AVIATION OXYGEN

Information on the use of supplementary oxygen in general aviation aircraft. The following information is presented to give the reader an informal overview on the use of oxygen in general aviation aircraft. The use of flow meters in factory supplied built in oxygen systems and the use of portable oxygen systems are the major topics discussed. If the reader still has questions about the use of oxygen in general aviation, please give us a call. We will be glad to answer any of your questions and provide you with assistance as necessary.

ABOUT OXYGEN

Composition of Oxygen.

Oxygen includes 21% of the atmosphere at all altitudes. The remaining atmosphere consists of 78% nitrogen and 1% traces of other gases. Oxygen under normal conditions is an odorless, colorless, tasteless, non-combustible gas. It is the most important single element on earth.

At each breath we fill our lungs with air. Millions of tiny air sacs (known as "alveoli") in our lungs inflate like tiny balloons. In the minutely thin walls enclosing each sac are microscopic capillaries though which blood is constantly transported, from the lungs to every cell in the body. The oxygen extracted from the air in the lungs is carried by the blood to every part of the body. Because the body has no way to store oxygen over a period of a long time, it leads a breath-to-breath existence.

The human body must have oxygen to convert fuel (the carbohydrates, fats, and proteins in our diet) into heat, energy, and life. The conversion of body fuels into life is similar to the process of combustion; fuel and oxygen is consumed, while heat and energy is generated. This process is known as "metabolism".

The rate of metabolism, which determines the need for and consumption of oxygen, depends on the degree of physical activity or mental stress of the individual. Not all people require the same amount of oxygen. A man walking at a brisk pace will consume about four times as much oxygen as he will while sitting quietly. Under severe exertion or stress, he could possibly be consuming eight times as much oxygen as resting.

There are four kinds of oxygen that are merchandised or sold to users; Aviation, Medical, Welding and Research. There is a ongoing controversy if there is any difference between the different types. Oxygen gas is produced from the boiling off of liquid oxygen. It would appear that the oxygen is therefor the same. Where we obtain oxygen, all the different types of oxygen are supplied from the same manifold system. Then someone says that medical oxygen has more moisture in it. That is partly true. The oxygen going to a hospital bed is plain oxygen that comes from liquid oxygen. At the bed location, there is a unit on the wall that adds moisture. At this moment we now have medical oxygen. If the oxygen is in a pressure vessel or in a manifold system (like inside a hospital) then it is regular oxygen. The cost of medical or welding oxygen is normally much less than the oxygen you get at an airport.

Also of interest, we have been told by the suppliers of welding oxygen, the purity level required for welding and cutting purposes is more critical than for breathing.

The bottom line about the different types of oxygen is in the insurance liability of the oxygen supplier. The gas is the same but the insurance liability is different.

Effects Due to Altitude.

As the total atmospheric pressure decreases with altitude, the available oxygen pressure decreases in proportion, thus necessitating supplementary oxygen. A lack of sufficient oxygen will bring on hypoxia. Symptoms of hypoxia may begin as low as 5,000 feet with decreased night vision. The retina of the eye is affected by even extremely mild hypoxia. At 8,000 feet, forced concentration, fatigue and headache may occur. At 14,000 feet, forgetfulness, incompetence and indifference makes flying without the proper supplementary oxygen quite hazardous. At 17,000 feet, serious handicap and collapse may occur. These effects do not necessarily occur in the same sequence nor to the same extent in all individuals.

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A FAA flight surgeon gave me an excellent definition on the term, Hypoxia. He called it "STUPIDITY". What typically happens when experiencing serious hypoxia symptoms, you get too stupid to realize that something is wrong.

For the regular smoker (especially with older people), these effects all occur at much lower altitudes. A person at sea level who regularly smokes a pack of cigarettes a day, may theoretically be at 7,000 feet. If that person were flying at 12,000 feet, the actual altitude experienced could be as much as 19,000 feet. Obviously an altitude requiring the use of oxygen. A person's age drastically effects night vision. A 60 year old has only 1/3 of the night vision of a 20 year old. Of importance, there is very little peripheral vision at night. The see and be seen concept of aircraft collision avoidance is obviously limited during night flying.

It is recommended that if one were to go above 18,000 feet, that person should be on oxygen for at least for 30 minutes prior to going above 18,000 feet. The time on oxygen lets the oxygen and nitrogen levels stabilize properly. Suggest that if you know you are going above 18,000 feet from sea level at the maximum climb rate, then put on the oxygen before takeoff. By the time you get to 18,000 it probably will have taken about 30 minutes.

People Living at High Altitudes.

A normal healthy person who lives at higher altitudes has somewhat adapted to the effects of high altitude. However that person still must have supplementary oxygen above 12,500 feet. The effects of hypoxia may be lesser for that person at 12,500 feet, but the problems are still there. Above 15,000 feet it doesn't make any difference what altitude you live at.

Requirement of More Oxygen for Passengers.

We have many pilots tell us women passengers need oxygen much sooner than they do. We are not talking high altitude either. Typically the problem seems to occur around 9,000 to 10,000 feet. The symptoms for the women passengers are sleepiness and headaches. Several doctors have told us the reason for women to be effected by the beginning symptoms of Hypoxia is caused by a difference in their hemoglobin content in their blood. Of interest, women also experience different conditions in breathing requirements while scuba diving. We have received several orders for oxygen equipment mainly for women passenger use at these low oxygen altitudes. A good rule of thumb is that women normally need oxygen about 2,000 feet sooner than men. Of course there are exceptions.

Another more obvious reason for more oxygen for passengers is due to nervousness of passengers who have had no or little experience flying in light aircraft. When one is nervous, the body is working harder, thus needing more oxygen.

Use of Oxygen in Pressurized Cabins.

Under normal conditions there is no need for supplementary oxygen in an aircraft equipped with a pressurized cockpit. However, there are conditions that can require additional oxygen. Many pressurized aircraft only bring the cabin altitude down to 10,000 feet. We have found that many people have trouble at 10,000 foot altitudes, in this case the equivalent altitude of 10,000 feet. There is a strong possibility that a heavy smoker could have problems with a lack of oxygen when in a pressurized cabin. We have a few customers who have purchased portable systems to provide the additional need for oxygen. Recently we have a customer with a Cessna 340 (pressurized cabin twin) that has been complaining about fatigue while flying at 25,000 feet. To solve his problem he is using the built in emergency constant flow system. The normal duration is not sufficient, but with the Nelson A-3 flow meter and oxygen conserving Oxymizer breathing device, he now has several hours of supplementary oxygen available to assist with his breathing needs.

Safety Considerations Dealing With High Pressure Cylinders.

The use of oxygen in general aviation is quite safe. The use of it is done on a regular basis throughout the world. Reading the manufactures instructions and going by them, as well as the use of common sense, make oxygen use practical. The use of oxygen, no different than the use of the aircraft itself, does have some potential problems. In that light, the following information is important and should be remembered when dealing with oxygen.

Although oxygen is non flammable, materials which burn in air will burn much more vigorously, and at a higher temperature, in oxygen. If ignited some combustibles such as oil, burn in oxygen with explosive violence. Some other materials which do not burn in air will burn vigorously in oxygen-enriched atmospheres.

A hazardous condition does exist if high pressure oxygen equipment becomes contaminated with hydrocarbons such as oil, grease, or other combustible materials which may include oil from the operator's hands or contaminated tools.

Oxygen under pressure presents a hazard in the form of stored energy.

Rapid release of high pressure oxygen through orifices, needle valves etc. in the presence of foreign particles can cause friction or impact resulting in temperatures which may be sufficient to ignite combustible materials and rapidly oxidize metals.

A cylinder will heat as it is filled from a high pressure source, due to the heat of compression generated as gas is forced into the cylinder. The more rapidly the cylinder is filled, the higher temperature rise in the cylinder. Excessive temperature may result in ignition of any combustible materials that are present.

Filling.

Containers must be refilled by a gas manufacture, gas distributor, or someone qualified in the refilling of aircraft oxygen cylinders. The markings stamped into cylinders shall not be removed or changed. The user shall not deface or remove any markings, labels, decals, tags or stencil marks applied by the supplier and used for identification of content.

The user shall not change, modify, tamper with, obstruct or repair the pressure-relief devices, container valves or in containers.

The user shall not repair or alter containers or container valves. Any other damage noted that might impair the safety of the container shall be called to the attention of the gas supplier refilling the container.

Transporting.

Containers should not be used as rollers, supports or for any purpose other than to contain the appropriate contents. The user should keep container valves closed at all times (charged or empty) except when the container is in use.

Storing.

Compressed gas containers should not be subjected to atmospheric temperatures above 130 degrees F. A flame shall never be permitted to come in contact with any part of a compressed gas container. Containers shall not be stored near readily ignitable substances such as gasoline or waste papers, or near combustibles including oil. Containers shall not be exposed to continuous dampness nor be stored in the sun.

Handling.

Compressed gases shall be handled only by properly trained persons. The user responsible for the handling of the container and connecting it for use shall check the identity of the gas by reading the label or other markings on the container before using. If container content is not identified by marking, the container shall be returned to the supplier without using it. Container color shall not be relied upon for content identification.

Connections that do not fit should not be forced. Threads on regulator connections or other auxiliary equipment should match those on container valve outlet. Regulators, gauges, hoses and other appliances provided for use with a particular gas or group of gases should not be used on containers containing gases having different chemical properties unless information obtained from the supplier indicates that this can be done safely. As an example, only pressure-regulating devices approved for use with oxygen should be used in oxygen service.

Putting in Service.

Container valve should be opened slowly for safety. Valve outlets should be pointed away from yourself and other persons. Valve wheels or levers should not be hammered in attempting to open or close the valve. For valves that are hard to open, or frozen because of corrosion, the supplier should be contacted for instructions. Before a regulator is removed from a container, the container valve should be closed and the regulator drained of gas pressure. Oxygen containers, valves, regulators, hose and other oxygen apparatus should be kept free from oil or grease and shall not be handled with oily hands, oily gloves or with greasy equipment.

Transfilling.

Transfilling of compressed gas from one tank to another is not recommended, but if done, must be carried out under carefully controlled conditions and requires appropriate equipment and done by properly trained and qualified personnel.

FAA and Oxygen (From FAA Publications)

Oxygen Requirements at Altitude.

The FAA requires that all pilots flying their aircraft above 12,500 feet for 30 minutes or longer or at 14,000 feet or above during the entire flight must use supplementary oxygen. The amount required is 1 litre of oxygen per minute for every 10,000 feet. For example, at 18,000 feet there should be a flow of 1.8 litres per minute of oxygen available via a standard breathing device. The FAA requires there should be a device so attached to each breathing device that visually shows the flow of oxygen. (Nelson flow meters meet this FAA requirement.) The FAA also regulates that passengers must have supplementary oxygen available over 15,000 feet and that it is recommended that supplementary oxygen be used at night at altitudes over 5,000 feet.

Effective Performance Time.

This is the amount of time during which a pilot is able to effectively or adequately fly his aircraft with an insufficient supply of oxygen. At altitudes below 30,000 feet this time may differ considerably from the time of total consciousness (the time it takes to pass out). Above 35,000 feet the times become shorter and eventually coincides, for all practical purposes, with the time it takes for blood to circulate from the lungs to the head.

Average Effective Performance Time for flying personnel without supplementary oxygen:

15,000 to 18,000 feet ....30 minutes or more

22,000 feet ....5 to 10 minutes

25,000 feet ....3 to 5 minutes

28,000 feet...........................2 1/2 to 3 minutes

30,000 feet ....1 to 2 minutes

35,000 feet ....30 to 60 seconds

40,000 feet ....15 to 20 seconds

45,000 feet ....9 to 15 seconds

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Factors which will determine the Effective Performance Time

1. **Altitude**. EPT decreases at high altitudes.
2. **Rate of ascent**. In general, the faster the rate, the shorter the EPT.
3. **Physical Activity.** Exercise decreases EPT considerably.
4. **Day-to-Day Factors.** Physical fitness and other factors (smoking, health, stress) may change your ability to tolerate hypoxia from day to day, thereby changing your EPT.

Cannulas.

The cannula type breathing devices can be used up to 18,000 feet. If a cannula is used, there must be a standby face mask available for each cannula used in case a head cold causes the user some nasal congestion.

Pilots should refer to FAR 23.1447 to see if any restrictions apply for their use of cannula type breathing devices in operating their aircraft.

Cylinders.

Oxygen cylinders should be hydrostatically tested every 5 years. Steel Cylinders are usually tested every 10 years. Specially constructed oxygen cylinders could have a shorter period for hydrostatically testing. There could also be a limit on how long the cylinder may be used when it was supplied as original equipment with a factory installed, built in oxygen system. Most cylinders can be used indefinitely. However, some aircraft may be required to replace the cylinders after 25 years. Factory supplied built in oxygen systems will have the necessary maintenance information in the aircraft manual.

Around the neck of the cylinder are letters and numbers stamped into the cylinder. Of importance to the pilot are three items. At the beginning of the numbers are the letters, DOT. This indicates that the cylinder as been approved by the Department of Transportation, which means they can be commercially filled. European cylinders may not have the DOT stamped on the cylinder. This could prevent the cylinder from being refilled in the USA. Owners of imported aircraft from Europe should be aware of this problem.

After the DOT label, there will be 4 numbers. These indicate the rate cylinder pressure. 2015 and 2216 are common.

After the end of all the numbers will be two numbers followed by a letter that looks like an inverted capital A and then two more numbers. This is the date of manufacture of the cylinder. The first numbers are the month (03 for example would be March) and the last two being the year of manufacture (96 for would be for 1996).

The date testing is required is based on this date, not when the cylinder was purchased. It is quite common to have a unused cylinder that could be one of two years old. Perhaps not fair for the buyer, but who said life was always fair.

Outlets in Built-In Systems.

We understand that some systems require the O-Ring seals in the manifold outlets to be replaced on a scheduled basis. Consult your aircraft manual for more information.

FAA Altitude Test Chamber.

We strongly recommend that anyone who uses or plans to use oxygen in aircraft attend one of the physiological training programs sponsored by the FAA and the military. Courses include information on hypoxia, hyperventilation, and as well as offering altitude-chamber rides, where you can safely experience your own reaction of oxygen deprivation. There is waiting list for the courses. The cost for the courses is minimal.

Courses are offered at many military bases around the country. You can get an application form by writing or calling the FAA Civil Aeromedical Institute <http://www.cami.jccbi.gov/education/index.html>, Airman Education Section AAM-420, P.O. Box 25082, Oklahoma City, Okla. 73125, (405) 686-4837. Better yet, contact your local FAA Accident Prevention Specialist and ask for AC Form 3150-7. We also have copies of the form.

WARNING: An instructor warned against the excessive use of lipstick and Chapstick type material on lips when using oxygen. He also said the you should not eat peanuts during the use of oxygen. In both cases, the excess oil along with ignition by a static electricity charge, could cause a potential reaction with oxygen.

Hyperventilation. The symptoms of hyperventilation and hypoxia are somewhat related and often are misunderstood. The FAA defines hyperventilation as follows: "Hyperventilation, or over breathing, is a disturbance of respiration that may occur in individuals as a result of emotional stress, fright or pain". The respiratory center of the brain reacts to the amount of carbon dioxide found in the blood stream. When you are in a physically relaxed state, the amount of carbon dioxide in your blood stimulates the respiratory center and your breathing rate is stabilized at about 12 to 20 breaths per minute. When physical activity occurs the body cells use more oxygen and more carbon dioxide is produced. Excessive carbon dioxide enters the blood and subsequently the respiratory center responds to this, and breathing increases in depth and rate to remove the over supply of carbon dioxide. Once the excess carbon dioxide is removed, the respiratory center causes the breathing rate to change back to normal.

To check for hypoxia or hyperventilation:

1. Check your oxygen equipment immediately. See if there is oxygen and the flow is at the proper rate for the altitude you are. The use of Nelson flow meters will verify if your system is working properly.
2. After three or four deep breaths of oxygen, the symptoms should improve markedly if the condition experienced was hypoxia. (Recovery from hypoxia is extremely rapid).
3. If the symptoms persist, you should consciously slow your breathing rate until symptoms clear and then resume your normal breathing. You can also breath into a bag, or talk aloud to overcome symptoms of hyperventilation.

Under conditions of emotional stress, fright or pain, the pilot's lung ventilation may increase, although the carbon dioxide output of the body cells remains at a resting level. As a result, he "washes out" carbon dioxide from his blood.

The most common symptoms are dizziness; hot and cold sensations, tingling of the lips and hands, legs, and feet; rapid heart rate; blurring of vision; muscle spasms; sleepiness; and finally unconsciousness.

After becoming unconscious, the breathing rate will be exceedingly low until enough carbon dioxide is produced to stimulate the respiratory center. Hyperventilation occurs as a result of the body's normal compensatory response to hypoxia.

However, excessive breathing does little good in overcoming hypoxia. Several aircraft accidents have been traced to probable hyperventilation. It is recommended that you induce hyperventilation by voluntarily breathing several deeps breaths at an accelerated rate (not while flying). You will begin to get some of the symptoms mentioned. Once you experience several of these symptoms, return to your normal rate of breathing. After you become familiar with the early warnings your body gives you, the likelihood of an accident caused by hyperventilation will be reduced. Caution: Do not hyperventilate while alone or in a standing position. You may fall and injure yourself.

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FAA Publications.

Strangely enough, the FAA does not have any publications available that cover the use of oxygen in general aviation. There is an excellent manual that is only given out when you go for an FAA Altitude Chamber ride.

Nitrogen Considerations.

There is a new breathing problem with the advent of the high rate of climb 250+ horsepower homebuilts. Substained rates of climb in excess of 2,000 feet per minute are possible with the Glasair and Lancair type of aircraft. Total time to climb to 20,000 feet can be less than 10 minutes. Problem here is that the average person's body cannot adapt to that change of altitude in that time period. I understand that it takes at least 20 minutes for the body to adjust to that change. The problem is nitrogen gas bubbles in the body. This is called "the Bends", the same problem that can occur in deep sea diving. Extreme pain can occur and if a nitrogen gas bubble occurs in the brain, death can occur. Climbing to 25,000 feet makes the possibility of the bends even more so. Some people may make it to 20,000 feet OK, but a even greater number of people may not make it to 25,000 feet in these short time periods.

To make things worse, there are no FAA requirements or recommendations about the effects of high rates of climb. Hopefully the FAA will and the manufactures of these aircraft will advise pilots about these problems. There are two ways of solving the problem for most situations. One is to limit the climb to 20,000 feet to less than 1,000 feet per minute. The other suggestion is to put on the oxygen soon as you start the engine and let your body start adapting sooner.

Flow Meters

A device visually indicating the flow of oxygen must be used with each breathing device. Typically what is supplied is an indicator in line between the breathing device and the hose connector. This in line type of indicator is operated by the flow of oxygen. As soon as there is aflow of oxygen, the red indication is replaced with a green reading. The change from red to green only shows that there is a flow of oxygen (which is the only thing the FAA requires). The green indication does not tell you that the system is working properly. As a matter of fact, the green indication on some of the red/green indicators will operate with a flow of oxygen required for less than 5,000 feet. You could actually be flying at 25,000 feet with the flow indicator showing green, but actually only have enough oxygen for 5,000 feet. In our opinion the typical red/green indicator is practically worthless and potentially very dangerous. The Nelson flow meters replace the red/green indicator.

To reduce the possibilities of hypoxia, the Nelson flow meters provide a fail safe means of visually observing the actual oxygen flow to the breathing device as well as providing a means to adjust the flow of oxygen as required.

Types of Oxygen Systems

There are several types of oxygen systems commonly found in general aviation aircraft:

1. Constant flow.
2. Altitude adjustable.
3. Altitude compensating.

Each type has advantages and disadvantages.

Constant Flow Systems.

The most common and lowest cost system found in general aviation is the constant flow type. The basic system includes three parts: the cylinder(s), regulator, and manifold system.

The cylinder is common to all systems. It can be made from steel, aluminum, or composites. The tank pressure is usually less than 2,200 pounds per square inch (psi). The regulators which step down the pressure from 2200 psi to 20-75 psi can be attached separately from the cylinder(s) or directly screwed onto the cylinder. Most regulators are of the diaphragm type. They typically hold a constant output pressure between 20 and 75 pounds, depending on the manufacturer, from either a full cylinder to one that is almost empty. A manifold system is built into the regulator for portable systems. For built-in systems there is a manifold system installed in the aircraft. The manifold system operates at the 20-75 pound pressure, and not the 2,000+ pounds cylinder pressure.

The constant flow type provides the same output pressure or flow regardless of altitude. There is virtually no maintenance required. It is low in cost and well as low in weight. The regulator output is typically 2.5 to 3.0 litres per minute at a regulated line pressure of 25 to 75 pounds. The output is controlled by a small orifice in the regulator itself or most commonly done by the connector going into the manifold system. The connector orifice can be a hole as small as .012 inches in diameter. Cessna aircraft with factory supplied built in oxygen systems use a constant flow type of system manufactured by Puritan. Most portable systems are also of the constant flow type.

We strongly recommend the manifold output pressure of all constant flow systems, Cessna built in systems in particular, be checked for factory recommended output pressure at least during the annual. This may or may not be a required check during the annual, but it should be. We found one customer's Cessna 210 that had a line pressure in excess of 200 pounds. The correct pressure should be about 70 pounds for the Cessna's built in Puritan system. Excess manifold pressure from the oxygen regulator can cause the hose going to a flow control device to burst.

The disadvantage of the constant flow system is that there is a waste of oxygen at lower oxygen altitudes. The system typically provides the pilot a flow of 2.5 litres per minute. This is the correct amount of oxygen at 25,000 feet. However, if the aircraft were only at 15,000 feet, only 1.5 litres per minute are required. There is a waste of 1 litre per minute of oxygen. The excess oxygen used has no serious medical effect other than drying out your nose quickly. Obviously, however there is an economic disadvantage.

Using a Nelson flow meter with a constant flow oxygen system eliminates the non required high flow rate of oxygen. The savings can be over 100%.

By setting the flow to what you actually need, two things are accomplished. The saving of oxygen is accomplished thus extending the use of oxygen in your aircraft or lowering oxygen costs. You also have improved the safety at oxygen altitudes by knowing that the system is working properly. If the floating ball is at the correct altitude setting, then everything is working properly.

With the Nelson flow meter used in a constant flow oxygen system you can have your cake and eat it too. The economical constant flow system with the addition of a low cost Nelson flow meter will provide you with a system that is reliable, safe, and economical.

Altitude Adjustable Systems.

An altitude adjustable oxygen system is similar to the constant flow system except there is an adjustable control to set the necessary flow. This adjustment is accomplished by turning a control knob so a reading on a gauge, calibrated in altitude, is the same as the aircraft's altimeter setting. There is a significant saving in oxygen, since you are not wasting the excess flow of oxygen. Not many built in systems use this type. However some portable systems have this feature. The military surplus A8A regulators of the altitude adjustable type are commonly used in many sailplanes.

One disadvantage to this type of system, other than it costs more, is that there is no positive indication of flow to the individual breathing devices. You cannot adjust individually the flow of oxygen to each of the breathing devices. Not all people require the same amount of oxygen (for example the smoker). The red/green indicator is commonly used to show flow. As previously mentioned, this doesn't tell you that the system is working properly.

The Nelson flow meters can effectively be used with this type of system. The flow meter can be set wide open.and the resulting flow from the altitude adjusting system can be observed in the flow meter. What is recommended is to have at least one Nelson flow meter installed so the pilot can monitor the resulting flow from the altitude adjustments made on the flow adjustment control on the regulator.

What most users do is to turn the altitude adjustment to the service ceiling of the aircraft and leave it there all the time. Do the adjusting on each of the Nelson flow meters. That way you can individually adjust each breathing station as required.

Altitude Compensating Systems.

The altitude compensating system is similar to the altitude adjustable systems except that the adjustment is done automatically instead of manually setting the flow rate to an altitude gauge. Beechcraft and Mooney use this type of system. Also, some portable systems have this feature. The systems work quite well in the automatic mode. There are again disadvantages to this type of system. Some systems do not turn on or provide any oxygen until the system is at 8 to 10,000 feet. If you want oxygen at a lower altitude, you are out of luck. Like the altitude adjustable system, you cannot individually adjust the flow of oxygen since all of the outlets are controlled by the automatic system. If there is a person on board who requires extra oxygen, you cannot provide additional oxygen for that person. In addition, usually there is no actual flow meter available to indicate if the automatic flow control device is working properly. The use of a Nelson Flow Meter in the pilots station will tell you if the automatic system is working properly.

http://www.c-f-c.com/supportdocs/abo1.htm

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Contact:cfc@c-f-c.com <mailto:cfc@c-f-c.com>