there was an awareness of the substances that were potentially at risk. Unfortunately, the security desk could not get beyond "We are aware of the alarm and are responding". Eventually we decided we would arrive on site quicker than the message would reach the security officers.

On arriving, I depressed the emergency stop on the compressor and we were able to quickly ascertain that there was no fire. We believe an "O-ring" failed on an air cylinder while it was being filled from the compressor. It is standard practise to set 12 cylinders filling and leave the compressor running until the cylinders are full, at which point the compressor shuts down automatically. Because of the failed seal, the compressor never reached shut down pressure, and as such we believe it had been running for around 3 days. Normally it runs for 1.5-2 hours. Due to this extended run, we believe the air filter has become saturated and caused water and oil to pass into the cylinders. Coupled with the increasing temperature the oil eventually burned off internally and we believe this is what activated the fire alarm.

We have identified a number of issues following this incident:

1. Firstly, all signage was removed from the outside of the store room during the car park re-painting and had not been re-installed. Signage warned of compressed gas (2), oxidising agent (5.1), and fuel. This meant that neither Henry, as a fire warden, nor the estates assistant or security officer were aware of the potential danger when entering the store.
2. I found on arrival that the emergency stop for the compressor had not been operated. Talking to Henry, the estates assistant, and present security officer, all were unaware of the availability of an emergency stop button.
3. We were made aware during the compressor's service last month that it did not have a timer cut-off installed. If this had been the case the compressor would have shut down after a specified amount of time regardless of pressure. This was due for installation within the next month, as such it is very unfortunate that this has occurred now, after over 2 years of successful operation.



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These issues present some opportunities for improving our practices to help prevent such an issue occurring in the future:

1. The signage detailing the contents of the stores needs to be reinstated immediately – this is of use mostly to the fire service in the event of a real fire.
2. We should implement signage aimed at estates assistants and security personnel giving details of the location of the emergency stop switch as well as information on what to do when fire searching this area.
3. An automatic time based cut off should be installed before reinstating the compressor to prevent further damage to equipment.

You may be interested in the impact of this on diving safety – as we are bound to comply with certain regulations, all of the affected equipment will require inspection and servicing by qualified agents of the manufacturers. As such, though an inconvenience, this incident will not impact on diving safety.

The feedback from the rest of the building fire wardens was excellent, as far as we are aware all procedures for the evacuation of the swimming pool, theatre etc. went to plan. Given it has been some time since our last out-of-hours evacuation we were very pleased.

Kind regards

Sam Walder, UBUC Equipment Officer, STA

Henry Bromell, STA

Greg Quick, UBUC, STA



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## Appendix 2 – Emails with Bristol Channel Diving Services

From: [equipment@ubuc.org](mailto:equipment@ubuc.org)

To: bristolchannel1@aol.com

Subject: Compressor contamination advice

Body text:

Dear recipient,

I spoke to Neil on the phone earlier about the compressor at the University of Bristol Underwater Club's store room. I promised I would send through some photos in regards to this.

Would you mind passing this email along to Neil as I don't seem to have his direct email address?

The photos show:

- Corrosion on one of the manifolds. This appears to be ionic corrosion due to the dissimilar metals.
- The mix of oil and water that has been run through the system as a result of the filter saturation. This has been drained into a bucket.
- General photos of the system from various points of time. You should just about be able to see the plumbing from this.

As discussed, your thoughts on the corrective measures to take in regards to oil that will be in the hard plumbing would be very helpful.

All the best

-Sam

Hi Sam

OK I think the corrosive nature of the fluid has eaten the rubber centre of the Dowty washer on the four hose block, and that is good and bad news.

The good news is that I don't think it has done any damage to the metals, however an inspection will guarantee this.

It does appear however to have had an effect on the rubber in the seal, hence the leak and stain. The hard plumbing is in sections with compression joints connecting each piece up, that means it can be split down and put in a car for cleaning 🐼.

The hard plumbing, valves, and other metal fittings can all be cleaned.

The bad news is that the corrosive fluid may very well have damaged the internal lining of the 12 hoses so it would be wise to replace them unfortunately, as it is not possible to inspect them internally !

This more so now I have seen the effect the fluid has had on the Dowty seal.

Let me have your thoughts.

Best regards

Neil



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Hi Sam

Me again !

Send me any "operating instructions" you had out to the compressor operators and I will review it ASAP

before the shitstorm hits

ATB

Neil

Hi Neil,

Thank you for all the information!

With regards to the 'corrosion' on the block, a closer inspection I believe shows some more good news. What I has thought was corrosion did not match with what any of our materials people, and a closer look shows it not to be. It is actually where oil and water has come through a very small leak (which over 3 days did not seem all that small) and has then dried out. This tallies with the deposit left all over the cylinder that had the blown out O-Ring. Photos of all of this attached.

On the whips... if that is the case that would be a shame. I have done a bit of digging to try and make sure on this aspect. I am quite sure now that the block did not have corrosion on it. Checking the compressor information it is filled with oil type N28355. The MSDS for this (here) suggests that the oil is very forgiving. The only material that is suggested could be a problem would be PVC (page 4 of the MSDS). What are your thoughts on this?

Great news on all the pipework. I had a look at where all the fixings are and there is just the one piece of pipe that is a bit big. Should be manageable though.

I want to try and get the bits that we need to replace on order this week if I can. I was going to at a minimum get a stack of filters for everything that needs them, new oil (as a precaution) and new whips/whip service kits. What are your thoughts on the whips now? If we did not need whole new whips am I best getting the service kits through Bower or do you know a better supplier?

Ah, "operating instructions"... well this is something we have not been very good on thus far (hence our current predicament). We don't have a formal training system currently, but people should be able to see the records here: <http://ubuc.org/maintenance/Manual.php?id=cp003> and the manual for the compressor here: <http://ubuc.org/maintenance/Resources/PE-TE-F02-0110E.pdf>. Unsurprisingly I will not be putting together a slightly more thorough safe system of work. I will send these over to you as I create them.

With regards to the cylinders and such, would you be able to quote me for 12 visual inspections plus 2 air purity tests (and anything else you can think of that we need). 2 purity tests as I think it would be wise to test the single and double filtered air sides of the system. We are having a good bit of "fun" sorting out our finances for this.

When would be a good time for us to come down for a day? I can only really do things in the new year now as I am away until about the 27th.



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Many thanks once again for all your help and advise!!

Best regards

-Sam

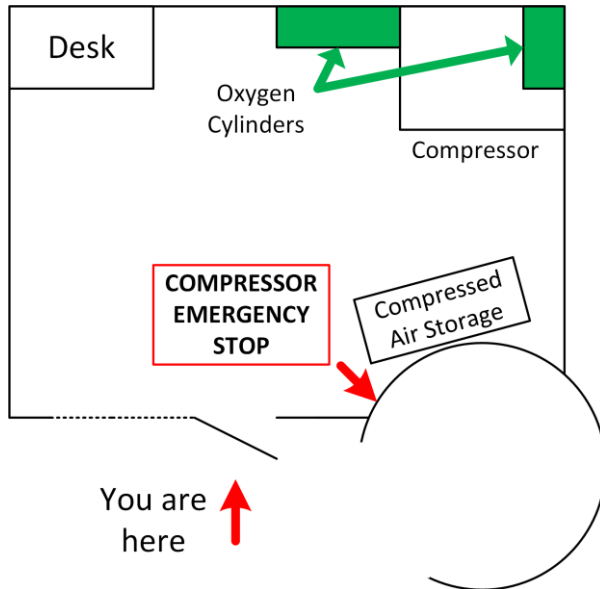
P.S.

I have cleaned the filter vessel and changed the filter on the compressor so that I could blow a bit of clean air through the pipework to blow out some of the oil/water mix. I think we managed to get a reasonable bit of it out, which is probably good for things.



# Underwater Club Stores

## Floor Plan



## Emergency Access

- Keys available from Richmond Building Estates Assistants
- Call Security Services 0117 311 1223

## Contacts

- Underwater Club equipment officer [equipment@ubuc.org](mailto:equipment@ubuc.org)
- Underwater Club committee [committee@ubuc.org](mailto:committee@ubuc.org)

## FIRE/EMERGENCY INFORMATION

- Large amount of high pressure air stored
- High pressure oxygen
- Rotating machinery
- Hot surfaces
- Loud machinery
- Chemical storage
- Significant electrical supply

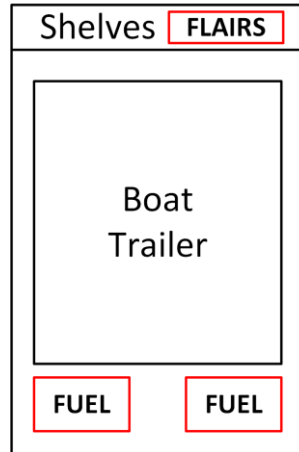


## Fire Searching

- Use normal UoB fire search practice
- Check for signs of fire through vents **above this sign**
- Operate compressor **E-stop** if possible
- If fire is suspected keep **well clear**
- Ensure the area above this store is evacuated

# Underwater Club Boat Stores

## Floor Plan



You are  
here

## Emergency Access

- Keys available from Richmond Building Estates Assistants
- Key is also hung behind
- Call Security Services 0117 311 1223

## Contacts

- Underwater Club equipment officer  
[equipment@ubuc.org](mailto:equipment@ubuc.org)
- Underwater Club committee  
[committee@ubuc.org](mailto:committee@ubuc.org)

## FIRE/EMERGENCY INFORMATION

- Petrol storage
- Marine flairs stored



## Fire Searching

- Use normal UoB fire search practice

## Appendix 4 -Safe System of Work

# Safe System of Work for Compressor Operation

<b>Task/activity</b>	Using the compressor for charging of compressed air and enriched air diving cylinders
<b>Date written</b>	December 2017
<b>Review date</b>	December 2018
<b>Responsible person</b>	UBUC Committee Members
<b>Location/main use</b>	The compressor is situated in the Underwater club stores in the car park of the Richmond Building
<b>Protection of others</b>	For the protection of others the operator must ensure that anyone in the room at the time the compressor is running is supplied with PPE appropriate for the length of time spent in the room.
<b>Emergency procedures</b>	<ul style="list-style-type: none"> <li>• Operate the emergency stop switch (just inside door to stores) if safe to do so.</li> <li>• Isolate electrical supply by switch on wall if safe to do so.</li> <li>• Contact emergency services: <ul style="list-style-type: none"> <li>○ University of Bristol Security Services 0117 331 1223</li> <li>○ Emergency services 999</li> </ul> </li> </ul> <p>There is a first aid kit in stores on the shelves. If this cannot be located first aid can be obtained from the estates assistants at the Bristol SU reception.</p>
<b>Competency of operators</b>	<p>All compressor operators must have signed and read this SSOW.</p> <p>All compressor operators must have had appropriate training which must have been shown to, and recognised by, the club's equipment officer.</p> <p>The operator may request the help of any other person familiar with the compressor, however the operator must remain on site.</p>
<b>Personal protective equipment</b>	Per NIOSH REL any persons using the compressor would need approximately 4 hours exposure to reach 100% of their daily noise dose limit. However, there is a risk of failure of seals/hoses that would be very loud. Therefore, any person(s) using the compressor for 4 hours or more MUST use hearing protection and it is highly recommended that any person(s) present in the room while the compressor is running uses hearing protection.
<b>Plant and equipment</b>	<ul style="list-style-type: none"> <li>• Compressor</li> <li>• Cylinders</li> <li>• Filling whips/manifolds</li> </ul>

<b>Materials, storage and safety information</b>	<ul style="list-style-type: none"> <li>Oil The compressor oil is contained within the main block of the compressor and there is spare oil stored on the shelves. Though not considered harmful users should be careful in handling so as not to create fire or slipping risks. More information can be found in the <a href="http://ubuc.org/maintenance/Manual.php?id=cp003">Material Safety Datasheet</a></li> <li>Waste condensate The waste condensate collected should be treated as waste oil</li> <li>Filter cartridges Waste filter cartridges should be treated as contaminated with waste oil</li> </ul> <p>For long term storage information refer to the manufactures guide: <a href="http://ubuc.org/maintenance/Manual.php?id=cp003">http://ubuc.org/maintenance/Manual.php?id=cp003</a></p>
<b>Inspection and maintenance</b>	<p>The compressor is subject to a written assessment by HSE every 5 years. A full service, organised by the committee, is carried out annually which includes inspection. Air is tested every 3 months (minimum). Operators must check the hours timer prior to starting the compressor as well as visually and audibly inspecting the compressor for basic issues.</p> <p>Maintenance details are recorded here: <a href="http://ubuc.org/maintenance/Manual.php?id=cp003">http://ubuc.org/maintenance/Manual.php?id=cp003</a></p>

## Critical Stages

1	<b>Information and instruction:</b> All users must have signed and read this method statement. All operators must have undertaken an approved training course
3	<b>Inspection:</b> A pre-use inspection should be carried out by the operator, where necessary in consultation with the operator's manual. Checks include: <ul style="list-style-type: none"> <li>Run hours</li> <li>Filter hours remaining</li> <li>Listen for leaks</li> <li>Check condition of hoses</li> <li>Check waste condensate and dispose of as appropriate</li> </ul> <p>In the event of an defects being discovered, isolate machine, label 'NOT IN USE' and report to the club committee.</p>
4	<b>PPE:</b> Ear defenders must be worn if operation will be for >4 hours a day. It is highly recommended that ear defenders are worn at all times
5	<b>Connect cylinders:</b> <ul style="list-style-type: none"> <li>Check cylinder test is in date before connecting, if in doubt do not fill</li> <li>Open cylinder valve briefly to blast out any moisture</li> <li>If cylinder is completely empty <b>do not fill</b>. Mark cylinder out of use/remove valve handle and report to committee</li> <li>Check cleanliness of filling whip and cylinder valve</li> <li>Connect cylinder to whip.</li> <li>Open valve on whip.</li> <li>Open valves on cylinders slowly. Do not allow a cylinders to be filled or drained too quickly</li> <li>Ensure all manifold valves are open. Open these slowly.</li> </ul>



	<ul style="list-style-type: none"><li>• Listen for any leaks before starting compressor</li></ul>
6	<b>Start compressor:</b> Turn on the power to the compressor and push the run button. Listen for leaks during filling.
7	<b>Stop compressor:</b> Compressor will stop automatically when final pressure is reached. The compressor can be stopped before this using the stop button. Compressor should be checked after 1.5 hours to ensure it has turned off. Check for leaks once filling has finished, and check pressure of cylinders to ensure all have been pumped.
10	<b>Accident, near misses and dangerous occurrences:</b> Any incidents occurring when using the compressor MUST be reported to the club committee.

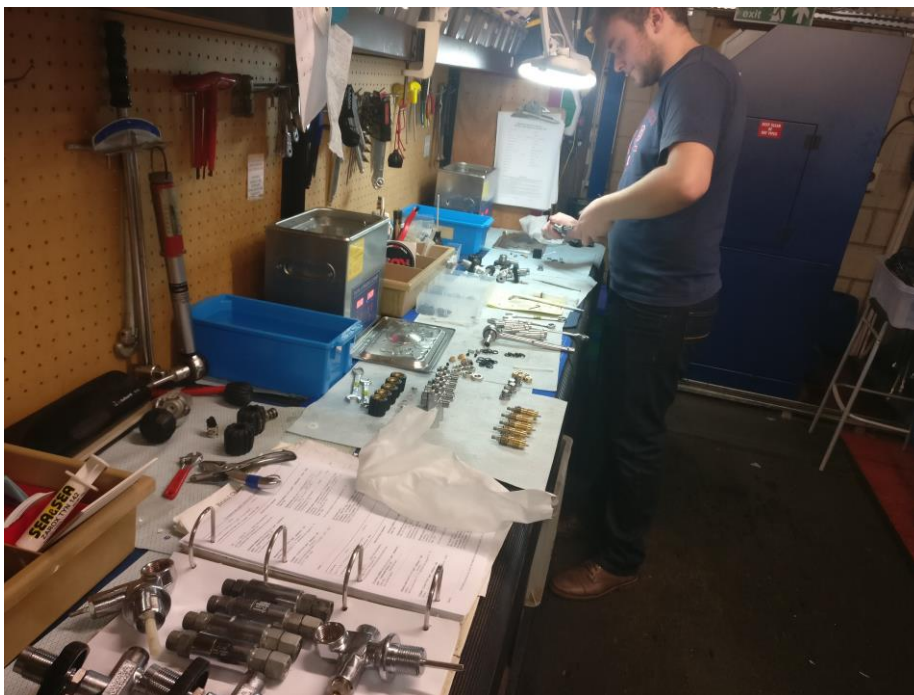
## Appendix 5 – Compressor Log Sheet

[illegible]

## Appendix 6 – Photos



Figure 1 - Disassembled cylinder filling valve



*Figure 2 - Greg helping the service the filling valves at Bristol Channel Diving Services*



*Figure 3 - The cylinder on which the O-ring failed. Note that it was in the DIN to A-clamp adaptor that the O-ring failed*





Figure 4 - the state of the filling station after removing the parts



Figure 5 - A bucket catching the drips from the filling whips



*Figure 6 - The inside of the valve from the cylinder on which the issue occurred*



*Figure 7 - Residue surrounding a leak on one of the manifolds*



Figure 8 - another shoot of the oil residue



Figure 9 - Photo showing the water in the manifold blocks