TESTED Dive Lab® Panama City Beach Florida

Diamond Topside Exhaust System Operations Manual

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The Tables/Settings are also available on the Kirby Morgan website

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⚠ DANGER

This word indicates an imminently hazardous situation, which if not avoided, will result in death or serious injury.

⚠ WARNING

This word indicates a potentially hazardous situation, which if not avoided, could result in death or serious injury.

! CAUTION

This word indicates a potentially hazardous situation, which if not avoided, may result in minor or moderate injury. It may also be used to alert against unsafe practices.

NOTICE

This word indicates a special attention or required action for basic operation.

IMPORTANT: A word about this manual. We have tried to make this manual as comprehensive and factual as possible. We reserve the right, however, to make changes at any time, without notice, in prices, colors, materials, equipment, specifications, models and availability. Since some information may have been updated since the time of printing, please contact Dive Lab if you have any questions. Periodically Operations and Maintenance Manuals are reviewed. Any updates/ changes will be posted on the Dive Lab website and may be downloaded for insertion/correction.

If you have any questions concerning this manual or the operation, contact the Dive Lab Inc. (850) 235-2715 or at divelab@divelab.com

⚠ WARNING

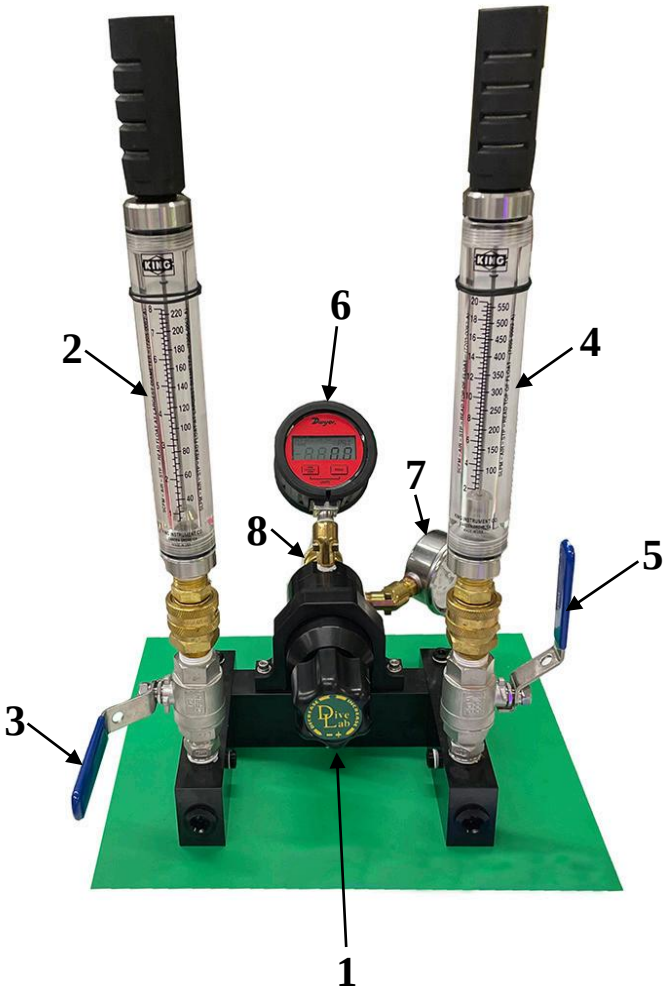
Diving with compressed breathing gas is a hazardous activity. Even if you do everything right there is always the potential for serious injury or death. No one piece of diving equipment can prevent the possibility that you may be injured or killed any time you enter the water. The information in this manual is intended for users of Kirby Morgan helmets and persons that maintain or service Kirby Morgan helmets.

TABLE OF CONTENTS

ABBREVIATIONS

ATA - Atmospheres Absolute
ALPM - Actual Liters Per Minute
BAR - Pressure of 14.5 psig
B.P. - Back Pressure
CFM - Cubic Foot per Minute (One Cubic Foot = 28.3 Liters)
FSW - Feet Sea Water
HEO2 - Helium Oxygen Mix
LPM - Liters Per Minute
MBR - Millibar is a Measurement of Pressure (68 mbr = 1 psig)
MSW - Meter Sea Water (One Meter = 3.28 Feet)
PSIG - Pounds per Square Inch
RMV - Respiratory Minute Volume / Also known as Ventilation Rate (The number of breaths per minute x the breathing volume)

NOMENCLATURE



1. Back Pressure Regulator Control Knob
2. 40-100 LPM Flow Meter
3. 40-100 LPM Flow Meter On/Off Valve
4. 100-500 LPM Flow Meter
5. 100-500 LPM Flow Meter On/Off Valve
6. Digital Pressure Gauge
7. Analog Pressure Gauge (Backup)
8. Return Line Hose Quick Connect, from Umbilical (Backside of Regulator)

INTRODUCTION

The Kirby Morgan Diamond Umbilical Supplied Deep Sea Diving Helmet was originally designed for surface supplied umbilical diving use in contaminated water.

The Diamond Helmet with return line can offer a higher level of protection, than helmets that exhaust into the water. The Diamond can also be used for diving in clean controlled water systems, where contamination from the diver's exhaust cannot be tolerated. This would include potable water systems, as well as highly refined water systems, such as those found in powerplants. Lastly, the Diamond can also be used for saturation diving, where the reclamation of the divers HEO2 breathing mixture is necessary, for reconditioning and re-use.

The Diamond when used for surface supplied air diving, vents all exhaust to the surface via a non-collapsible 5/8" I.D. surface return hose up to 300 feet in length. Unlike conventional in-water exhaust, the Diamond has a two-stage exhaust regulator that controls and routs the divers' exhaled gas into the return line umbilical and up to the surface. The helmet exhaust works due to the differential pressure between the diver at depth, and the surface.

DIAMOND THEORY OF OPERATION SURFACE SUPPLY AND RETURN

The basic concept of the exhaust system is simple, the first stage of the exhaust regulator has a flexible composite rubber/stainless-steel diaphragm. As the diver exhales, the first stage exhaust diaphragm rises off its seat, allowing the exhaled gas to enter the second stage exhaust cavity. In the second stage cavity, the diaphragm is sealed tightly against a tapered sealing surface, containing multiple pie shaped exhaust veins along with a bias assist spring that assists the progressive, controlled peeling away of the second stage diaphragm, allowing gas to exit into the surface return hose.

The second stage exhaust diaphragm instantly re-seals, when the first stage no longer sees a positive pressure during exhalation. The supply pressure requirements for air diving have been based around the diver being able to breath at the extreme work rate of 75 RMV in accordance with EN-15333-1. And 62.5 RMV, in accordance with the US Navy requirements. For optimal overall inhalation breathing performance, the normal recommended supply pressure will provide the best inhalation performance at low and moderate work rates and will meet the requirements of EN15333-1 at 75 RMV. Using a significantly higher supply pressure than the normal recommended, should only be used when the diver is working at the extreme work rates >60 RMV.

DIAMOND HELMET RECOMMENDED SUPPLY PRESSURES

Depth		Supply Pressures	
fsw	msw	bar	psig
0 - 50	0 - 15.2	6.9	100
50 - 100	15.2 - 30.5	10	145
100 - 130	30.5 - 40	12	175
130 - 165	40 - 50.3	15.2	220
165 - 200	50.3 - 61	15.5 - 17.2	225 - 250

SATURATION DIVING USE

Diamond return line helmet can also be used for mix gas saturation bell diving. When used for saturation diving, its use is primarily intended to allow the breathing gas to be reclaimed for re-use. However, unlike surface supply air diving, when used for mix gas bell diving the main supply and exhaust umbilicals are usually kept at 50 meters or less in length. When used for bell diving, the system is integrated with a bell exhaust system, which regulates the exhaust differential at 20-30 psig (1.4 bar). Compared to the surface supply, air diver can have a differential pressure as great as 75 psig (5 bar). The information herein primarily deals with surface supply air diving.

SURFACE RETURN UMBILICAL

The Diamond uses a 5/8 I.D. urethane plastic return umbilical. This umbilical works well due to its non-collapsing ridged construction with smooth interior and exterior making cleaning and decontamination easy. For surface supply diving down to depths of 165 fsw (50 msw), using up to 300 feet (91 meters) of return line umbilical, with the topside back pressure exhaust system. When diving to depths of 100 fsw (30 msw) or less - up to 500 feet (152 meters of return line can be used.

TOPSIDE EXHAUST SYSTEM

As mentioned previously, the primary purpose of the topside system is to minimize exhaust pressure in the helmet to prevent inadvertent activation of the open circuit exhaust. This topside system is required, when diving to depths greater than 100 fsw (30 meters), due air density and differential pressure. The topside system can be used starting at the surface, with the back pressure regulator backed out fully, and the 220 lpm flow lined up. Once the diver reaches a depth of approximately 30 fsw (9 msw), the 0-220 lpm flow meter can be used to monitor the divers work rate. The accuracy of the system increases with depth. To determine the divers work rate, the topside operator adjusts the back pressure regulator in, or out, according to the *Diamond Back Pressure/Exhaust Flow Table*. The table starts at 10 fsw and goes up in 10 fsw increments to 200 fsw. In addition to fsw, the table also shows meters sea water (msw), as well as atmospheres absolute (ATA). Across the top of the table from left to right is the Respiratory Minute Volume (RMV) which starts at 8-10 RMV and goes out to 72-75 RMV. To use the topside

exhaust system, the topside operator will note the divers' depth and average flow, on the selected flow meter, and then adjust the back pressure as necessary according to table.
Note: T*he maximum depth of the system based on 75 RMV work rate is 170 fsw (52 msw). The maximum depth of the system based on 62.5 RMV is 200 fsw (61 msw)*. Each diver requires a complete separate topside control system.

TOPSIDE EXHAUST BACK PRESSURE COMPONENTS

The divers exhaust umbilical connects to the topside back pressure regulator via a ½" brass quick connect, which is in turn attached to the inlet side of the regulator. As the divers' exhaust enters the back pressure regulator, it is blocked by a spring-loaded bias valve assembly. The bias valve works by simply blocking the air flow from the umbilical, until the pressure is great enough to overcome the spring set pressure, and allow air to flow to the flow meter isolation valves. Both a 100 psig digital, and 100 psig analog pressure gage show the return line umbilical set pressure. The digital gauge has a full-scale accuracy of 1% and therefor used as is the primary gage. The mechanical analog pressure gauge has a full-scale accuracy of 2% and is a backup to the electronic gage. Either gauge may be used.
The regulator outlet feeds both the 40-220 and 100-550 lpm flow meters. The 40-220 lpm flow meter should be used anytime the maximum flow is less than 200 lpm. Once the divers' flow exceeds 200 lpm, the 100-550 lpm flow meter should be used. One flow meter should be lined up at all times, whenever the exhaust umbilical is connected. In addition to reading lpm, the flow meters also show output in Standard Cubic Feet per Minute (SCFM).
For optimal exhaust performance (minimum exhalation effort), the topside exhaust back pressure is set according to the Diamond Back Pressure/ Exhaust Flow Table, based on the flow meter in use. Turning the regulator knob in, clockwise increases back pressure, turning the knob counterclockwise decreases back pressure.

OPERATION

As an example, a diver at a depth of 110 fsw (33.5 msw) working at the extreme breathing rate of 75 RMV without using the topside back pressure control system, would have an exhalation pressure in a range of + 14-16 mbr. With the proper back pressure, it would be in the 6-8 mbr range. Exhausting into the water in a contaminated water situation is not desirable and defeats the purpose of a surface return exhaust system.
The topside exhaust control system must be capable of controlling the exhaust pressure based on the divers' depth and respiratory rate.
If diving to depths of 100 fsw (30msw) or less the topside back pressure system is not needed. However, the topside unit can be used if desired once the diver's depth is deeper than 20 fsw. When the diver is at depths shallower than 30 fsw, accuracy of the flow meters is not reliable, especially at light to moderate work rates. Once the diver is deeper than 40 fsw, the accuracy greatly improves. The 0-220 lpm flow meter will generally work well to depths of approximately

100 fsw, providing the breathing RMV is less than 50. At higher work rates the 0-550 lpm flow meter should be used.

USING THE BACK PRESSURE TABLE

The table was designed to allow the topside operator to keep the divers exhalation pressure as low as possible. To achieve this, the table was developed using a breathing simulator. The table is based on a maximum breathing respiratory minute volume of 75 RMV.
The 75 RMV - represents extreme work that could probably not be sustained by most fit divers for more than a minute, when working underwater, especially when deeper that 60 fsw (18msw). In developing, the table testing started at the maximum recommended air diving depth of 170 fsw (6.15msw), starting at 75 RMV and working down to 10 RMV. At 170 fsw (52 msw), the optimum back pressure reading from the digital depth gauge is between 55 and 60 psi. At the next lower work rate the back pressure remains the same, however as the work rate decreases, so does the required back pressure reading. As mentioned previously, the main purpose of the back pressure for a given depth and work rate, is to minimize exhalation effort to prevent exhausting into the water. By matching the back pressure to the divers' depth and flow in LPM, exhaust pressure will be very low.

EXAMPLE

Example, a diver is at a depth of 106 fsw (30 msw), the exhaust flow on the 0-550 lpm flow meter, shows a flow bouncing between 180 to 215 lpm. The console Operator then checks the Table and selects the closest depth to the divers' actual depth, which would be 110 fsw, then slowly adjusts the regulator for a back pressure between 34 - 39 psig, as shown on the Table. Once that pressure is achieved, the Operator will recheck the flow once more, to make sure nothing has changed. This average flow is the actual air being breathed by the diver. This can be read as scfm or slpm, however breathing rate is always calculated in liters per minute. Breathing rate, also known as respiratory minute volume (RMV), is the size of the breath multiplied by the number of breaths per minute.
To compute the RMV, simply divide the average flow by the depth in atmospheres (ATA's)from the depth section. This will give you the basic RMV rate that the diver is doing. For even greater accuracy in determining the RMV, the topside Operator can take the high average flow and low average flow, add them together then divide by 2, which gives the average flow then divide this by the depth in ATA's.
Adjusting for optimal back pressure based on depth and flow optimizes for low exhalation effort. In addition, the flow meter system allows for the simple calculation of the divers' respiratory work rate, which can be useful for planning air usage. As previously mentioned, the topside back pressure exhaust system is not necessary for minimizing exhaust pressure at depths less than 100 fsw (30 msw). However, it can be used starting at depths of 30-40 fsw to monitor the divers RMV and to calculate air usage.
The exhaust pressure table for the Diamond Helmet is used for optimal performance of the Diamond exhaust system.

DIAMOND BACK PRESSURE/EXHAUST FLOW TABLE

Operating Instructions

Diamond Back Pressure/ Exhaust Flow Table

Step 1
Determine depth

Step 3
Find the closest matching flow reading from the table

110 / 33.5	4.33	Flow LPM	45 - 65	85 - 110	115 - 150	150 - 185	180 - 235	230 - 290	280 - 350
		BP (psig)	26 - 28	30 - 32	31 - 35	32 - 36	34 - 39	36 - 41	37 - 41

Step 2
Take the average reading from your flow meter. Example is 180 to 210. The average flow is 195

Step 4
Recommended Back Pressure regulator setting

DIAMOND HELMET RECOMMENDED SUPPLY PRESSURES

Depth		Supply Pressures	
fsw	msw	bar	psig
0 - 50	0 - 15.2	6.9	100
50 - 100	15.2 - 30.5	10	145
100 - 130	30.5 - 40	12	175
130 - 165	40 - 50.3	15.2	220
165 - 200	50.3 - 61	15.5 - 17.2	225 - 250

ABBREVIATIONS / COLORS

ATA – Atmospheres Absolute
FSW – Feet Sea Water
LPM – Liters Per Minute
MSW – Meter Sea Water
RMV – Respiratory Minute Volume

FORMULAS

(Depth + 33) ÷ 33 = ATA
FSW ÷ 3.28 = MSW
LPM ÷ ATA = RMV
To calculate RMV with the greatest accuracy, simply take the highest and lowest flow reading, add them together, then divide by 2. Take the result and divide by the divers' depth and ATA's

* For Air Diving to the maximum depth of 200 fsw (61 msw)
NOTE: When diving in the depth >170 fsw (51.8 msw), the Divers' respiratory work rate (RMV), should **not** exceed 63 RMV

** At this Depth and RMV flow accuracy cannot be accurately determined

Please check Divelab.com website for any updates

DIAMOND BACK PRESSURE/EXHAUST FLOW TABLE (CONTINUED)

Depth fsw/msw	ATA	BP-Back Pressure (psig) LPM-Liters Per Minute	RMV 10-15	RMV 20-24	RMV 30-34	RMV 37-40	RMV 48-50	RMV 60-63	RMV 73-75
10 / 3	1.3	Flow LPM	n/a**	n/a**	n/a**	40 - 60	35 - 90	55 - 105	70 - 120
		BP (psig)	n/a**	n/a**	n/a**	1 - 2	1 - 2	1 - 2	1 - 2
20 / 6.09	1.60	Flow LPM	n/a**	n/a**	35 - 65	40 - 80	55 - 100	80 - 120	105 - 135
		BP (psig)	n/a**	n/a**	1 - 2	1 - 2	1 - 2	2 - 3	3 - 5
30 / 9.1	1.90	Flow LPM	n/a**	30 - 55	50 - 75	55 - 90	75 - 110	100 - 130	115 - 160
		BP (psig)	n/a**	1 - 2	2 - 3	2 - 3	3 - 4	3 - 5	4 - 6
40 / 12.2	2.21	Flow LPM	10 - 40	40 - 60	45 - 80	70 - 95	90 - 125	120 - 150	140 - 180
		BP (psig)	2 - 3	3 - 4	4 - 5	4 - 6	5 - 7	6 - 8	7 - 9
50 / 15.2	2.51	Flow LPM	15 - 45	50 - 70	70 - 85	85 - 105	110 - 135	140 - 170	170 - 200
		BP (psig)	3 - 4	4 - 6	5 - 7	5 - 8	7 - 9	8 - 13	9 - 13
60 / 18.3	2.82	Flow LPM	25 - 45	55 - 70	75 - 95	95 - 120	125 - 150	155 - 185	190 - 230
		BP (psig)	5 - 7	7 - 9	9 - 10	9 - 12	11 - 14	11 - 14	15 - 18
70 / 21.3	3.12	Flow LPM	30 - 45	65 - 80	85 - 105	110 - 130	135 - 170	170 - 210	200 - 250
		BP (psig)	7 - 8	10 - 13	13 - 14	13 - 17	15 - 18	15 - 20	16 - 20
80 / 24.4	3.42	Flow LPM	35 - 50	70 - 85	90 - 110	120 - 145	150 - 190	185 - 225	225 - 275
		BP (psig)	11 - 13	14 - 16	16 - 18	17 - 19	18 - 22	20 - 23	21 - 24
90 / 27.4	3.72	Flow LPM	35 - 55	75 - 95	100 - 125	125 - 155	150 - 200	200 - 245	245 - 300
		BP (psig)	17 - 20	21 - 24	22 - 25	24 - 28	26 - 30	27 - 31	27 - 33
100 / 30.5	4.03	Flow LPM	40 - 60	80 - 105	110 - 135	135 - 170	170 - 220	220 - 260	260 - 330
		BP (psig)	22 - 24	25 - 28	28 - 31	28 - 32	29 - 33	33 - 36	31 - 37
110 / 33.5	4.33	Flow LPM	45 - 65	85 - 110	115 - 150	150 - 185	180 - 235	230 - 290	280 - 350
		BP (psig)	26 - 28	30 - 32	31 - 35	32 - 36	34 - 39	36 - 41	37 - 41
120 / 36.6	4.63	Flow LPM	56 - 65	90 - 120	120 - 155	150 - 200	200 - 250	250 - 320	300 - 380
		BP (psig)	29 - 32	32 - 35	34 - 37	35 - 40	37 - 43	39 - 44	39 - 45
130 / 39.6	4.93	Flow LPM	50 - 75	95 - 130	130 - 170	165 - 210	210 - 270	270 - 340	320 - 400
		BP (psig)	32 - 35	36 - 40	39 - 42	39 - 43	42 - 47	44 - 48	44 - 50
140 / 42.7	5.24	Flow LPM	55 - 80	100 - 135	145 - 170	170 - 220	220 - 290	280 - 350	340 - 425
		BP (psig)	33 - 35	38 - 41	40 - 44	42 - 45	43 - 48	45 - 50	45 - 51
150 / 46	5.55	Flow LPM	55 - 80	110 - 145	145 - 190	170 - 240	230 - 310	300 - 380	355 - 450
		BP (psig)	37 - 40	41 - 44	44 - 47	43 - 49	47 - 51	50 - 56	50 - 57
160 / 49	5.84	Flow LPM	55 - 75	110 - 150	150 - 195	190 - 250	240 - 320	310 - 390	370 - 470
		BP (psig)	38 - 41	42 - 45	43 - 45	45 - 50	48 - 51	49 - 54	51 - 58
165 / 50.3	6	Flow LPM	60 - 85	115 - 155	155 - 205	195 - 260	245 - 330	320 - 410	380 - 480
		BP (psig)	41 - 43	44 - 48	47 - 50	49 - 53	50 - 55	53 - 59	54 - 60
170 / 51.8*	6.15	Flow LPM	60 - 90	115 - 160	160 - 220	200 - 270	250 - 340	330 - 410	400 - 500
		BP (psig)	42 - 46	45 - 48	47 - 52	50 - 54	51 - 57	55 - 60	55 - 60
180 / 55*	6.45	Flow LPM	50 - 100	90 - 165	150 - 240	230 - 290	270 - 360	350 - 430	430 - 540
		BP (psig)	38 - 45	43 - 49	45 - 52	48 - 53	52 - 58	57 - 62	62 - 68
190 / 58*	6.76	Flow LPM	50 - 100	95 - 170	160 - 230	230 - 290	290 - 390	360 - 450	440 - 550
		BP (psig)	36 - 42	42 - 47	46 - 52	49 - 56	52 - 61	58 - 65	65 - 70

NOTE: Yellow Shaded Table Area - Use 100-550 LMP Flow Meter