Appendix
Breathing Gas Requirements
EXO Balance Regulator Full-Face Mask

If you have any questions regarding proper set-up, operation, or maintenance of your Kirby Morgan mask contact KMDSI (850) 928-7772 or at kmdsi@KirbyMorgan.com or Dive Lab Inc. (850) 235-2715 or at Divelab@aol.com. There are also detailed checklists for the set-up and maintenance of your mask on the Dive Lab web site at www.divelab.com.

8.2 Regulator Performance

8.2.1 EXO-BR® Regulator

The EXO-BR® regulator on the EXO Full-Face Mask offers high performance. The regulator has been tested at Dive Lab at Panama City, Florida. It meets or exceeds all current U.S. Navy and European diving standards.

8.2.2 Minimum Operating Temperature

The minimum operating temperature recommended for this regulator for surface supplied diving is 33 degrees F and for scuba is 37 degrees F, only in regards to regulator performance. At the time of this writing, no hot water shroud is available for this mask for heating the diver's breathing gas.

Without a hot water shroud, the diver may be subject to hypothermia due to cold gas inspiration temperatures. Kirby Morgan makes no physiological recommendations regarding minimum safe operating temperatures for divers using this mask.

⚠ WARNING

Diving in cold water, i.e., at temperatures below 50 degrees F, may subject the diver to severe respiratory heat loss. This may lead to a decrease in body core temperature also known as "hypothermia." Hypothermia is extremely dangerous and can lead to a loss of reasoning ability, decreased manual dexterity, uncontrollable shivering, unconsciousness, and death.

8.3 Cage Code

The cage code for identifying KMDSI products for U.S. government purposes is 58366.

8.4 CR Standards

These masks meet or exceeds all standards established by Dive Lab of Panama City, Florida, and is CR (Commercially Rated) marked.

8.5 CE Approved

The EXO-BR is CE Approved.

8.6 Operational Specifications & Limitations for Surface-Supplied Diving

-Umbilical minimum I.D. 3/8" (9.5 mm) of not more than two sections, total length not to exceed 600 feet (183m).

This mask meets or exceeds all requirements of NPD, HSE (UK), US Navy and US Coast Guard. It is CE certified and CR rated by Dive Lab, Panama City, FL, USA.

⚠ DANGER

Decompression diving always involves the risk of decompression sickness. Omitted decompression due to a loss of the breathing gas supply or other accidents can cause serious injury or death. Use of a Kirby Morgan helmet or mask cannot prevent this type of injury.

8.6.1 Using the EXO-BR Regulator with a Low Pressure Compressor Supply

The EXO-BR Regulator Low Pressure Compressor Supply Pressure Requirements table in this manual are designed to assist you in selecting the proper compressor for the depths at which you plan to work and for the work load at which you will be working. In physiological terms, work load is normally defined in terms of exercise rate. Exercise rate is normally determined by heart rate and may also be defined by your breathing rate. The higher your heart rate and the higher your rate of breathing, the harder you are working. For a highly fit diver, the limiting factor in how hard you can work underwater is how much breathing gas your mask will supply.

For practical purposes, the U.S. Navy defines breathing work rates in terms of "RMV" which stands for Respiratory Minute Volume." RMV is defined as the amount of breathing gas that flows in and out of your lungs in one minute.

Work Rate Expressed as Respiratory Minute Volume (RMV)*			
Work Load	**RMV**	**Cubic Feet/Minute (CFM)**	**Equivalent Land Based Exercise**
Rest	7-10 RMV	0.2 - 0.35 CFM	
Light Work	10-20 RMV	0.35 - 0.7 CFM	Walking 2 miles per hour
Moderate Work	20-37 RMV	0.7 - 1.3 CFM	Walking 4 miles per hour
Heavy Work	37-54 RMV	1.3 - 1.9 CFM	Running 8 miles per hour
Severe Work	55-100 RMV	1.94 - 3.5 CFM	
** source: U.S. Navy Diving Manual*			

Users should ensure that the compressor or supply system meets both the supply pressure and output volume required for the deepest anticipated depth and ventilation rate. Below is the formula used for computing the volume of air being used at a given ventilation rate at depth.

Note: This is the bare minimum. As a safety margin, it is best to plan on an additional 10%-20% of breathing gas to ensure the supply system can keep up.

{(Depth + 33) ÷ 33} x RMV} x .10 or .20 safety margin.

Best Practice:

- When using a LP compressor always base the output pressure on the lowest pressure during compressor cycling.
- Complete a flow test of the compressor / air system and all umbilicals at least once a year and/or whenever in doubt as to the capability.
- Always take the standby diver into consideration when planning air usage.

- Always allow for at least 10-20% greater volume than what is needed for the maximum ventilation anticipated.

• Never use less than 40 RMV for planning purposes.
• Always dive with a fully functional man worn emergency gas supply system (EGS) of sufficient capacity based on the hazards of the task, have the cylinder valve open and the emergency valve shut.
• When using HP supply systems (Control Consoles) use the recommended pressures for depth as listed in the table for High Pressure Regulators Settings found in this chapter. For best overall performance avoid using pressures excessively higher than what is required for depth especially if diving shallow.

If using umbilicals longer than 600 feet, or umbilicals with an internal diameter less than 3/8" (9.5mm), or other configurations not mentioned, E-mail or call KMDSI or Dive Lab, Inc., for further guidance and information.

8.6.2 Using the EXO-BR Regulator Low-Pressure Compressor Supply Pressure Requirements Table

To use this table, you must know your compressor's maximum pressure output, the diver's maximum planned depth, the volume of gas the compressor is capable of pumping, and the diver's anticipated work load. These tables are **NOT** designed for use with the Kirby Morgan SuperFlow 350 or 450 regulators.

SCFM stands for "Standard Cubic Feet Per Minute" and is a measure of the volume of air the compressor delivers. This measurement is made at sea level. SLPM is an abbreviation for Standard Liters Per Minute and is the metric equivalent of SCFM.

Example #1: You are using a 5120 compressor with a maximum output pressure of 200 p.s.i.g. A Quincy 5120 compressor is designed to deliver 88.5 cubic feet of free air at 200 p.s.i.

You know you will be doing a long job, positioning sand bags for a pipeline crossing at a depth of 160 FSW. Look in the table at the left hand column and find the maximum pressure output for your compressor, i.e, 200 p.s.i. You will see that at 200 p.s.i.g. the compressor will supply sufficient air to maintain 40 RMV at depths down to 220 FSW, with a sufficient volume of air.

Example #2: You plan to use a 325 compressor with a maximum output pressure of 150 p.s.i.g. A Quincy 325 delivers 19.20 cubic feet of free air at 150 p.si.

To carry sandbags for a pipeline crossing at a depth of 160 FSW, although the 325 would provide sufficient air for the diver to perform work at 40 RMV, it would not provide the recommended safety margin of 10%-20%. If your work load increased to 50 RMV, the compressor would not be sufficient to support that work load and would leave you feeling starved for air.

Remember that if a decompression chamber is on the same circuit as the diver, the diver will be starved for air if the chamber is blown down while the diver is in the water. Whenever possible, there should be at least one air source devoted to diving operations and a separate air source used solely to operate the decompression chamber.

Once the diver begins to consume air faster than the compressor can supply it, the diver will feel starved for air. This is a very dangerous situation underwater.

⚠ WARNING

The EXO-BR Regulator® Low-Pressure Compressor Supply Pressure Requirements tables presented in this manual are intended for use with properly adjusted and maintained KMDSI® EXO Balanced Regulator Full-Face masks only. None of the KMDSI® supply tables have been evaluated on other makes of masks and should not be used with other manufacturers' helmets or masks.

⚠ WARNING

To properly supply the diver with breathing air, the mask as well as the umbilical and associated supply system must be properly configured, maintained, and adjusted.

EXO-BR Regulator® Low-Pressure Compressor Supply Pressure Requirements Table*					
Supply Pressure Surface Gauge Reading	RMV (Respiratory Minute Volume)	Maximum Recommended Depth		Required SCFM**	Required SLPM**
		FSW	MSW		
90 P.S.I.G . (6.21 BAR)	40 (heavy work)	104	32	7.0	198
	50 (heavy work)	76	23	7.0	198
	62.5 (severe work)	61	18.8	7.5	212
	75 (severe work)	50	15.4	8.0	227
100 P.S.I.G. (6.9 BAR)	40 (heavy work)	108	33	7.25	205
	50 (heavy work)	90	27	7.9	223
	62.5 (severe work)	75	22.9	8.7	246
	75 (severe work)	59	18	8.9	252
110 P.S.I.G. (7.59 BAR)	40 (heavy work)	117	35	7.7	218
	50 (heavy work)	100	30	8.6	244
	62.5 (severe work)	83	25	9.3	263
	75 (severe work)	68	21	9.7	275
120 P.S.I.G. (8.28 BAR)	40 (heavy work)	127	38.7	8.2	232
	50 (heavy work)	113	34	9.4	266
	62.5 (severe work)	93	28	10	283
	75 (severe work)	75	23	9.7	275
130 P.S.I.G. (8.97 BAR)	40 (heavy work)	145	44	9.1	258
	50 (heavy work)	125	38	10	283
	62.5 (severe work)	106	32	11	311
	75 (severe work)	85	26	11.36	322
140 P.S.I.G. (9.66 BAR)	40 (heavy work)	160	48	10	283
	50 (heavy work)	135	41	11	311
	62.5 (severe work)	114	35	12	340
	75 (severe work)	92.5	29	12	340
150 P.S.I.G. (10.35 BAR)	40 (heavy work)	170	52	10.5	297
	50 (heavy work)	149	45	11.7	331
	62.5 (severe work)	126	38	13	368
	75 (severe work)	105	32	13.3	377

The above values were derived from actual breathing simulator tests using an ANSTI wet simulator with 600' long umbilical 3/8'' I.D (9.5mm) at Dive Lab, Inc. The respiratory work rates and test procedures used are based on internationally recognized test practices and procedures.

*** includes a 20% safety factor*

Note: Most sustained work rates by professional divers average between 20 to 40 RMV. When calculating supply requirements, KMDSI® recommends using no less than 40 RMV.

EXO-BR Regulator® Low-Pressure Compressor Supply Pressure Requirements Table*					
Supply Pressure Surface Gauge Reading	RMV (Respiratory Minute Volume)	Maximum Recommended Depth		Required SCFM**	Required SLPM**
		FSW	MSW		
160 P.S.I.G . (11.04 BAR)	40 (heavy work)	186	57	11.3	320
	50 (heavy work)	157	48	12.2	345
	62.5 (severe work)	134	41	13.4	379
	75 (severe work)	112	34	14	396
170 P.S.I.G. (11.73 BAR)	40 (heavy work)	203	62	12.2	345
	50 (heavy work)	170	52	13	368
	62.5 (severe work)	143	43	14	396
	75 (severe work)	121	37	14.9	422
180 P.S.I.G. (12.42 BAR)	40 (heavy work)	219	67	13	368
	50 (heavy work)	180	55	13.7	388
	62.5 (severe work)	158	48	15.4	436
	75 (severe work)	130	39	15.7	445
190 P.S.I.G. (13.11 BAR)	40 (heavy work)	220	67	13	368
	50 (heavy work)	192	58	14.5	411
	62.5 (severe work)	165	50	16	453
	75 (severe work)	141	43	16.8	476
200 P.S.I.G. (13.80 BAR)	40 (heavy work)	220	67	13	368
	50 (heavy work)	205	62	15.3	433
	62.5 (severe work)	174	53	16.7	473
	75 (severe work)	147	45	17.4	493
210 P.S.I.G. (14.49 BAR)	40 (heavy work)	220	67	13	368
	50 (heavy work)	214	65.8	16	453
	62.5 (severe work)	186	56	17.6	498
	75 (severe work)	159	48	18.5	524
220 P.S.I.G. (15.18 BAR)	40 (heavy work)	220	67	13	368
	50 (heavy work)	220	67	16.3	462
	62.5 (severe work)	194	59	18.2	515
	75 (severe work)	165	50	19	538

The above values were derived from actual breathing simulator tests using an ANSTI wet simulator with 600' long umbilical 3/8'' I.D (9.5mm) at Dive Lab, Inc. The respiratory work rates and test procedures used are based on internationally recognized test practices and procedures.

Note: Most sustained work rates by professional divers average between 20 to 40 RMV. When calculating supply requirements, KMDSI® recommends using no less than 40 RMV. For more information, check the Dive Lab website, www.divelab.com

⚠ WARNING

It is important for the user/diver to take excessive currents into consideration. The exhaust system on the EXO-BR® Regulator will help prevent water intrusion when diving in heavy currents. The EXO-BR® exhaust system does not limit the diving depth.

The umbilical assembly should be composed of good quality diving hose that meets industry standards. Generally, gas hose will be married to the communications wire, pneumofathometer hose, and strength member in a manner that will allow the strength member to receive all the strain.

There are also good quality umbilicals available that are assembled at the factory using a twisted method which does not require marrying. Regardless of the system used, the umbilical is the diver's life line and should always be of excellent quality and maintained carefully.

If you have any questions regarding proper set-up, operation, or maintenance of your Kirby Morgan mask contact KMDSI (850) 928-7772 or at kmdsi@KirbyMorgan.com or Dive Lab Inc. (850) 235-2715 or at Divelab@aol.com.

8.6.3 Using a High-Pressure Breathing Gas Supply

High pressure (HP) control consoles are capable of suppling air or mix gas at pressures and volumes much greater than low pressure air compressors, and are often preferred by military and and scientific divers. HP air systems are often used as back up supply for LP compressor diving.

When using HP air or mix gas systems, The regulator is normally loaded to 100-150 psig on the surface and increased to the bottom setting as the diver descends or when the diver reaches the bottom. During ascent the pressure is reduced to between 100-150 p.s.i.g. once the diver is shallower than 100 feet. A high-pressure gas supply is typically used under the following conditions:

- When the work load exceeds the capabilities of the compressor to supply a sufficient volume and pressure of breathing gas, regardless of the depth.
- When the diver is using pre-mixed gas.
- As a back-up for a low-pressure compressor
- Any time a high-pressure supply is available

The regulator is loaded as the diver increasingly descends and unloaded as the diver returns to the surface. If the diver experiences a free-flow with his regulator, when the bias adjustment knob is properly set and the regulator has been maintained correctly, the pressure setting on the high-pressure regulator setting may be too high and may need to be decreased.

⚠ WARNING

The demand regulator and side block assemblies have a maximum design pressure of 225 p.s.i.g. (15.5 bar) over-bottom. Higher pressures could lead to component failure and serious personal injury.

⚠ WARNING

Gas systems used to supply Kirby Morgan helmets and masks must be capable of supplying gas to the diver at the required pressure and flow rates as stated in the operational specifications. The use of unregulated gas sources is extremely dangerous.

The use of standard SCUBA type regulators is unacceptable, as there are no provisions for adjusting the intermediate pressure to the diver. Only proven systems that allow for varying the gas supply pressure to the diver should be used for umbilical diving.

The following table provides recommended pressures when using a high-pressure breathing gas supply and dome loaded regulator. Generally speaking, the topside regulator should be set at 140 p.s.i.g. over bottom pressure for optimum regulator performance.

Topside High-Pressure Regulator Settings for use with the Kirby Morgan EXO-BR Regulator®

Depth		Regulator Setting P.S.I.G.		Regulator Setting BAR	
FSW	MSW	Optimum P.S.I.G.	Maximum P.S.I.G.	Optimum BAR	Maximum BAR
0-60	0-18	140	200	9.7	13.8
61-100	19-30	165	220	11.4	15
101-132	31-40	190	250	13	17
133-165	41-50	275	300	19	20.7
166-220	51-61	300	320	20.7	22