= 2700 litres / 50 litres per min =
54 minutes
This would give a dive time of 54 min at 15 m before reaching the reserve of 50 bar .

= = = Reserves = = =

It is strongly recommended by diver training organisations and codes of practice that a portion of the usable gas of the cylinder be held aside as a safety reserve . The reserve is designed to provide gas for longer than planned decompression stops or to provide time to resolve underwater emergencies .

The size of the reserve depends upon the risks involved during the dive . A deep or decompression dive warrants a greater reserve than a shallow or a no stop dive . In recreational diving for example , it is recommended that the diver plans to surface with a reserve remaining in the cylinder of 500 psi , 50 bar or 25 % of the initial capacity , depending of the teaching of the diver training organisation . This is because recreational divers practicing within " no @-@ decompression " limits can normally make a direct ascent in an emergency . On technical dives where a direct ascent is either impossible (due to overhead obstructions) or dangerous (due to the requirement to make decompression stops) , divers plan larger margins of safety . The simplest method uses the rule of thirds : one third of the gas supply is planned for the outward journey , one third is for the return journey and one third is a safety reserve .

Some training agencies teach the concept of minimum gas , rock bottom gas management or critical pressures which allows a diver to calculate an acceptable reserve to get two divers to the surface in an emergency from any point in the planned dive profile .

Professional divers may be required by legislation or industry codes of practice to carry sufficient reserve gas to enable them to reach a place of safety , such as the surface , or a diving bell , based on the planned dive profile . This reserve gas is usually required to be carried as an independent emergency gas supply (EGS) , also known as a bailout cylinder , set or bottle . This usually also applies to professional divers using surface @-@ supplied diving equipment .

= = = Weight of gas consumed = = =

The density of air at sea level and 15 ° C is approximately 1 @.@ 225 kg / m3 . Most full @-@ sized diving cylinders used for open circuit scuba hold more than 2 kilograms (4 @.@ 4 lb) of air when full , and as the air is used , the buoyancy of the cylinder increases by the weight removed . The decrease in external volume of the cylinder due to reduction of internal pressure is relatively small , and can be ignored for practical purposes .

As an example , a 12 @-@ litre cylinder may be filled to 230 bar before a dive , and be breathed down to 30 bar before surfacing , using 2 @,@ 400 litres or 2 @.@ 4 m3 of free air . The mass of gas used during the dive will depend on the mixture - if air is assumed , it will be approximately 2 @.@ 9 kilograms (6 @.@ 4 lb) .

The loss of the weight of the gas taken from the cylinder makes the cylinder and diver more buoyant . This can be a problem if the diver is unable to remain neutrally buoyant towards the end of the dive because most of the gas has been breathed from the cylinder . The buoyancy change due to gas usage from back mounted cylinders is easily compensated by carrying sufficient diving weights to provide neutral buoyancy with empty cylinders at the end of a dive , and using the buoyancy compensator to neutralise the excess weight until the gas has been used .

The change in buoyancy of diving cylinder during the dive can be more problematic with side @-@ mounted cylinders , and the actual buoyancy at any point during the dive is a consideration with any cylinder that may be separated from the diver for any reason . Cylinders which will be stage @-@ dropped or handed off to another diver should not change the diver 's buoyancy beyond what can be compensated using their buoyancy compensator . Cylinders with approximately neutral buoyancy when full generally require the least compensation when detached .

= = Filling cylinders = =

Legal constraints to filling scuba cylinders will vary by jurisdiction .

In South Africa cylinders may be filled for commercial purposes by a person who is competent in the use of the filling equipment to be used , who knows the relevant sections of the applicable standards and regulations , and has written permission from the owner of the cylinder to fill it . The cylinder must be in test and suitable for the gas to be filled , and the cylinder may not be filled above the developed pressure for the temperature reached when it is filled . An external inspection of the cylinder must be made , and specified details of the cylinder and fill must be recorded . If the fill is of a gas other than air , the analysis of the completed fill must be recorded by the filler and signed by the customer . If the residual pressure in a cylinder presented for filling does not produce a reasonably strong flow of gas from the valve when opened the filler may refuse to fill the cylinder unless an acceptable reason is given for it being empty , as there is no way for the filler to check if it has been contaminated .

Diving cylinders should only be filled with suitably filtered air from diving air compressors or with other breathing gases using gas blending or decanting techniques . In some jurisdictions , suppliers of breathing gases are required by legislation to periodically test the quality of compressed air produced by their equipment and to display the test results for public information . The standards for industrial gas purity and filling equipment and procedures may allow some contaminants at levels unsafe for breathing , and their use in breathing gas mixtures at high pressure could be harmful or fatal .

Special precautions need to be taken with gases other than air :

oxygen in high concentrations is a major cause of fire and rust .

oxygen should be very carefully transferred from one cylinder to another and only ever stored in containers that are cleaned and labeled for oxygen use .

gas mixtures containing proportions of oxygen other than 21 % could be extremely dangerous to divers who are unaware of the proportion of oxygen in them . All cylinders should be labeled with their composition .

cylinders containing a high oxygen content must be cleaned for the use of oxygen and their valves lubricated only with oxygen service grease to reduce the chance of combustion .

Contaminated air at depth can be fatal . Common contaminants are : carbon monoxide - a by @-@ product of combustion , carbon dioxide - a product of metabolism , and oil and lubricants from the compressor .

Keeping the cylinder slightly pressurized at all times during storage and transportation reduces the possibility of inadvertently contaminating the inside of the cylinder with corrosive agents , such as sea water , or toxic material , such as oils , poisonous gases , fungi or bacteria . A normal dive will end with some pressure remaining in the cylinder ; if an emergency ascent has been made due to an out @-@ of @-@ gas incident , the cylinder will normally still contain some pressure and unless the cylinder had been submerged deeper than where the last gas was used it is not possible for water to get in during the dive .

Contamination by water during filling may be due two two causes . Inadequate filtration and drying of the compressed air can introduce small quantities of fresh water condensate , or an emulsion of water and compressor lubricant , and failing to clear the cylinder valve orifice of water which may have dripped from wet dive gear , which can allow contamination by fresh or seawater . Both cause corrosion , but seawater contamination can cause a cylinder to corrode rapidly to the extent that it may be unsafe or condemned after even a fairly short period . This problem is exacerbated in hot climates , where chemical reactions are faster , and is more prevalent where filling staff are badly trained or overworked .

The blast caused by a sudden release of the gas pressure inside a diving cylinder makes them very dangerous if mismanaged . The greatest risk of explosion exists while filling , but cylinders have also been known to burst when overheated . The cause of failure can range from reduced wall thickness or deep pitting due to internal corrosion , neck thread failure due to incompatible valve threads , or cracking due to fatigue , sustained high stresses , or overheating effects in aluminum .

= = Inspection and testing = =

Most countries require diving cylinders to be checked on a regular basis . This usually consists of an internal visual inspection and a hydrostatic test . The inspection and testing requirements for scuba cylinders may be very different from the requirements for other compressed gas containers due to the more corrosive environment .

In the United States , an annual visual inspection is not required by the USA DOT , though they do require a hydrostatic test every five years . The visual inspection requirement is a diving industry standard based on observations made during a review by the National Underwater Accident Data Center .

In European Union countries a visual inspection is required every 2 @.@ 5 years , and a hydrostatic test every five years .

In Norway a hydrostatic test (including a visual inspection) is required 3 years after production date , then every 2 years .

Legislation in Australia requires that cylinders are hydrostatically tested every twelve months .

In South Africa a hydrostatic test is required every 4 years , and visual inspection every year . Eddy current testing of neck threads must be done according to the manufacturer 's recommendations .

A hydrostatic test involves pressurising the cylinder to its test pressure (usually 5 / 3 or 3 / 2 of the working pressure) and measuring its volume before and after the test . A permanent increase in volume above the tolerated level means the cylinder fails the test and must be permanently removed from service .

An inspection includes external and internal inspection for damage , corrosion , and correct colour and markings . The failure criteria vary according to the published standards of the relevant authority , but may include inspection for bulges , overheating , dents , gouges , electrical arc scars , pitting , line corrosion , general corrosion , cracks , thread damage , defacing of permanent markings , and colour coding .

When a cylinder is manufactured , its specification , including manufacturer , working pressure , test pressure , date of manufacture , capacity and weight are stamped on the cylinder .

After a cylinder passes the test , the test date , (or the test expiry date in some countries such as Germany) , is punched into the shoulder of the cylinder for easy verification at fill time . There is an international standard for the stamp format .

Compressor operators may be required to check these details before filling the cylinder and may refuse to fill non @-@ standard or out @-@ of @-@ test cylinders .

= = Safety = =

Before any cylinder is filled , verification of testing dates and a visual examination for external damage and corrosion are required by law in some jurisdictions , and are prudent even if not legally required at other places . Test dates can be checked by looking at the visual inspection sticker and the hydro @-@ test date is stamped on top of the cylinder .

Before use the user should verify the contents of the cylinder and check the function of the cylinder valve . This is usually done with a regulator connected to control the flow . Pressure and gas mixture are critical information for the diver , and the valve should open freely without sticking or leaks from the spindle seals . Breathing gas bled from a cylinder may be checked for smell . If the gas does not smell right it should not be used . Breathing gas should be almost free of smell , though a very slight aroma of the compressor lubricant is fairly common . No smell of combustion products or volatile hydrocarbons should be discernible . Failure to recognize that the gas was not on or that cylinder was empty by divers conducting a pre @-@ dive evaluation has been noted .

A neatly assembled setup , with regulators , gauges , and delicate computers stowed inside the BCD , or clipped where they will not be walked on , and stowed under the boat bench or secured to a rack , is the practice of a competent diver .

As the scuba set is a life support system , no unauthorised person should touch a diver 's gear ,

even to move it , without their knowledge and approval .
Full cylinders should not be exposed to temperatures above 65 ° C and cylinders should not be filled to pressures greater than the developed pressure appropriate to the certified working pressure of the cylinder .
Cylinders should be clearly labelled with their current contents . A generic " Nitrox " or " Trimix " label will alert the user that the contents may not be air , and must be analysed before use . In some parts of the world a label is required specifically indicating that the contents are air , and in other places a colour code without additional labels indicates by default that the contents are air .
In a fire , the pressure in a gas cylinder rises in direct proportion to its absolute temperature . If the internal pressure exceeds the mechanical limitations of the cylinder and there are no means to safely vent the pressurized gas to the atmosphere , the vessel will fail mechanically . If the vessel contents are ignitable or a contaminant is present this event may result in an explosion .

= = = Accidents = = =

The major diving accident and fatality research studies that have been conducted globally including work by the Divers Alert Network , the Diving Incident Monitoring Study , and Project Stickybeak have each identified cases where the mortality was associated with the diving cylinder .
Some recorded accidents associated with diving cylinders :
Valve ejected due to mix up with valve threads 3 / 4 " NPSM and 3 / 4 " BSP (F) caused damage to a dive shop compressor room .
Dive Instructor leg nearly amputated by ejected valve while attempting to remove valve from pressurised cylinder .
Valve ejected during filling due to thread failure , sank dive boat . Bursting disks in cylinder valves replaced by solid bolts .
Filling hose failure severely injured operator when hose hit his face . Wound exposed jaw bone . 14 stitches to close the wound .
Cases of lateral epicondylitis have been reported caused by the handling of diving cylinders .

= = = Handling = = =

Cylinders should not be left standing unattended unless secured so that they can not fall in reasonably foreseeable circumstances as an impact could damage the cylinder valve mechanism , and conceivably fracture the valve at the neck threads . This is more likely with taper thread valves , and when it happens most of the energy of the compressed gas is released within a second , and can accelerate the cylinder to speeds which can cause severe injury or damage to the surroundings .

= = = Long term storage = = =

Breathing quality gases do not normally deteriorate during storage in steel or aluminium cylinders . Provided there is insufficient water content to promote internal corrosion , the stored gas will remain unchanged for years if stored at temperatures within the allowed working range for the cylinder , usually below 65 ° C. If there is any doubt , a check of oxygen fraction will indicate whether the gas has changed (the other components are inert) . Any unusual smells would be an indication that the cylinder or gas was contaminated at the time of filling . However some authorities recommend releasing most of the contents and storing cylinders with a small positive pressure .

= = = Transportation = = =

Diving cylinders are classified by the UN as dangerous goods for transportation purposes (US : Hazardous materials) . Selecting the Proper Shipping Name (well known by the abbreviation PSN) is a way to help ensure that the dangerous goods offered for transport accurately represent the

hazards .
IATA Dangerous Goods Regulations (DGR) 55th Edition defines the Proper Shipping Name as " the name to be used to describe a particular article or substance in all shipping documents and notifications and , where appropriate , on packagings " .
The International Maritime Dangerous Goods Code (IMDG Code) defines the Proper Shipping Name as " that portion of the entry most accurately describing the goods in the Dangerous Goods List which is shown in upper @-@ case characters (plus any letters which form an integral part of the name) . "

= = = = International air = = = =

International Civil Aviation Organisation (ICAO) Technical Instructions for the Safe Transport of Dangerous Goods by Air states that provided that pressure in diving cylinders is less than 200 kilopascals (2 bar ; 29 psi) , these can be carried as checked in or carry @-@ on baggage . It maybe necessary to empty the cylinder to verify this . Once emptied , the cylinder valve should be closed to prevent moisture entering the cylinder . Security restrictions implemented by individual countries may further limit or forbid the carriage of some items permitted by ICAO , and airlines and security screening agencies have the right to refuse the carriage of certain items .

= = = = Europe = = = =

Since 1996 the carriage of dangerous goods legislation of the UK has been harmonized with that of Europe .
Road transport
The 2009 (amended 2011) UK Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations (CDG Regulations) implement the European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR) . Dangerous goods to be carried internationally in road vehicles must comply with standards for the packaging and labelling of the dangerous goods , and appropriate construction and operating standards for the vehicles and crew .

The regulations cover transportation of gas cylinders in a vehicle in a commercial environment . Transportation of pressurised diving gas cylinders with a combined water capacity of less than 1000 litres on a vehicle for personal use is exempt from ADR .
Transport of gas cylinders in a vehicle , for commercial purposes , must follow basic legal safety requirements and , unless specifically exempted , must comply with ADR . The driver of the vehicle is legally responsible for the safety of the vehicle and any load being carried , and insurance for the vehicle should include cover for the carriage of dangerous goods .
Diving gases , including compressed air , oxygen , nitrox , heliox , trimix , helium and argon , are non @-@ toxic , non flammable , and may be oxidizer or asphyxiant , and are rated in Transport category 3 . The threshold quantity for these gases is 1000 litres combined water capacity of the cylinders . Pressure must be within the rated working pressure of the cylinder . Empty air cylinders at atmospheric pressure are rated in Transport category 4 , and there is no threshold quantity .
Commercial loads below the 1000 litres threshold level are exempt from some of the requirements of ADR , but must comply with basic legal and safety requirements , including :
Driver training
Cylinders should be transported in open vehicles , open containers or trailers , with a gas @-@ tight bulkhead separating driver from load . If cylinders must be carried inside a vehicle it must be well ventilated .
Ventilation . Where gas cylinders are carried inside a vehicle , in the same space as people , the windows should be kept open to allow air to circulate .
Cylinders must be secured so that they cannot move during transport . They shall not project beyond the sides or ends of the vehicle . It is recommended that cylinders are transported vertically , secured in an appropriate pallet .

Cylinder valves must be closed whilst in transit and checked that there are no leaks . Where applicable , protective valve caps and covers should be fitted to cylinders before transporting . Cylinders should not be transported with equipment attached to the valve outlet (regulators , hoses etc .) .

A fire extinguisher is required on the vehicle .

Gas cylinders may only be transported if they are in @-@ date for periodic inspection and test , except they may be transported when out of date for inspection , testing or disposal .

Cylinders should be kept cool (at ambient temperatures) and not stowed in places where they will be exposed to sources of excessive heat .

Product identification labels attached to cylinders to identify the contents and provide safety advice must not be removed or defaced .

It is not necessary to mark and label the vehicle if carrying dangerous goods below the threshold level . The use of hazard labels can assist the emergency services , and they may be displayed , but all hazard labels must be removed when the relevant dangerous goods are not being transported .

When the journey is complete the gas cylinders should be immediately unloaded from the vehicle .

All loads above the threshold must comply with the full requirements of ADR .

= = = = USA = = = =

Transportation of hazardous materials for commercial purposes in the USA is regulated by Code of Federal Regulations Title 49 - Transportation , (abbreviated 49 CFR) . A cylinder containing 200 kPa (29 @.@ 0 psig / 43 @.@ 8 psia) or greater at 20 ° C (68 ° F) of non @-@ flammable , nonpoisonous compressed gas , and being transported for commercial purposes is classified as HAZMAT (hazardous materials) in terms of 49 CFR 173 @.@ 115 (b) (1) . Cylinders manufactured to DOT standards or special permits (exemptions) issued by the Pipeline and Hazardous Materials Safety Administration and filled to the authorized working pressure are legal for commercial transport in the USA under the provisions and conditions of the regulations . Cylinders manufactured outside the USA may be transported under a special permit , and these have been issued for solid metal and composite cylinders with working pressures of up to 300 bar (4400 psi) by several manufacturers .

Surface transport

Commercial transportation of breathing gas cylinders with a combined weight of more than 1000 pounds may only be done by a commercial HAZMAT transportation company . Transport of cylinders with a combined weight of less than 1000 pounds requires a manifest , the cylinders must have been tested and inspected to federal standards , and the contents marked on each cylinder . Transportation must be done in a safe manner , with the cylinders restrained from movement . No special licence is required . DOT regulations require content labels for all cylinders under the regulations , but according to PSI , labelling of breathing air will not be enforced . Oxygen or non @-@ air oxidizing (23 @.@ 5 + % O2) mixtures must be labelled . Private (non @-@ commercial) transport of scuba cylinders is not covered by this regulation .

Air transport

Empty scuba tanks or scuba tanks pressurized at less than 200 kPa are not restricted as hazardous materials . Scuba cylinders are only allowed in checked baggage or as a carry @-@ on if the cylinder valve is completely disconnected from the cylinder and the cylinder has an open end to allow for a visual inspection inside .

= = Gas cylinder colour @-@ coding and labeling = =

= = = Worldwide = = =

The colours permitted for diving cylinders vary considerably by region , and to some extent by the gas mixture contained .

In some parts of the world there is no legislation controlling the colour of diving cylinders . In other regions the colour of cylinders used for commercial diving , or for all underwater diving may be specified by national standards .

In many recreational diving settings where air and nitrox are the widely used gases , nitrox cylinders are identified with a green stripe on yellow background . Aluminium diving cylinders may be painted or anodized and when anodized may be coloured or left in their natural silver . Steel diving cylinders are usually painted , to reduce corrosion , often yellow or white to increase visibility . In some industrial cylinder identification colour tables , yellow shoulders means chlorine and more generally within Europe it refers to cylinders with toxic and / or corrosive contents ; but this is of no significance in scuba since gas fittings would not be compatible .

Cylinders that are used for partial pressure gas blending with pure oxygen may also be required to display an " oxygen service certificate " label indicating they have been prepared for use with high partial pressures and gas fractions of oxygen .

= = = European Union = = =

In the European Union gas cylinders may be colour @-@ coded according to EN 1098 @-@ 3 . In the UK this standard is optional . The " shoulder " is the domed top of the cylinder between the parallel section and the pillar valve . For mixed gases , the colours can be either bands or " quarters " .

Air has either a white (RAL 9010) top and black (RAL 9005) band on the shoulder , or white (RAL 9010) and black (RAL 9005) " quartered " shoulders .

Heliox has either a white (RAL 9010) top and brown (RAL 8008) band on the shoulder , or white (RAL 9010) and brown (RAL 8008) " quartered " shoulders .

Nitrox , like Air , has either a white (RAL 9010) top and black (RAL 9005) band on the shoulder , or white (RAL 9010) and black (RAL 9005) " quartered " shoulders .

Pure oxygen has a white shoulder (RAL 9010) .

Pure helium has a brown shoulder (RAL 9008) .

Trimix has a white , black and brown segmented shoulder .

These breathing gas cylinders must also be labeled with their contents . The label should state the type of breathing gas contained by the cylinder .

= = = = Offshore = = = =

Breathing gas containers for offshore use may be coded and marked according to IMCA D043 .

IMCA colour coding for individual cylinders allows the body of the cylinder to be any colour that is not likely to cause misinterpretation of the hazard identified by the colour code of the shoulder .

= = = South Africa = = =

Scuba cylinders are required to comply with the colours and markings specified in SANS 10019 : 2006 .

Cylinder colour is Golden yellow with a French grey shoulder .

Cylinders containing gases other than air or medical oxygen must have a transparent adhesive label stuck on below the shoulder with the word NITROX or TRIMIX in green and the composition of the gas listed .

Cylinders containing medical oxygen must be black with a white shoulder .