SCUBAPRO

UWATEC

i300 DEEP

Smart MICROBUBBLE MANAGEMENT

ADAPTIVE COMPUTERS

Smart PRO Wrist

UWATEC dive computers have long included the Bühlmann ZH-L8 ADT mathematical model that allows the computer to adapt to actual diver behaviors and environmental conditions. The name of the model was derived from ZH - Zurich where the model was developed, L8 refers to the number of body tissue groups that the model considers and ADT is short for 'adaptive'.

With an adaptive model, if a diver exceeds the prescribed ascent rate, works too hard, or is exposed to really cold water, the dive computer may ask the diver to complete a compensation decompression stop. Another advantage of the adaptive model is that it allows UWATEC dive computers to more accurately predict the remaining gas requirements on deep dives and it provides more accurate monitoring of the CNS loading for Nitrox divers.

UWATEC has now proven that divers who conduct repetitive dives even within the standard no decompression limits produce microbubbles. Microbubbles may be a precondition for the formation of larger bubbles that can lead to decompression illness. Microbubbles usually present no visible symptoms to the diver, but may cause permanent damage. Divers with a PFO (Patent Foramen Ovale - a hole between the two chambers of the heart) are particularly susceptible.

With two additional letters, the Bühlmann adaptive model has been expanded to be called the ZH-L8 ADT MB. This stands for microbubble, because the UWATEC Smart can be programmed for microbubble suppression.

Smart PRO Console

Smart COM

The Smart COM displays the cylinder pressure, calculates and displays the Remaining Bottom Time (RBT), and warns when RBT is less than 3 minutes.

- Displays tank pressure - psi (bar)
- Remaining dive time at current depth (RBT)
- User adjustable tank reserve warning
- Low air warning
- Quantity of air used
- RBT is less than 3 alarm
- RBT less than 0 alarm

GAS CONSUMPTION

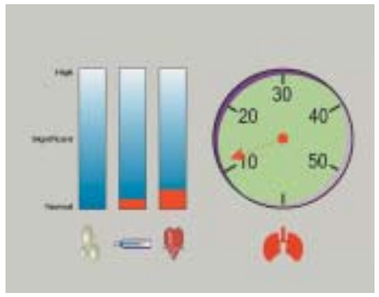
On deeper dives, divers need to carry sufficient gas reserves to ascend and complete any necessary decompression stops.

The Smart COM displays a Remaining Bottom Time field, which is an estimate of the time remaining at the current depth until an ascent must be commenced. Once the ascent commences, the Smart COM has already included a prediction of the gas reserves necessary to ascend at the prescribed ascent rate and complete the necessary decompression stops. The baseline for the RBT is the "tank reserve value" which can be set via Smart TRAK in 5 bar increments between 20 and 120 bar. An RBT of 0 means that if an ascent is commenced at that time and carried out at the correct ascent rate, respecting all decompression stops, the diver will be on the surface with approximately the tank reserve left in the tank.

The calculation is based on the diver's current rate of gas consumption, temperature and the current tank pressure and starts 1.5 minutes after the start of a dive. It is updated every 4 seconds. The computer accurately modifies the Remaining Bottom Time according to variations in the diver's rate of breathing. If the diver is experiencing heavy exertion, then the RBT is reduced. If the diver is relaxed, then the RBT is extended.

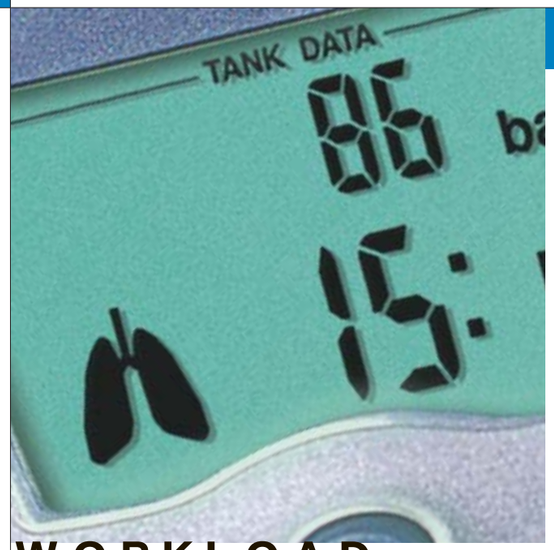
The accuracy of this calculation is due to the pressure sensor's ability to accurately measure a single breath of air. The accuracy is further enhanced because it considers the ambient temperature and air pressure is affected by ambient temperature variations. This is particularly useful for a diver who is diving through thermoclines.

At the conclusion of a dive the Smart COM displays the "differential pressure". This value represents the gas that is consumed during the dive. Also displayed are any warnings that may have occurred throughout the dive, in this example both RBT and Workload warnings are displayed.



After a dive, the data from the Smart COM can be downloaded to Personal Computer with the Smart TRAK software that is included with the Smart COM. The actual rate of breathing is displayed in l/min, as is the workload level. Also displayed is microbubble buildup and temperature.

The Smart COM considers the effect that exertion has on the decompression schedule. When the lung symbol appears the diver should relax the breathing rate.



WORKLOAD

Some dive computer models assume an average workload throughout the dive. However, an unfit diver, for example, who is working hard at depth will breathe more heavily.

Even fit divers sometimes find themselves working hard in situations such as swimming against a current or removing an anchor that is stuck under a rock.

In such high workload circumstances the diver can absorb more nitrogen, particularly in the muscle tissue groups. This additional uptake of nitrogen, in turn, is exposing the diver to a greater risk of microbubble formation and the possibility of decompression sickness.

The Smart COM understands that different divers have different levels of fitness and different levels of exertion on different dives. The Smart COM can actually influence a diver who is working hard, to reduce the level of exertion, by relaxing and breathing more slowly.

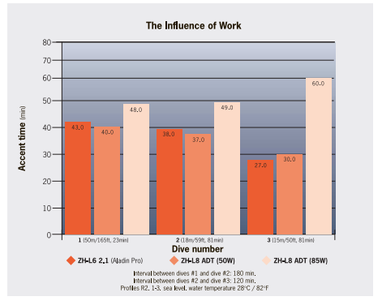
The Smart COM can do this because it is accurately monitoring the diver's rate of air consumption and changes in the rate of air consumption.

If a diver persists in working hard at depth the Smart COM may ask the diver to complete an additional decompression stop.

With Smart TRAK the sensitivity of the breathing rate warning is adjustable according to the diver's level of fitness.

- High breathing rate alarm (High Air Consumption)
- Adaptive decompression model Bühlmann ZH-L8 ADT MB
- CNS clock is adjusted by O_2 uptake according to workload
- User adjustable air workload warning
- Workload is displayed in Smart TRAK

With the Smart TRAK software that is supplied with the Smart COM, the sensitivity of the workload setting can be set by the diver according to their own level of fitness.



Earlier mathematical models assumed a mean workload output of 50W. With the ZH-L8 ADT MB model, even at level 0, if workload is increased to 85W then on a (15m) 50ft dive the ascent time is increased from 30 to 60 mins.

The Smart PRO and Smart COM include the effect of temperature on the decompression schedule and display both the ambient and water temperature.

TEMPERATURE

- Displays ambient temperature, on the surface
- Measures and displays water temperature
- Includes temperature in decompression model
- Logs temperature (dive computer)
- Logs temperature (Smart TRAK)

The human body likes to maintain a core temperature of (37°C) 98°F and it has strategies such as shivering (involuntary muscle activity), to help maintain that temperature in cold situations.

Diving in cold water causes vasoconstriction, i.e. a reduction of blood flow to arms and legs in favor of the main organs, in an attempt to conserve body heat. The skin is the tissue that is most affected by this. Vasoconstriction does not take place right away since the diver starts with a uniformly warm body. So, nitrogen absorption in the skin at first is normal. As the diver ascends and starts offgassing, vasoconstriction is now limiting the process.

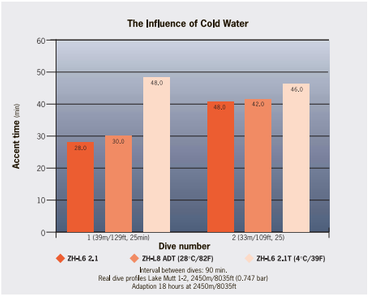
So, diving in cold water makes the diver more susceptible to microbubble build up in the skin tissues and the possibility of "skin bends".

The Smart computer is constantly monitoring and displaying the ambient temperature and is considering the temperature in the calculation of the decompression schedule, with the objective of minimising skin bends.

For example, in normal dives, the spinal tissue is usually considered as the first tissue to affect the decompression schedule. However, when it comes to diving in cold water the Smart considers that the skin is the most important tissue.

As a consequence, for a diver in cold water, the Smart may suggest a shorter no-decompression schedule, or in the case of a decompression dive, longer decompression stops.

A diver can view the whole temperature profile of a dive with the Smart TRAK software and a Personal Computer.



On a cold water dive a fixed model advises a 28 minute ascent, whereas the ZH-L8 ADT MB advises a 48 minute ascent. On the second dive the skin tissues, which were the leading tissues at the end of dive 1, are already relatively cold at the beginning of the dive so they have a slower speed. Hence the smaller difference in total ascent time.

Smart can provide a visual warning to the diver to take an advisory level stop and reduce microbubble formation.

6 microbubble levels ▶	L0	time min:sec	L1	time min:sec	L2	time min:sec	L3	time min:sec	L4	time min:sec	L5	time min:sec
3m/10ft	1st	6.00	2nd	7.00	3rd	8.00	3rd	9.00	3rd	10.00	4th	13.00
6m/20ft			1st	3.00	2nd	5.00	2nd	5.00	2nd	7.00	3rd	10.00
Level stop 9m/30ft					1st	1.00	1st	2.00	1st	5.00	2nd	7.00
12m/40ft											1st	6.00
15m/50ft												
Max Depth [30m/99ft] / 16 min — Total Ascent time		9.00		13.00		17.00		19.00		25.00		39.00

The above table demonstrates what sort of level stop profiles can occur for a diver on the second of two "repetitive" dives. The first dive is to (30 m) 99 ft for 16 minutes and the second dive follows a surface interval of 1 hour and 49 minutes and is also for 99 feet and 16 minutes. To demonstrate the likely level stops a diver could expect for the 2nd dive, at various levels of microbubble suppression, UWATEC Engineers "dived" 6 UWATEC Smart Dive Computers with no suppression for the first dive, while computers 2 to 6 were set at the 5 different levels of microbubble suppression on the second dive. At level 0 the 6 minute stop at (3 m) 10 ft is actually a decompression stop, which is mandatory. While this is actually displayed separately on the UWATEC Smart Dive Computer's screen, for convenience we have included this 6 minute stop in the final stops in the above table.

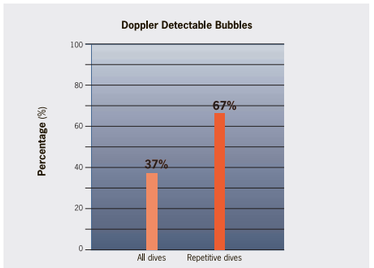
- 6 microbubble suppression levels
- User adjustable microbubble suppression
- Integrates level stops and deco stops
- Total time to ascend includes level stop data
- Warns if level stop is ignored
- "Cascading" microbubble levels
- Surface warning of reduced microbubble suppression levels
- Cautions diver on high microbubble count

SMART REDUCES MICROBUBBLES

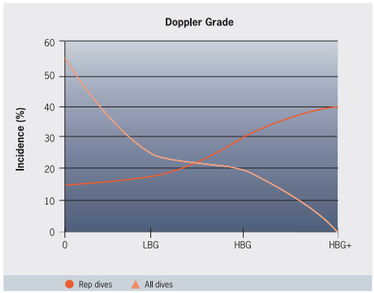
Divers who have long term exposure to microbubbles risk soft tissue damage. Examples of soft tissue include the brain, spinal tissues and the retina. Divers who are at risk include professional divers such as instructors and dive masters who typically do a lot of repetitive diving. Sport divers who conduct multiple repetitive dives over the duration of a dive holiday are also at risk from microbubble build up.

Microbubbles don't produce visible symptoms and they can only be measured with the aid of a Doppler detecting device. This hand held device generates an ultrasonic signal that strikes a microbubble in a diver's body to reflect back a distinct chirping sound. This is recorded and the recordings are then analyzed. The more "chirps" that can be heard on a recording, the greater the incidence of microbubbles in a diver.

As part of a major study DAN Europe "Doppler Scanned" divers from a substantial sample of 1058 dives within 30 minutes of each dive's conclusion. The participating divers were average open water divers, who conducted typical open water dives with a large range of depths and bottom times. DAN Europe discovered that in the case of repetitive dives 67% of all divers produced High Grade Microbubbles. This correlates with the DAN Diving Accident Reports of the last 15 years that show a relatively higher frequency of Decompression Illness after repetitive dives.



Post dive Doppler monitoring of 1058 dives observed Doppler detectable microbubbles in 37% of all the monitored dives and 67% of the repetitive dives.



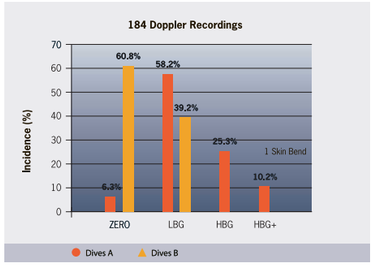
Not only was there a higher incidence of microbubbles in repetitive dives, but there was a higher incidence of high bubble grade microbubbles - level 2 or higher on the Spencer Scale.

Experiments with deeper stops at the conclusion of a repetitive dive were proven to reduce microbubbles by up to 61% and in some cases eliminated microbubble formation. So, for example, if a diver has done three dives in one day, if on all dives the diver considered doing a series of deeper stops prior to the conclusion of the dives, microbubbles were substantially reduced.

A Smart Dive Computer can be programmed to suppress the formation of microbubbles according to the diver's actual diving circumstances. The diver selects the level of suppression required for the particular dive. The Smart Dive Computer then assesses the likely microbubble build up from the previous dives and recommends an advisory deeper stop or "level stop" to be completed prior to the conclusion of the last dive.

A diver may manually select prior to the dive, 6 levels of suppression from level 0 where there is no suppression to level 5 where there is maximum suppression.

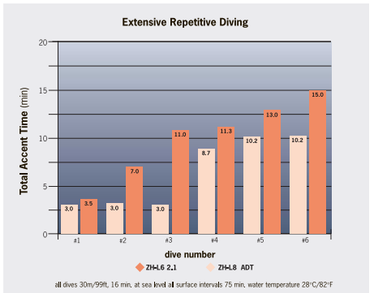
Unlike decompression stops, which are compulsory, level stops are advisory. This is because the effects of microbubble formation are largely a long term condition, whereas decompression illness produces symptoms which require immediate treatment. If a diver ignores the recommended level stops by more than (1.5 m) 5 ft, the Smart "cascades" down to the next microbubble level.



Dives A, Regular: HBG in 5/9 Divers and 1 Skin Bend
Dives B, with extra Deep Stop: Occasional LBG only

DBG	Zero	LBG	HBG	HBG+
Dives A	6.3%	58.2%	25.3%	10.2%
Dives B	60.8%	39.2%	—	—

UWATEC set up two series (one week apart, with 9 volunteer divers) of three repetitive dives to (30 m) 99 ft for 16 minutes bottom time including 2 minutes 40 second descent with 75 minutes of surface interval. The second series included the following stops on the third dive: 12m 2 min; 9m 3min; 6m 5min; and 3m 6 min. The second series totally eliminated Very High and High Grade Microbubbles and significantly reduced Low Grade Microbubbles.



In comparing earlier fixed models with the ZH-L8 ADT MB model, even at level 0 the no decompression times for the first ascent are nearly identical, whereas for the following dives the total ascent times are greater by up to a factor of four.

Smart constantly monitors and displays the CNS O_2 loading whether diving on air or any Nitrox mix up to 100% O_2.

NITROX

Nitrox allows divers to greatly extend bottom times and reduces the risk of decompression sickness. This is because Nitrox has a lower percentage of nitrogen than air.

However, Nitrox has a higher percentage of oxygen, so it presents the sport diver with different risk factors.

Oxygen is a very active molecule with the ability to “burn” the tissues in the Central Nervous System (CNS). These include the brain, spinal and other nerve tissues. The onset of problems from oxygen toxicity provide no warning, are immediate and can result in death.

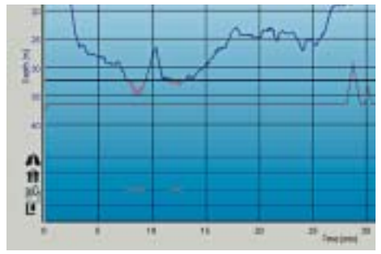
Smart dive computers monitor and warn on oxygen toxicity limits for both the accumulated “CNS clock” and the current partial pressure of oxygen.

The results are displayed continuously and when 75% of the CNS toxicity limit is reached an acoustic alarm is sounded and the CNS% value display flashes. Should a diver reach 100%, then ascent must be commenced immediately.

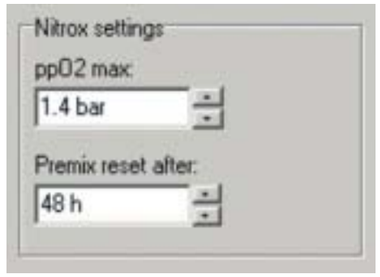
A Smart dive computer will also warn when the tolerable partial pressure of oxygen has been reached.

Smart allows divers to program the oxygen mix from 21% O_2 (air) to 100% (pure oxygen) in 1% increments. The mix can be manually selected by the diver allowing different mixes to be dived with on any one day. A diver may also simulate a Nitrox dive with the Smart dive planner.

- Nitrox dive planner
- ppO_2 alarm
- CNS clock 75% alarm
- CNS clock 100% alarm
- Easy to change oxygen mix from 21% to 100%
- Oxygen mix percentage display
- Adjustable maximum ppO_2
- CNS clock is adjusted by oxygen uptake according to workload
- Included Smart TRAK software indicates oxygen fraction at every point in the dive



Smart TRAK displays the ppO_2 limit as a black bar on the graph at the depth at which the ppO_2 limit is reached. In this instance for a 33% mix at 1.4 bar it is 105 ft (32 m).



With Smart TRAK software the Nitrox diver can change the maximum partial pressure of oxygen on both the Smart COM and the Smart PRO. For a diver who anticipates diving on the same nitrox mixture for a number of dives, with Smart TRAK it is possible to set the mixture reset to the default air (21% O_2) for an interval of up to 48 hours after a dive.

Smart TRAK allows the diver to store to a PC and analyse the dive history in the comfort of home, to extend the diving experience.

SMART TRAK

The Smart COM holds about 50 hours of dive data in its logbook and the Smart PRO holds about 100 hours. The key parameters of these dives can be retrieved and displayed on the respective Smart screens.

For more detailed storage and analysis, Smart TRAK, which is supplied with Smart, can assist divers to store data that’s limited only by the capacity of a PC’s hard drive. With a Smart dive computer sampling rate of 4 seconds, this program allows divers to analyze their dives with amazing detail.

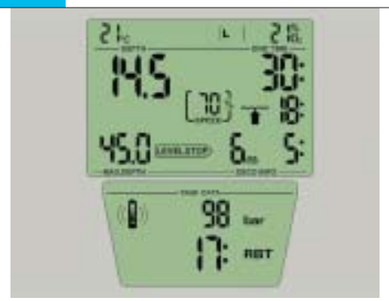
Smart TRAK is an invaluable tool for the diver to analyze their behavior and further improve their diving technique.

The complete dive profile is displayed, as are any attention messages or alarms. The software indicates the level of nitrogen saturation of the 8 body tissues that Smart monitors.

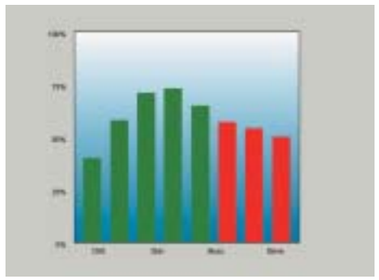
If microbubble formation is estimated to have occurred, Smart TRAK also displays this.

The actual Smart screen data that’s displayed during a dive is also displayed on your PC screen with Smart TRAK. For the Smart COM user this includes the air consumption screen.

Smart TRAK is a powerful database that allows divers to store and retrieve other useful information such as details about the dive location, conditions, weather and buddy details.

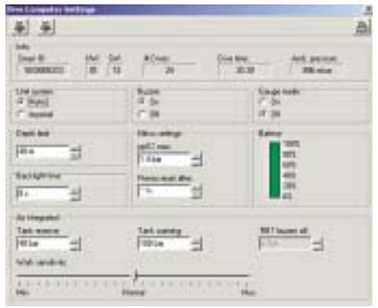


Smart TRAK replays actual screen data for the Smart COM and the Smart PRO in 4 seconds intervals.



Smart TRAK displays tissue saturation status throughout the dive. Ingassing tissues are shown in red, outgassing tissues are shown in green.

Smart TRAK is a powerful database program that allows the diver to store useful information for later retrieval.



With Smart TRAK the diver can change key parameters on the Smart PRO and the Smart COM.

PRODUCT FEATURES AT A GLANCE

Smart PRO Console

Smart PRO Wrist

Smart COM

	SMART COM	SMART PRO WRIST	SMART PRO CONSOLE
PROTECTIVE SCREEN SHIELD	■	■	■
ILLUMINATED DISPLAY	■	■	■
AUTO TURN ON/OFF	■	■	■
ALL POSITION VIEW (APV) DISPLAY	■	■	■
DISPLAYS TANK PRESSURE - BAR (PSI)	■		■
USER ADJUSTABLE TANK RESERVE FOR RBT - CALCULATION	■		
USER ADJUSTABLE MICROBUBBLE SUPPRESSION	■	■	■
AUTO ALTITUDE COMPENSATION 0 - 4,000M (13,000FT)	■	■	■
ALTITUDE ADAPTATION TIME	■	■	■
DISPLAYS ALTITUDE SECTOR	■	■	■
PROHIBITED ALTITUDE ADVICE	■	■	■
NITROX DIVE PLANNER	■	■	■
DIVE DEPTH 0-120M (0-395FT)	■	■	■
DISPLAY AMBIENT AND WATER TEMPERATURE	■	■	■
DIVE TIME	■	■	■
MAXIMUM DEPTH	■	■	■
NO STOP TIME	■	■	■
ADAPTIVE DECOMPRESSION MODEL B.HLMANN ZH-L8 ADT MB	■	■	■
REQUIRED DEEPEST DECO STOP (DEPTH)	■	■	■
REQUIRED DEEPEST DECO STOP (TIME)	■	■	■
INTEGRATES LEVEL STOPS AND DECO STOPS	■	■	■
REMAINING DIVE TIME AT CURRENT DEPTH (RBT)	■		
USER ADJUSTABLE LOW AIR WARNING	■	■	■
TOTAL TIME TO ASCEND INCLUDING DECO AND LEVEL STOP DATA	■	■	■
VARIABLE ASCENT RATE 7-20M/MIN (23-67FT/MIN)	■	■	■
NO STOP TIME IS LESS THAN 1 MINUTE ALARM	■	■	■
RBT IS LESS THAN 3 MINUTES ALARM	■		■
RBT LESS THAN 0 MINUTE ALARM	■		■
HIGH BREATHING RATE ALARM (HIGH AIR CONSUMPTION)	■	■	■
IGNORED DECOMPRESSION STOP ALARM	■	■	■
WARNS IF LEVEL STOP IS IGNORED	■	■	■
"CASCADING" MICROBUBBLE LEVELS	■	■	■
ASCENT FASTER THAN 110% ALARM	■	■	■
ASCENT FASTER THAN 140% ALARM	■	■	■
ASCENT FASTER THAN 160% ALARM	■	■	■
ASCENT FASTER THAN 180% ALARM	■	■	■
PPO2 MAX HAS BEEN REACHED ALARM	■	■	■
CNS 02 PERCENTAGE HAS REACHED 75% ALARM	■	■	■
CNS 02 PERCENTAGE HAS REACHED 100% ALARM	■	■	■
MISSED DECOMPRESSION STOP INSTRUCTIONS	■	■	■
DISPLAYS ON THE SURFACE OF REDUCED MB-LEVEL	■	■	■
DESATURATION TIME	■	■	■
NO FLY ICON AND TIME	■	■	■
SURFACE INTERVAL	■	■	■
LOGBOOK CONTAINS 50 HOURS OF DIVING	■		■
LOGBOOK CONTAINS 100 HOURS OF DIVING	■		■
QUANTITY OF AIR USED	■		■
MEASURES WATER TEMPERATURE	■	■	■
CAUTIONS DIVER ON HIGH MICROBUBBLE LEVELS	■	■	■
LONG LIFE BATTERY	■	■	■
PERCENT OF REMAINING BATTERY LIFE	■	■	■
USER SWITCHABLE METRIC/IMPERIAL	■	■	■
USER ADJUSTABLE WORKLOAD WARNING	■		■
EASY TO CHANGE OXYGEN MIX FROM 21% TO 100%	■	■	■
OXYGEN MIX PERCENTAGE DISPLAY	■	■	■
ADJUSTABLE MAXIMUM OXYGEN PARTIAL PRESSURE (PPO2) VIA SMARTTRAK	■	■	■
CNS CLOCK IS ADJUSTED BY O2 UPTAKE ACCORDING TO WORKLOAD	■		■
INCLUDED SMART TRAK SOFTWARE INDICATES O2 FRACTION	■	■	■
ADJUSTABLE BACKLIGHT DURATION	■	■	■
ADJUSTABLE DEPTH LIMIT ALARM VIA SMARTTRAK	■	■	■
ADJUSTABLE PREMIX RESET VIA SMARTTRAK	■	■	■
GAUGE MODE	■	■	■
BUZZER SUPPRESSION IN SMART TRAK	■	■	■
SMARTTRAK COMPATIBLE - CD INCLUDED	■	■	■
INFRARED COMMUNICATION (IRDA) WITH SMARTTRAK	■	■	■