LECTURES IN BIOMEDICAL ENGINEERING

MEDICAL GASES
OXYGEN CONCENTRATORS
SUCTION PUMPS
VENTILATORS

2020

UHANDISI WA BIOMEDICAL

GESI ZA MATIBABU
WATAFITI WA OKSIJENI
SAMPU PAMPU
VENTILATORS

Medical gases

WHAT ARE MEDICAL GASES?

Take a deep breath. That air that you are breathing is about 78% Nitrogen, 21% Oxygen and 1% everything else. Breathe out again, and the air you exhale has lost some Oxygen (now 16%) and gained some Carbon-Dioxide (about 5%). There is also water, dust, pollen, virus particles, smoke and any number of other contaminants in room air.

Now, lets say you injure a lung and it doesn't work properly. If you could then breathe 100% Oxygen instead of normal air (21% O2), then the remaining lung will be able to better oxygenate your blood and keep your tissues healthy. If, however, you are a newborn baby and your eyes are still developing, we would only want to give at most 40% Oxygen to avoid a condition called *retinopathy of prematurity* - blindness in infants. So there is value in being able to vary the proportion of Oxygen in a therapeutic gas.

Gezi Za Matibabu

GESI ZA MATIBABU NI NINI?

Vuta pumzi. Hewa hiyo unayoipumua ni karibu na 78% Nitrojeni, oksijeni 21% na 1% kila kitu kingine. Pumua tena, na hewa unayoipoteza imepoteza oksijeni (sasa 16%) na ikapata Carbon-Dioxide (karibu 5%). Kuna pia maji, vumbi, poleni, chembe za virusi, moshi na idadi yoyote ya uchafu mwingine katika hewa ya chumba.

Sasa, hebu sema unaumia mapafu na haifanyi kazi vizuri. Ikiwa unaweza kupumua oksijeni 100% badala ya hewa ya kawaida (21% O2), basi mapafu iliyobaki yataweza kuboresha damu yako na kuweka tishu zako kuwa na afya. Ikiwa, hata hivyo, wewe ni mtoto mchanga na macho yako bado yanaendelea, tunataka tu kutoa oksijeni zaidi ya 40% ili kuepusha hali inayoitwa retinopathy ya utangamano - upofu kwa watoto wachanga. Kwa hivyo kuna thamani ya kuweza kubadilisha idadi ya oksijeni katika gesi ya matibabu.

Meanwhile, if you have a weak heart, you might receive an intra-aortic balloon - a device that takes the load off the heart's left-ventricle by pushing blood out of the aorta. The balloon needs to be rapidly inflated and deflated using a low-viscosity gas; these balloons are driven by medical-grade Helium.

Also, if you are having abdominal surgery and you don't want a great big scar, you may wish to have laparoscopic surgery (you may have heard of "keyhole surgery"). To do this, a surgeon will inflate your abdomen with Carbon-Dioxide so that there is more room to see and move.

To prepare you for surgery, an anaesthetist will knock you out using Nitrous Oxide (N2O) as a carrier gas for the anaesthetic agent. During childbirth or dental surgery you may also need to breathe Nitrous Oxide to reduce the pain of labour or of tooth extraction. There are various other medical gases, but in hospitals, you will find medical-grade Oxygen, air, Nitrous-Oxide and a few others. Let's talk about bottled supplies first.

Wakati huo huo, ikiwa una moyo dhaifu, unaweza kupokea puto ya ndani - kifaa ambacho huondoa mzigo kwenye eneo la kushoto la moyo kwa kusukuma damu nje ya aorta. Puto inahitaji kuongezeka kwa kasi na kuharibiwa kwa kutumia gesi yenye mnato wa chini; baluni hizi zinaendeshwa na daraja la matibabu Helium.

Pia, ikiwa unafanya upasuaji wa tumbo na hautaki kovu kubwa, unaweza kutamani kufanyia upasuaji wa laparoscopic (labda umesikia "upasuaji wa kisima"). Ili kufanya hivyo, daktari wa upasuaji atakuingiza tumbo lako na Carbon-Dioxide ili kuna nafasi zaidi ya kuona na kusonga.

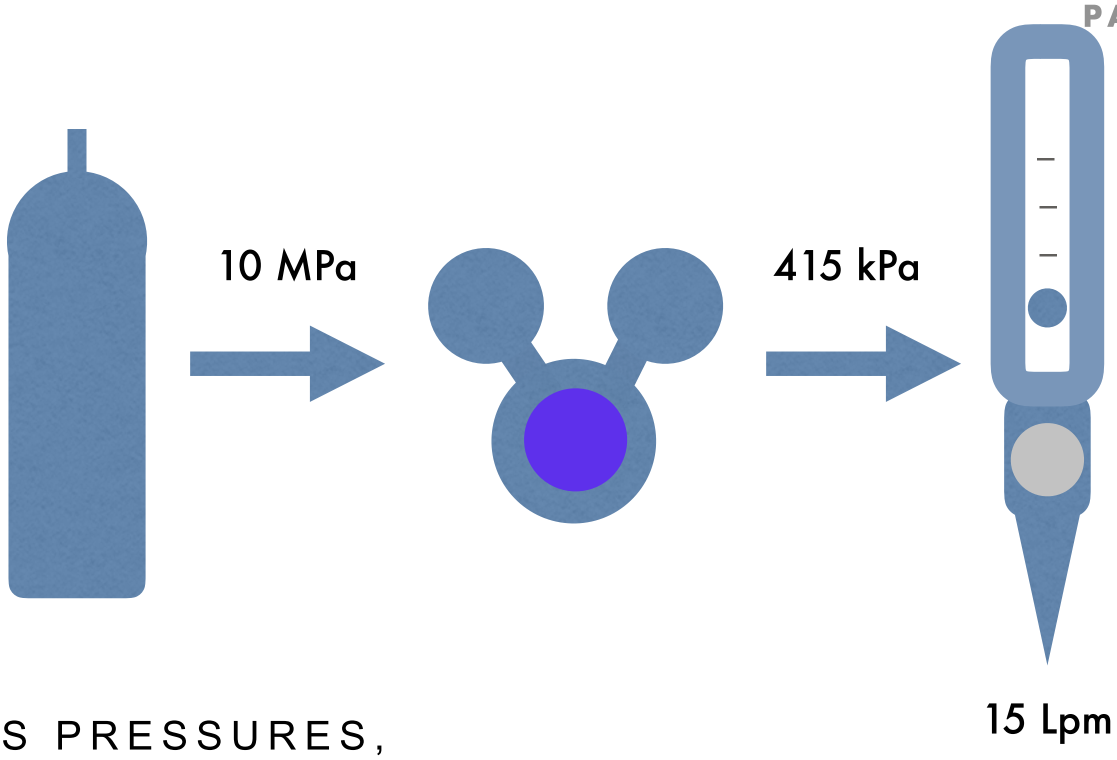
Ili kukuandaa kwa upasuaji, daktari wa watoto atakufukuza kwa kutumia Nitrous Oxide (N2O) kama gesi ya kubeba kwa wakala wa anesthetic. Wakati wa kuzaa au upasuaji wa meno unaweza pia kuhitaji kupumua Nitrous Oxide ili kupunguza maumivu ya kazi au uchimbaji wa meno. Kuna gesi zingine tofauti za matibabu, lakini katika hospitali, utapata oksijeni ya kiwango cha matibabu, hewa, Nitrous-Oxide na wengine wachache. Wacha tuzungumze juu ya vifaa vya chupa kwanza.

WARNING! HYPOXIA

Some medical gases contain no Oxygen. If these are breathed directly, asphyxiation, brain damage and death can occur.

ONYO! HYPOXIA!

Gesi zingine za matibabu hazina oksijeni. Ikiwa haya yamepumuliwa moja kwa moja, pumu, uharibifu wa ubongo na kifo vinaweza kutokea.



GAS PRESSURES, FLOWS AND DEVICES

GAS PRESSURES

So, generally, there are three pressures you will need to keep in your head when dealing with medical gases. Let's call them *mains pressure, line pressure* and *low pressure*. Starting with *mains,* we are dealing with the enormous pressures that are kept inside a pressurised gas bottle or cylinder. A full cylinder has about 10 MPa in it and its pressure will decrease linearly[1] with the remaining gas volume, until it is all but consumed. There is an exception to this rule, but to understand this, we must talk about the regulated or *line* pressure.

SHINIKIZO LA GESI, MTIRIRIKO NA VIFAA

SHINIKIZO LA GESI

Kwa hivyo, kwa ujumla, kuna mashiko matatu ambayo utahitaji kuweka katika kichwa chako wakati wa kushughulika na gesi za matibabu. Wacha tuwaite shinikizo la mains, shinikizo la mstari na shinikizo la chini. Kuanzia na mains, tunashughulika na shinikizo kubwa ambazo huhifadhiwa ndani ya chupa au silinda iliyoshinikizwa ya gesi. Silinda kamili ina MPa 10 ndani yake na shinikizo lake litapungua kwa usawa na kiasi kilichobaki cha gesi, hadi yote itakapomalizika. Kuna ubaguzi kwa sheria hii, lakini kuelewa hii, lazima tuzungumze juu ya shinikizo iliyodhibitiwa au ya mstari.

1 Remember Boyle's law - if the temperature and cylinder capacity are fixed, the pressure will be proportional to the remaining gas volume. This means that you can use pressure gauge on a cylinder to indicate remaining volume.

The *line* pressure is usually fixed throughout a site or institution. Where I work it is typically 415 kPa. This is a relatively high pressure - you wouldn't want it anywhere near your face, for instance - but it is a good working pressure for a lot of medical equipment. To get from 10 MPa down to 415 kPa, you need a regulator. We'll look closer at regulators in a minute, but for now, you should understand that they are a device that *fixes* the output pressure regardless of *changes* in the input pressure. Remember our cylinder? Its gas pressure can go from 10 MPa down to almost zero (actually lets draw the line at 1 MPa = 1000 lkPa). The regulator will produce the same[2] output regardless.

Lastly, some medical device sits on the end of this high-pressure supply and consumes gas steadily. Whatever happens, at the end of the process, all devices vent to atmospheric pressure. Some are designed to essentially produce a known flow rate of a therapeutic gas - typically these are in the range of 5-10 litres-per-minute (lpm) for supplemental O2 or nebuliser gas delivery. If the supply of these is blocked, the pressure can rise to just about anything, so most such devices has some kind of pressure relief valve.

Shinidi ya mstari kawaida huwekwa katika tovuti au taasisi. Ambapo mimi hufanya kazi ni kawaida 415 kPa. Huu ni shinikizo la juu sana - hautalitaka mahali popote karibu na uso wako, kwa mfano - lakini ni shinikizo zuri la kufanya kazi kwa vifaa vingi vya matibabu. Ili kutoka 10 MPa hadi kilo 415, unahitaji mdhibiti. Tutaangalia karibu wasimamizi kwa dakika moja, lakini kwa sasa, unapaswa kuelewa kuwa ni kifaa ambacho hurekebisha shinikizo la matokeo bila kujali mabadiliko katika shinikizo la kuingiza. Kumbuka silinda yetu? Shinikizo lake la gesi linaweza kwenda kutoka MPa 10 hadi karibu sifuri (kwa kweli inacha kuchora mstari kwa 1 MPa = 1000 lkPa). Mdhibiti atatoa mazao sawa bila kujali.

Mwishowe, kifaa kingine cha matibabu kinakaa mwisho wa usambazaji huu wa shinikizo kubwa na hutumia gesi polepole. Chochote kinachotokea, mwisho wa mchakato, vifaa vyote huingia kwa shinikizo la anga. Baadhi imeundwa kutoa kimsingi kiwango cha mtiririko wa gesi ya matibabu - kawaida hizi ziko katika anuwai ya lita 5 hadi 10 kwa dakika (lpm) kwa O2 au utoaji wa gesi ya nebuliser. Ikiwa usambazaji wa haya umezuiliwa, shinikizo linaweza kuongezeka kwa karibu kila kitu, kwa hivyo vifaa vingi vile vina aina fulani ya valve ya misaada ya shinikizo.

[2] Except for common-mode properties, which we'll get to shortly

ATMOSPHERIC PROBLEMS

Some people find it easy to think of atmospheric pressure as a *real* pressure at 1 atm = 101.3 kPa, or as a *zero pressure* reference. If you can switch between the two easily, you should have no trouble dealing with gas pressures. If you are good at electrical theory, you will remember that an earth or reference node is arbitrarily set at zero volts, even though the actual earth has current flowing at different times and places. It is similar with gases: you can decide that the room pressure is zero, in the sense that it won't change, regardless of how much gas you pump in to it.

If you are good with chemistry, you may be more comfortable thinking of pressure as a version of chemical concentration for gases - that is, the more pressure, the higher the effective concentration from a reaction point of view. In *that* case, an absolute vacuum has zero pressure (and zero chemical concentration), and a typical atmosphere has heaps of gas molecules and a very non-zero pressure of 101.3 kPa.

SHIDA ZA ATMOSPHERIC

Watu wengine wanaona ni rahisi kufikiria shinikizo la anga kama shinikizo halisi kwa 1 atm = 101.3 kPa, au kama kumbukumbu ya shinikizo zero. Ikiwa unaweza kubadilisha kati ya hizo mbili kwa urahisi, haifai kuwa na shida ya kushughulika na shinikizo za gesi. Ikiwa wewe ni mzuri kwa nadharia ya umeme, utakumbuka kuwa dunia au nodi ya kumbukumbu imewekwa kiholela kwa volts zero, ingawa dunia halisi ina mtiririko wa sasa kwa nyakati na mahali tofauti. Ni sawa na gesi: unaweza kuamua kuwa shinikizo ya chumba ni sifuri, kwa maana kwamba haibadilika, bila kujali ni gesi ngapi unasukuma ndani.

Ikiwa wewe ni mzuri na kemia, unaweza kuwa vizuri kufikiria shinikizo kama toleo la mkusanyiko wa kemikali kwa gesi - ambayo ni, shinikizo zaidi, juu ya mkusanyiko mzuri kutoka kwa maoni ya athari. Katika hali hiyo, utupu kabisa una shinikizo ya sifuri (na mkusanyiko wa kemikali sifuri), na mazingira ya kawaida yana chungu ya molekuli za gesi na shinikizo isiyo ya sifuri ya 101.3 kPa.

GAS BOTTLE SAFE HANDLING

- Gas bottles are high pressure at 10,000 kPa!
- Put the cap on!
- Put the chains on!
- Use a trolley if possible
- Get help to move it

UTUNZAJI SALAMA WA CHUPA YA GESI

- Chupa za gesi ni shinikizo kubwa kwa 10,000 kPa!
- Weka kofia!
- Weka minyororo!
- Tumia trolley ikiwa inawezekana
- Pata msaada wa kuihama

In medical devices, the language sneakily goes between both concepts. For instance, a ventilator delivers pressure to a patient at 10 cmH2O (referenced above an atmosphere with a reference pressure of 0 cmH2O), and that gas has a partial pressure of Oxygen that is 21% of one atmosphere - this is a reference to a typical O2 partial pressure for one non-zero atmostphere's gas composition. In this space, you will need to be able to move seamlessly between the two concepts, but for bottled gases and regulators, we are talking about pressure *relative* to an atmospheric pressure of zero.[3]

Katika vifaa vya matibabu, lugha hujificha kati ya dhana zote mbili. Kwa mfano, mvukeji wa hewa hutoa shinikizo kwa mgonjwa kwa 10 cmH2O (iliyorejelewa juu ya anga na shinikizo ya kumbukumbu ya 0 cmH2O), na kwamba gesi ina shinikizo la Oksijeni ambalo ni 21% ya mazingira moja - hii ni kumbukumbu ya kumbukumbu. shinikizo la kawaida la O2 kwa muundo wa gesi moja isiyo ya sifuri. Katika nafasi hii, utahitaji kuweza kusonga mbele kati ya dhana hizi mbili, lakini kwa gesi na vidhibiti vya chupa, tunazungumza juu ya shinikizo linalohusiana na shinikizo la anga la sifuri.

[3] In instrumentation, this is sometimes described as *gauge* pressure as a physical gauge is really comparing the pressure on either side of a spring/diaphragm, as opposed to *absolute* pressure, where the instrument is comparing pressure to absolute zero. Nearly all working pressures are *gauge* pressures, unless you are measuring the local atmostpheric pressure itself with an *absolute*-pressure instrument.

A NOTE ON THE LUNGS AND MECHANICAL VENTILATION

If you think about the way your lungs work, the gas-exchange tissue need not be very strong. When you want to inhale, you breathe in by having your diaphragm move downwards, expanding the volume within your chest and decreasing the pressure. The pressure differential (non-zero atmospheric pressure here!) causes gas to flow from the atmosphere into your lungs. When your diaphragm pushes upwards, the lung pressure is higher and gas is pushed out into the atmosphere. These pressures are relatively small and very close to atmospheric pressure throughout each breath-cycle. Meanwhile, if you have a device putting 10 lpm into your lungs, the pressure can rise *very* quickly and the lungs may rupture leading to catastrophic injury. As a biomedical engineer, you must always check your relief valves. There is further discussion of ventilators below.

UJUMBE KWENYE MAPAFU NA UINGIZAJI HEWA WA MITAMBO

Ikiwa unafikiria juu ya jinsi mapafu yako inavyofanya kazi, tishu za kubadilishana gesi hazihitaji kuwa na nguvu sana. Unapotaka kuvuta pumzi, unapumua kwa kufanya diaphragm yako isongee chini, kupanua kiasi ndani ya kifua chako na kupunguza shinikizo. Tofauti ya shinikizo (shinikizo isiyo ya sifuri ya anga hapa!) Husababisha gesi kutiririka kutoka angani kwenda kwenye mapafu yako. Wakati diaphragm yako inasukuma juu, shinikizo la mapafu ni kubwa na gesi inasukuma nje angani. Shiniki hizi ni ndogo na ni karibu sana na shinikizo za anga katika kila mzunguko wa pumzi. Wakati huo huo, ikiwa unayo kifaa cha kuweka 10 jioni ndani ya mapafu yako, shinikizo linaweza kuongezeka haraka sana na mapafu yanaweza kupasuka na kusababisha jeraha la janga. Kama mhandisi wa biomedical, lazima uangalie valves zako za misaada kila wakati. Kuna majadiliano zaidi ya viingilizi chini.

GAS BOTTLE INSPECTION

- Look for colour coding on bottles
- Check labels, dates, heat indicator
- Look for rust and damage
- Check cylinder, regulator and yoke fittings

GAS BOTTLE INSPECTION/UKAGUZI WA CHUPA YA GESI

- Tafuta utengenezaji wa rangi kwenye chupa
- Angalia lebo, tarehe, kiashiria cha joto
- Tafuta kutu na uharibifu
- Angalia silinda, mdhibiti na vifaa vya nira

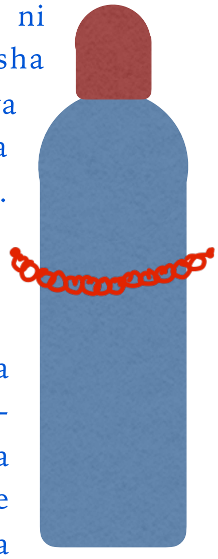
BOTTLED GASES

By understanding bottled[4] gases, we can get a feel for the use and handling of gases. There are other ways to use generate and use gases that we will get to shortly.

The thing about bottled gases is that they essentially separate gas production from consumption by providing a practical gas transport and storage container. By manufacturing a steel gas bottle, an enormous quantity of gas (a bit less than 10 cubic metres of uncompressed gas can fit in a G-size cylinder). There are risks associated with high-pressure gas storage: a cylinder failure can result in a deadly explosion, not to mention loss of therapeutic supply. There are many safe-handling measures and inspection standards and controls that are used in my home country to keep cylinders from bursting. In the developing world you may come upon old cylinders that are prone to rust and damage.

VIPU VYA CHUPA

Kwa kuelewa gesi zilizo na chupa, tunaweza kupata hisia kwa matumizi na utunzaji wa gesi. Kuna njia zingine za kutumia kutengeneza na kutumia gesi ambayo tutapata kwa muda mfupi mfupi.



Jambo juu ya gesi ya chupa ni kwamba kimsingi hutenganisha uzalishaji wa gesi kutoka kwa matumizi kwa kutoa usafiri wa gesi na chombo cha kuhifadhia. Kwa kutengeneza chupa ya gesi ya chuma, gesi kubwa (kiasi cha chini ya mita za ujazo 10 za gesi isiyo na shinikizo inaweza kutoshea kwenye silinda ya G-saizi). Kuna hatari zinazohusiana na uhifadhi wa gesi yenye shinikizo kubwa: kutofaulu kwa silinda kunaweza kusababisha mlipuko mbaya, bila kutaja upotezaji wa usambazaji wa matibabu. Kuna hatua nyingi za utunzaji salama na viwango vya ukaguzi na udhibiti ambao hutumiwa katika nchi yangu kuweka silinda kutoka kupasuka. Katika ulimwengu unaoendelea unaweza kuja kwenye mitungi ya zamani ambayo huwa na kutu na uharibifu.

[4] I prefer the terms “bottle” rather than “cylinder”, although both are used in the profession.

In some places, cylinders are only rented and may be maintained and refilled by the gas supplier. They may be delivered on pallets as part of a bulk supply system. Let's have a look at some bottles.

Katika maeneo mengine, silinda hukodishwa tu na inaweza kudumishwa na kujazwa tena na muuzaji wa gesi. Inaweza kutolewa kwenye pallets kama sehemu ya mfumo wa usambazaji wa wingi. Wacha tuangalie chupa kadhaa.

COLOUR CODES

The contents of each cylinder is indicated by the colour painted on the outside. There are national standards for these and they tend to follow through with matching colours for the associated gas hoses, attachments and devices.

In Australia, it is *white* for Oxygen and *black-and-white* for medical air. There are a few other medical colours, such as *blue* for Nitrous-Oxide, *brown* for Helium and *grey* for CO2. Oh, and these are just the coding on the shoulder of the cylinder; on the body you would normally see white for medical gases, but not always and an uppercase *N* to show that it is from the *NEW* colour-coding standard. This means that old cylinders may contain the same gas but be coloured differently; different countries have different colour-coding standards and so on. It is a mess, but too bad - if you want to make the world a better place, get used to dealing with messy circumstances.

KARATASI ZA RANGI

Yaliyomo ndani ya silinda yote yanaonyeshwa na rangi iliyochwa nje. Kuna viwango vya kitaifa vya haya na huwa kawaida kufuata na rangi inayolingana kwa hoses za gesi zinazohusiana, viambatisho na vifaa.

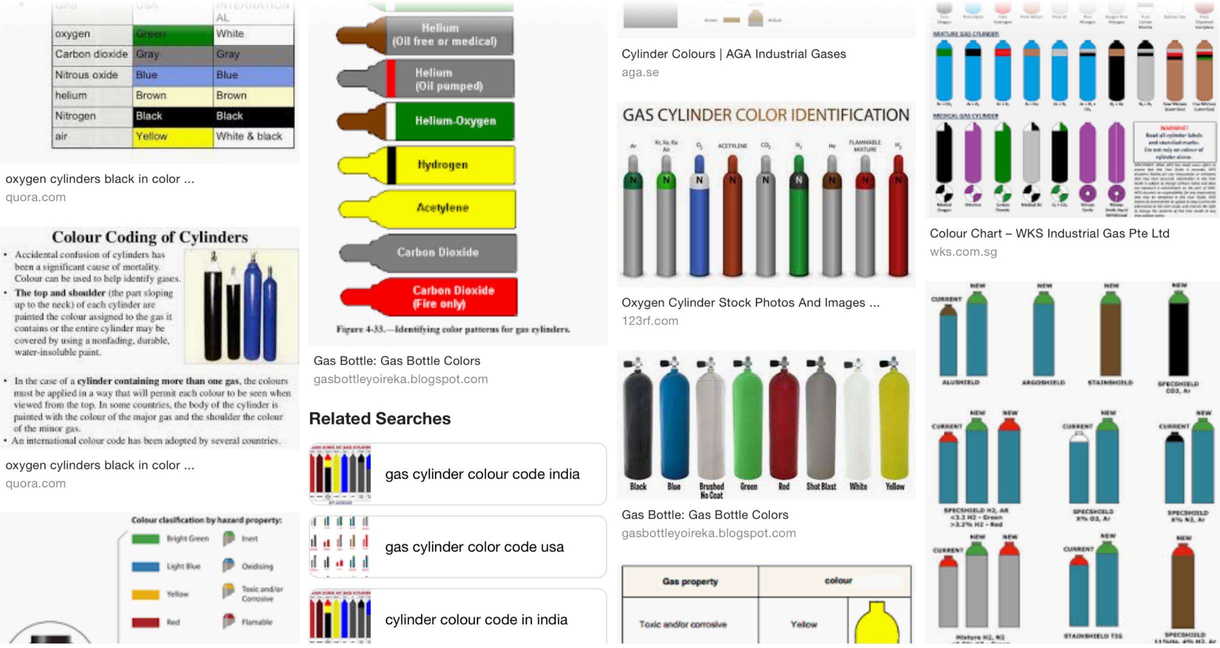
Huko Australia, ni nyeupe kwa oksijeni na nyeusi-na-nyeupe kwa hewa ya matibabu. Kuna rangi zingine chache za matibabu, kama vile rangi ya bluu kwa Nitrous-Oxide, hudhurungi kwa Helium na kijivu kwa CO2. Lo, na haya ni kuweka tu kwenye bega la silinda; juu ya mwili kawaida utaona nyeupe kwa gesi ya matibabu, lakini sio kila wakati na alama ya juu ya N kuonyesha kuwa ni kutoka kwa kiwango kipya cha kuweka alama. Hii inamaanisha kuwa mitungi ya zamani inaweza kuwa na gesi ile ile lakini ikapakwa rangi tofauti; nchi tofauti zina viwango tofauti vya utengenezaji wa rangi na kadhalika. Ni fujo, lakini mbaya sana - ikiwa unataka kuifanya dunia kuwa mahali pazuri, jizoea kushughulika na hali mbaya.

GAS BOTTLE SIZES

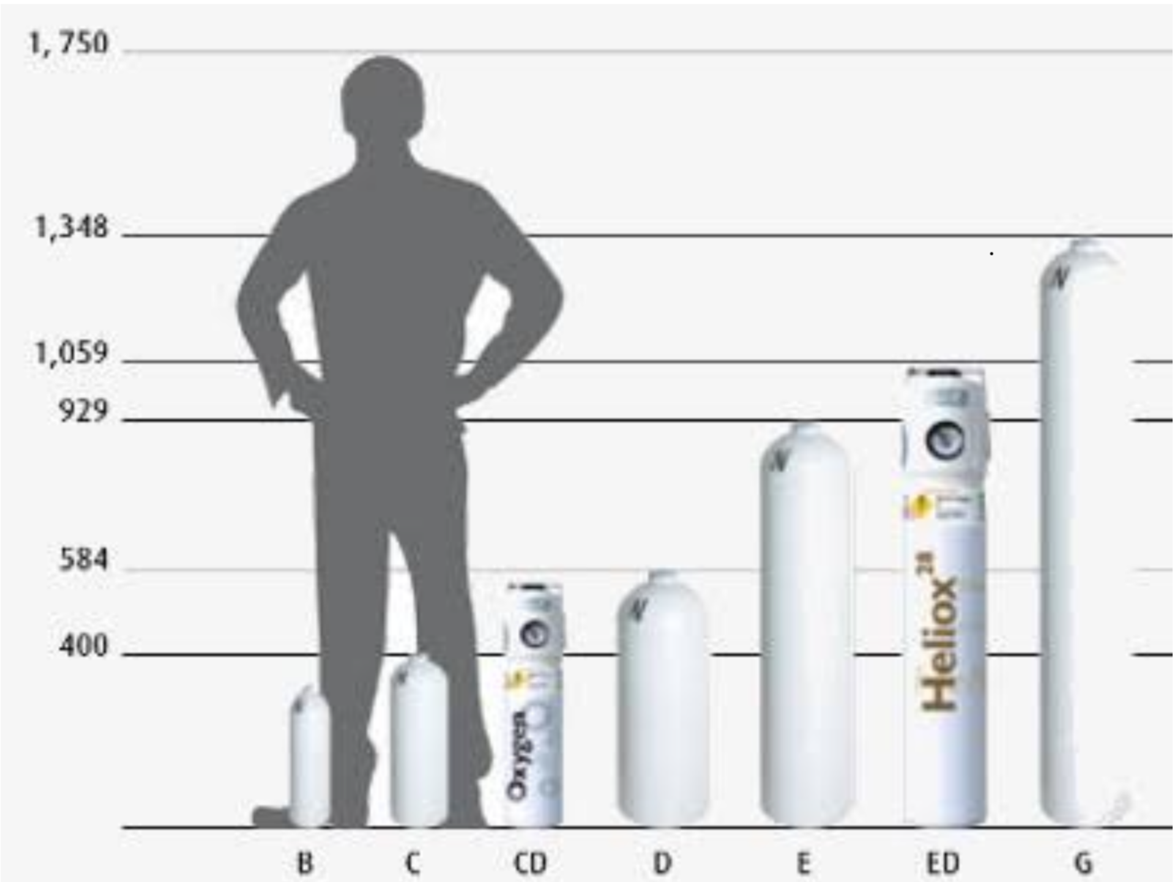
In my work, nearly all bottled gas is either *C* or *G* size, although other sizes exist. *C* is a good size for personal and portable gas therapy and resuscitation devices. *G* is a good size for bulk gas storage and manifolds. In general, your site will be dominated by only a few sizes, but you might find a wider variation across different healthcare services or sites in your region.

SISI ZA BOTI ZA GESI

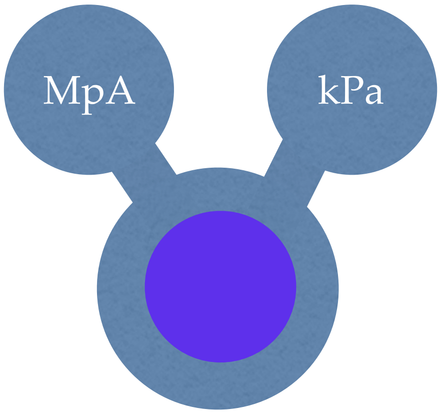
Katika kazi yangu, karibu gesi zote za chupa ni ukubwa wa C au G, ingawa saizi zingine zipo. C ni saizi nzuri kwa tiba ya gesi ya kibinafsi na ya portable na vifaa vya kufufua. G ni saizi nzuri kwa uhifadhi wa gesi nyingi na vitu vingi. Kwa ujumla, wavuti yako itatawaliwa na saizi chache tu, lakini unaweza kupata tofauti zaidi katika huduma tofauti za huduma za afya au tovuti katika eneo lako.



oxygen | Green | White
Carbon dioxide | Gray | Gray
Nitrous oxide | Blue | Blue
helium | Brown | Brown
Nitrogen | Black | Black
air | Yellow | White & black
oxygen cylinders black in color ...
quora.com
Colour Coding of Cylinders
Accidental confusion of cylinders has been a significant cause of mortality. Colour can be used to help identify gases.
The top and shoulder (the part sloping up to the neck) of each cylinder are painted the colour assigned to the gas it contains or the entire cylinder may be covered by using a nonfading, durable, water-insoluble paint.
In the case of a cylinder containing more than one gas, the colours must be applied in a way that will permit each colour to be seen when viewed from the top. In some countries, the body of the cylinder is painted with the colour of the major gas and the shoulder the colour of the minor gas.
An international colour code has been adopted by several countries.
oxygen cylinders black in color ...
quora.com
Colour clasification by hazard property:
Bright Green
Inert
Light Blue
Oxidising
Yellow
Toxic and/or Corrosive
Red
Flamable
Helium (Oil free or medical)
Helium (Oil pumped)
Helium-Oxygen
Hydrogen
Acetylene
Carbon Dioxide
Carbon Dioxide (Fire only)
Figure 4-33.—Identifying color patterns for gas cylinders.
Gas Bottle: Gas Bottle Colors
gasbottleyoireka.blogspot.com
Related Searches
gas cylinder colour code india
gas cylinder color code usa
cylinder colour code in india
Cylinder Colours | AGA Industrial Gases
aga.se
GAS CYLINDER COLOR IDENTIFICATION
Oxygen Cylinder Stock Photos And Images ...
123rf.com
Black
Blue
Brushed No Coat
Green
Red
Shot Blast
White
Yellow
Gas Bottle: Gas Bottle Colors
gasbottleyoireka.blogspot.com
Gas property
colour
Toxic and/or corrosive
Yellow
Colour Chart – WKS Industrial Gas Pte Ltd
wks.com.sg



1, 750
1,348
1,059
929
584
400
Oxygen
Heliox28
B
C
CD
D
E
ED
G



MEDICAL GAS REGULATORS/

USAJILI WA GESI YA KAWAIDA

The magic done by a regulator is to convert a widely-varying mains-pressure or bottled gas pressure down to a useful, steady line-pressure. The secret here is a spring-loaded diaphragm. The diaphragm is usually just a rubber disc, sometimes with a metal backing plate.

Uchawi unaofanywa na mdhibiti ni kubadili shinikizo-tofauti-za-maini au shinikizo la gesi iliyowekwa kwa chupa chini ya shinikizo muhimu na thabiti la laini. Siri hapa ni diaphragm ya spring iliyojaa. Diaphragm kawaida ni disc tu ya mpira, wakati mwingine na sahani ya msaada ya chuma.

REGULATOR MAINTENANCE

- 10 MPa in, 415 kPa out
- Needs a kit every 3 years
- Output pressure tends to drift: Needs a reference gauge and an Allen key to adjust.
- Has an emergency relief port

MATENGENEZO YA MDHIBITI

- MPa 10 ndani, 415 kPa nje
- Inahitaji kit kila miaka 3
- Shindano ya pato huelekea kuteleza: Inahitaji kipimo cha kumbukumbu na ufunguo wa Allen kurekebisha.
- Inayo bandari ya misaada ya dharura

On one side of the diaphragm you have the mains pressure; on the other side, the regulated line-pressure. The idea is this: You tension up a spring so that it pushes on the diaphragm with a fixed force. The diaphragm has a fixed area, so we have a fixed force-per-unit-area.

The diaphragm is built so that pushing on the high-pressure side causes a small needle-valve to close, while the pre-tensioned spring opposes that pressure, causing the needle valve to open. If the force from the gas supply on the high-pressure side is higher than the force from the spring, the valve tends to close, allowing only enough gas through to counteract the spring force. As the supply pressure drops, the spring causes the diaphragm to open the needle-valve slightly more to increase output flow and raise the line pressure.

Upande mmoja wa diaphragm una shinikizo la mains; kwa upande mwingine, kudhibitiwa kwa shinikizo la mstari. Wazo ni hili: Unachanganya chemchemi ili kusukuma diaphragm kwa nguvu iliyowekwa. Mchoro una eneo la kudumu, kwa hivyo tuna nguvu ya kudumu kwa kila eneo.

Mchoro umejengwa ili kusukuma kwa upande wa shinikizo kubwa husababisha valve ndogo ya sindano kufunga, wakati spring iliyokuwa na mvutano inapinga shinikizo hilo, na kusababisha valve ya sindano kufunguliwa. Ikiwa nguvu kutoka kwa usambazaji wa gesi kwa upande wa shinikizo-juu ni kubwa kuliko nguvu kutoka chemchemi, valve huelekea kufunga, ikiruhusu gesi ya kutosha tu kupingana na nguvu ya chemchemi. Wakati shinikizo la usambazaji linaposhuka, chemchemi husababisha diaphragm kufungua sindano-sindano kidogo zaidi ili kuongeza mtiririko wa pato na kuinua shinikizo la mstari.

REGULATOR MANAGEMENT

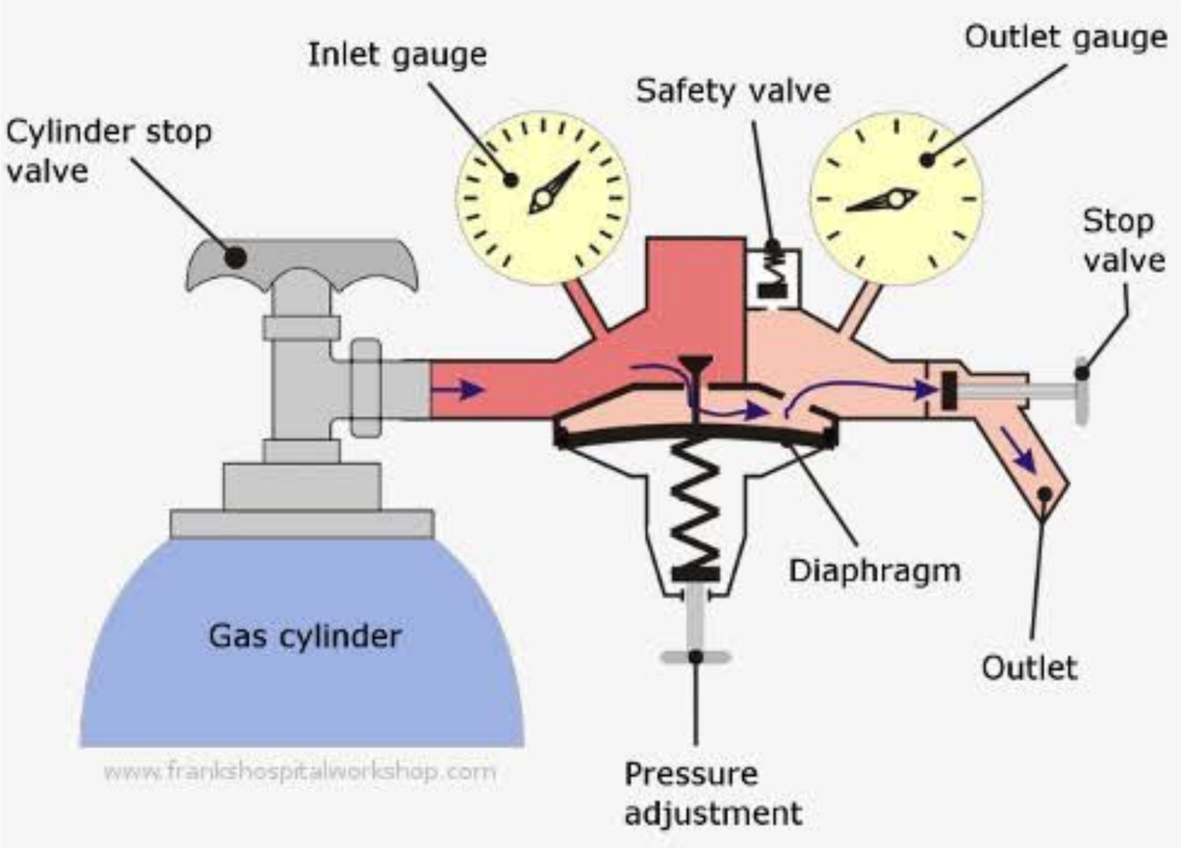
See if you can find the relevant standards for your region and compare them with the line pressure found at your hospital or site. When you find a regulator, check that its output is fixed to the line pressure.

USIMAMIZI WA MDHIBITI

Angalia ikiwa unaweza kupata viwango vinavyofaa kwa mkoa wako na kulinganisha na shinikizo ya mstari inayopatikana katika hospitali yako au tovuti. Unapopata mdhibiti, angalia kwamba pato lake limewekwa kwa shinikizo la mstari.

As you can see, the spring is acting as a mechanical equivalent for gas pressure, and the regulated pressure can be easily adjusted by turning a screw to increase or decrease the tension in the spring.

Kama unavyoona, chemchemi inafanya kazi kama sawa mitambo kwa shinikizo la gesi, na shinikizo lililodhibitiwa linaweza kubadilishwa kwa urahisi kwa kugeuza ungo kuongeza au kupunguza mvutano katika chemchemi.



GAS FITTINGS AND INDEXING

You can imagine that there is an enormous risk where the wrong gas is accidentally delivered to a patient. This infamously happened in my own country in 2016[5]. The main risk is where gases with no oxygen (such as Nitrous-Oxide, Carbon-Dioxide, Helium) are accidentally delivered in place of Oxygen. To mitigate this risk, there are several controls in place:

1. Colour coding of bottles
2. Pin-indexing of the yoke fittings on medical gas bottles
3. Ring-indexing of regulator and gas-line outlets
4. Colour-coding of hoses, fittings, adaptors and accessories to match

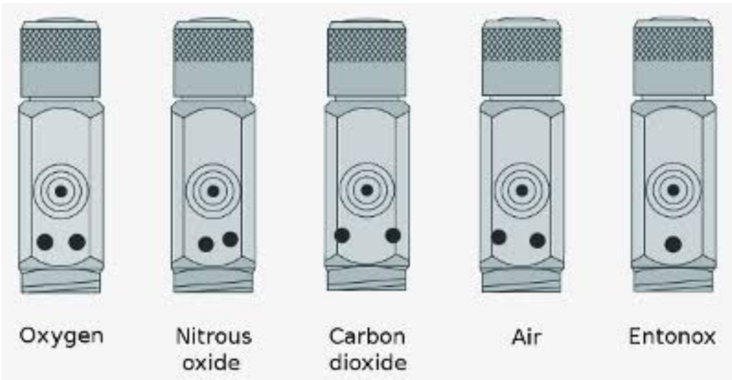
VIPIMO VYA GESI NA INDEXING

Unaweza kufikiria kuwa kuna hatari kubwa ambapo gesi mbaya hutolewa kwa mgonjwa kwa bahati mbaya. Hii ilifanyika vibaya katika nchi yangu mnamo 2016. Hatari kuu ni kwamba gesi ambazo hazina oksijeni (kama vile Nitrous-Oxide, Carbon-Dioxide, Helium) hutolewa kwa bahati mbaya badala ya Oksijeni. Ili kupunguza hatari hii, kuna udhibiti kadhaa mahali:

1. Uwekaji rangi wa chupa
2. Kuweka alama juu ya fititi za nira kwenye chupa za gesi ya matibabu
3. Utaratibu wa pete ya mdhibiti na maduka ya mstari wa gesi
4. Uwekaji wa rangi wa hoses, fittings, adapta na vifaa vya mechi

Bull nose fitting

Pin-index fitting fitting



[5] Read the report: https://www.health.nsw.gov.au/Hospitals/Documents/bankstown-lidcombe-incident-final-report.pdf

USEFUL PRESSURES

- 1 atm - “A good place to start”
- 1.01 bar. “About 1 to 1”
- 101.3 kPa. “About 100 to 1”
- 760 mmHg. “760 to 1”
- 1033 cmH2O. “About 1000 to 1”
- 14.7 psi. “About 15 to 1”

SHINIKIZO NI MUHIMU

- 1 atm - "Mahali pazuri pa kuanza"
- Baa ya 1.01. "Karibu 1 hadi 1"
- 101.3 kPa. "Karibu 100 hadi 1"
- 760 mmHg. "760 hadi 1"
- 1033 cmH2O. "Karibu 1000 hadi 1"
- 14.7 psi. "Karibu 15 hadi 1"

ABUNDANT OXYGEN MAKES THINGS VERY EASY TO BURN!/OKSIJENI NYINGI HUFANYA VITU KUWA RAHISI SANA KUCHOMA!

FLOW-METER TESTING AND MAINTENANCE

- O2 flow-meters need new o-rings every year
- Flowmeters tend to leak
- Dust and contamination tends to cause the pea or rotameter to bind.
- Needle valves may wear into non-linear adjustment
- Sensitive to different gases/densities
- No need for calibration

UPIMAJI WA MITA NA MATENGENEZO

- Mita ya mtiririko wa O2 inahitaji pete mpya za o kila mwaka
- Maua huwa yanavuja
- Vumbi na uchafu huelekea kusababisha pea au mzunguko wa kufunga.
- Valves za sindano zinaweza kuvaa kwa marekebisho yasiyo ya mstari
- Nyeti kwa gesi tofauti / wiani
- Hakuna haja ya calibration

BOTTLED GAS MANIFOLD SUPPLY

A manifold is essentially a way to connect a large number of gas bottles to a single, regulated line. The challenge with a large number of bottles is that when they are empty, it takes time to change them over, so bottles are connected in pairs or as a pair of sets, with one half operating at any given time. When that half of the bottled gas supply is empty, a change-over regulator switches to the other half, alerting the user that they are now running on the backup supply. The user can then replace the empty cylinders and reset the alarm.

UTOAJI WA GESI YA CHUPA

Maneno mengi kimsingi ni njia ya kuunganisha idadi kubwa ya chupa za gesi kwenye mstari mmoja, uliodhibitiwa. Changamoto na idadi kubwa ya chupa ni kwamba wakati hazina kitu, inachukua muda kuzibadilisha, kwa hivyo chupa zimeunganishwa katika jozi au kama jozi ya seti, na nusu moja inafanya kazi wakati wowote. Wakati hiyo nusu ya usambazaji wa gesi ya chupa iko tupu, mdhibiti wa ubadilishaji hubadilika kwa nusu nyingine, akimwonyesha mtumiaji kuwa sasa wanaendelea kwenye usambazaji wa nakala rudufu. Mtumiaji anaweza kisha kuchukua nafasi ya mitungi tupu na kuweka kengele tena.

TAKE CARE WITH FLOW-METERS

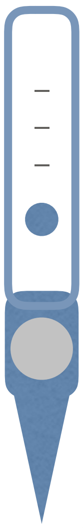
- Since gravity is a vector, it is important to make sure the flow-meter tube is vertical
- Since different gases have different densities and viscosities, make sure

JIHADHARINI NA MITA ZA MTIRIRIKO

- Kwa kuwa mvuto ni vekta, ni muhimu kuhakikisha kuwa bomba la mtiririko wa wima ni wima
- Kwa kuwa gesi tofauti zina wiani tofauti na viscosities, hakikisha

FLOW-METERS

Flow-meters are really simple. They are a common output device at the low-pressure end of a gas supply system. They consist of a very precisely ground glass tube with a tapering bore and a pea or rotameter that rests at the lowest point of the bore, which is also the narrowest point.

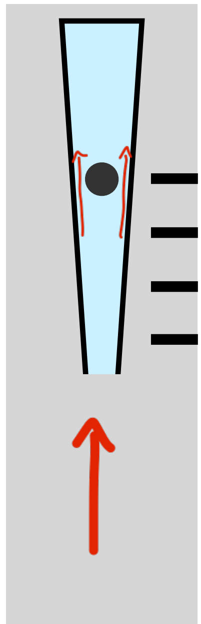


When gas flows up through the glass tube, it pushes the pea upwards to where the bore is wider, allowing more gas to pass around the outside of the pea. The pea rises to the height that balances the force from the flow of gas below against the weight of the pea being held down by gravity. The annular space around the pea is essentially a variable resistance against the flow of the gas. As the pea rises higher, the resistance goes down. The input to t h eflow-meter is usually a needle valve that can be gradually opened or closed by rotating a screw attached to a thumb wheel on the front of the flow-meter.

Flow-meters are often found on the output of Oxygen concentrators, which will we discuss shortly. They don't usually need calibrating, as the dimensions of the ground glass tube rarely vary significantly, and gas flow is not a very precise therapy. Nevertheless, it is useful to keep hold of an flow-meter or tube so that you can quickly measure the output of other gas appliances.

MITA YA MTIRIRIKO

Mita ya mtiririko ni rahisi sana. Ni kifaa cha kawaida cha kutoa katika mwisho wa shinikizo la chini la mfumo wa usambazaji wa gesi. Zinaweza kuwa na bomba la glasi la glasi la usahihi kabisa na kuzaa kwa bomba na pea au mzunguko ambao umekaa chini ya kiwango cha chini, ambayo pia ni hatua nyembamba.



Wakati gesi inapita kwenye bomba la glasi, inasukuma pea juu hadi mahali ambapo kuzaa ni pana, ikiruhusu gesi zaidi kupita karibu na nje ya pea. Rea huinuka hadi kufikia urefu ambao hulinganisha nguvu kutoka mtiririko wa gesi chini dhidi ya uzito wa pea iliyokuwa ikishikiliwa na mvuto. Nafasi ya annular karibu na chai kimsingi ni kupinga kutofautiana dhidi ya mtiririko wa gesi. Wakati pea inavyoongezeka juu, upinzani unashuka. Uingizaji wa mita ya mtiririko kawaida ni sindano ya sindano ambayo inaweza kufunguliwa polepole au kufungwa kwa kuzungusha ungo uliowekwa kwenye gurudumu la kidole mbele ya mita ya mtiririko.

Mita za mtiririko mara nyingi hupatikana kwenye pato la viwango vya oksijeni, ambayo tutazungumzia hivi karibuni. Kwa kawaida hazihitaji kufanya hesabu, kwani vipimo vya bomba la glasi ya ardhini mara chache hutofautiana sana, na mtiririko wa gesi sio tiba sahihi kabisa. Walakini, ni muhimu kushikilia mita ya mtiririko au bomba ili uweze kupima haraka pato la vifaa vingine vya gesi.

REGULATOR-FLOW-METERS

Regulator-flow-meters do the jobs of both pressure and flow regulation in a single, compact device. The advantage here is that an O2 bottle can be carried around by a patient or resuscitation team and by using one of these devices, a low-pressure stream of therapeutic gas can be delivered.

They are relatively simple, and tend to be maintenance-free. The regulator is enclosed and can't be adjusted; the flow-metering is by a series of pin-holes in a disc - the desired flow-rate is selected by rotating the disc. There is no flow-measurement or feedback - it is open-loop control. If a pin-hole is damaged or blocked, the flow-rate will be incorrect and you may never know without comparing it to a calibrated reference.

MDHIBITI MITA ZA MTIRIRIKO

Mita-mtiririko wa mita hufanya kazi za shinikizo zote mbili na mtiririko wa kifaa moja, kifaa kibichi. Faida hapa ni kwamba chupa ya O2 inaweza kusafirishwa karibu na mgonjwa au timu ya kufufua na kwa kutumia moja ya vifaa hivi, mkondo wa shinikizo la chini la gesi ya matibabu inaweza kutolewa.

Ni rahisi, na huwa isiyo na matengenezo. Mdhibiti imefungwa na haiwezi kubadilishwa; metering flow ni kwa safu ya mashimo ya siri kwenye diski - kiwango cha mtiririko kinachohitajika huchaguliwa kwa kuzungusha diski. Hakuna kipimo cha mtiririko au maoni - ni udhibiti wazi wa kitanzi. Ikiwa shimo la pini limeharibiwa au limezuiwa, kiwango cha mtiririko kitakuwa sio sahihi na unaweza kamwe kujua bila kulinganisha na rejeleo lenye kipimo.

USE NO OIL!

- Neoprene decays with oxygen
- Look for leaks!
- Make a small bottle of soapy water
    - 84% water, 15% dish soap, 1% glycerin
    - Put the bubbles (rather than the fluid) on the suspected leak and watch it grow
- Get teflon thread tape
- Work in a ventilated space

USITUMIE MAFUTA!

- Kuungua kwa Neoprene na oksijeni
- Tafuta uvujaji!
- Tengeneza chupa ndogo ya maji ya sabuni
- 84% maji, sabuni ya sahani 15%, 1% glycerin
- Weka Bubbles (badala ya maji) kwenye uvujaji unaoshukiwa na uangalie unakua
- Pata mkanda wa nyuzi za teflon
- Fanya kazi katika nafasi iliyowekwa hewa

A NOTE ABOUT EXPIRED AIR

You may remember having heard that people "breathe in Oxygen and breath out Carbon-Dioxide". It is worth noting that humans normally only consume a few percent (5%) of the Oxygen that they breathe in, and replace that percentage with CO2 (5%) when they breathe out. This means that *expired* air is still safe to breathe, being about 16% O2. This matters when performing *expired-air-resuscitation* ("Mouth-to-mouth") whereby a healthy person can help an unconscious casualty to breathe by using their own expired air.

UJUMBE JUU YA HEWA ILIYOMALIZIKA MUDA

Unaweza kukumbuka kusikia kuwa watu "wanapumua oksijeni na kupumua Carbon-Dioxide". Inafaa kumbuka kuwa wanadamu kwa kawaida hutumia asilimia chache (5%) ya Oksijeni ambayo wanapumua, na badala ya asilimia hiyo na CO2 (5%) wakati wanapumua. Hii inamaanisha kuwa hewa iliyomaliza muda wake bado ni salama kupumua, kuwa karibu 16% O2. Hii inajali wakati wa kutekeleza roho-kufufua kumalizika ("Mdomoni hadi kwa kinywa") ambayo mtu mwenye afya anaweza kusaidia jeraha kukosa fahamu kupumua kwa kutumia hewa yao wenyewe.

Oxygen concentrators

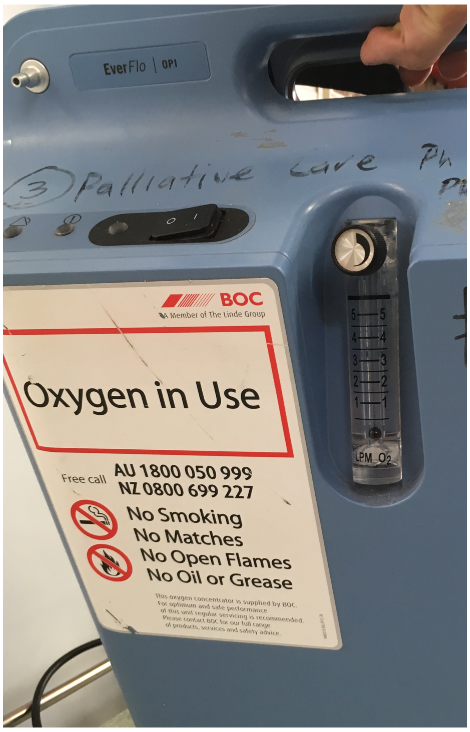
Here are a couple of Oxygen concentrators - one from the text[6] and one from my home country. Aside from their different colour and shape, they are basically the same. They both:

- Filter air from the outside world
- Take mostly of the Oxygen out of it
- Deliver that Oxygen-rich gas through a low-pressure outlet
- Have a flow-meter on the output so the user can measure the rate of gas delivery.

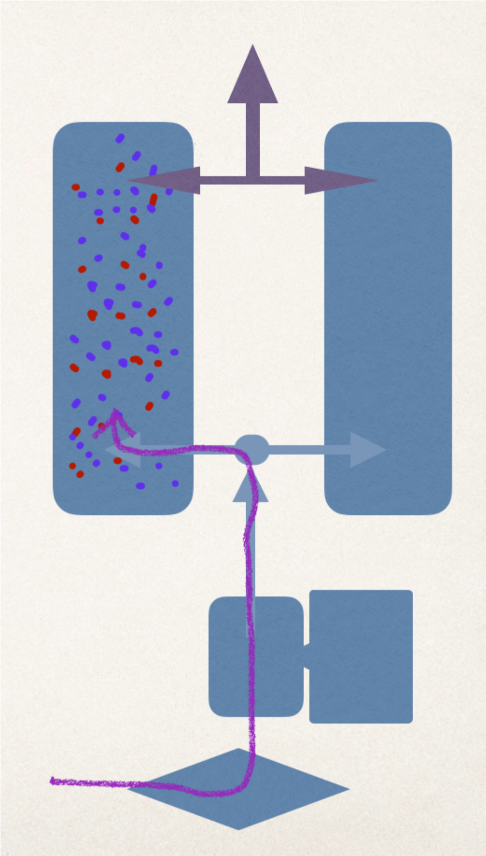
Viwango vya oksijeni

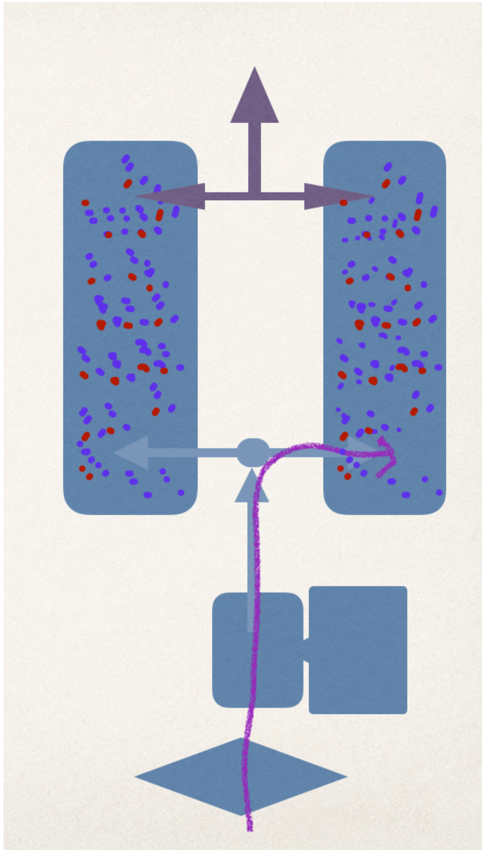
Hapa kuna vijiti kadhaa vya oksijeni - moja kutoka maandishi na moja kutoka nchi yangu ya nyumbani. Mbali na rangi na sura zao tofauti, kimsingi ni sawa. Wote wawili:

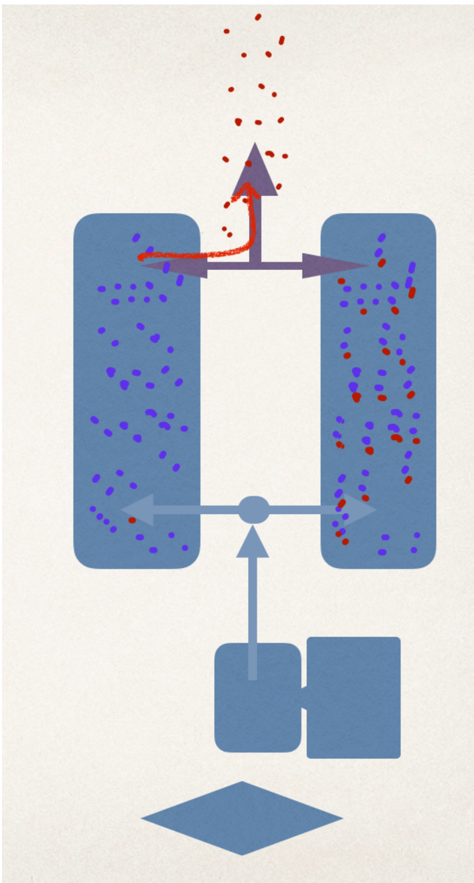
- Filter hewa kutoka kwa ulimwengu wa nje
- Chukua oksijeni zaidi ndani yake
- Toa gesi hiyo yenye oksijeni kwa njia ya duka ndogo ya shinikizo
- Kuwa na mita ya mtiririko kwenye pato ili mtumiaji aweze kupima kiwango cha utoaji wa gesi.

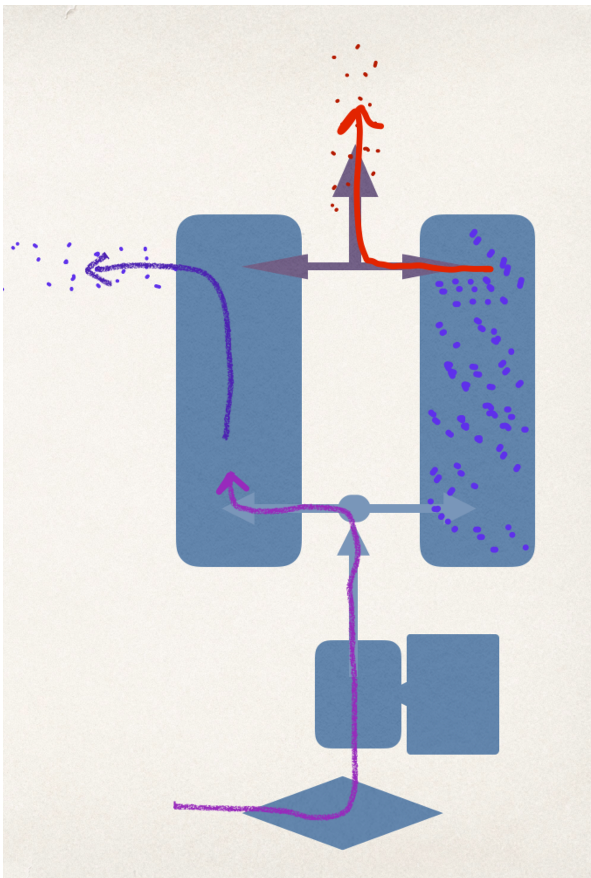


[6] See Robert Malkin's text, 2002









Step 1: Filtered air is pumped into one chamber where its Nitrogen begins to absorb.

Step 2: Air is pumped into the second chamber while the first chamber is still absorbing Nitrogen.

Step 3: The remaining Oxygen is released from the first chamber and sent to the patient. Nitrogen is released from the Zeolite crystals.

Step 4: Nitrogen from the first chamber is vented to atmosphere while the second chamber releases its Oxygen.

Hatua ya 1: Hewa iliyochujwa hupigwa ndani ya chumba kimoja ambamo Nitrojeni yake huanza kunyonya.

Hatua ya 2: Hewa hupigwa ndani ya chumba cha pili wakati chumba cha kwanza bado kinachukua Nitrojeni.

Hatua ya 3: Oksijeni iliyobaki inatolewa kutoka kwenye chumba cha kwanza na hutumwa kwa mgonjwa. Nitrogeni hutolewa kutoka fuwele za Zeolite.

Hatua ya 4: Nitrojeni kutoka kwenye chumba cha kwanza hutolewa kwa anga wakati chumba cha pili kinatoa oksijeni yake.

WHAT'S IN THE AIR?

To understand what an O2 concentrator does, we must first understand what is happening in the air. Air is mostly Nitrogen (78%): a non-toxic, odourless gas that simply passes in an out of your lungs without interacting with you biology. The rest of the air is mostly Oxygen (21%), which is critical to our biology. Without having access to Oxygen, we would die very quickly. The last fraction of air (1%) contains traces of just about everything else.

KUNA NINI HEWANI?

Kuelewa kile kiini cha O2 hufanya, lazima kwanza tuelewe kile kinachotokea angani. Hewa zaidi ni nitrojeni (78%): gesi isiyo na sumu, isiyo na harufu ambayo hupita nje ya mapafu yako bila kuingiliana na wewe baolojia. Hewa iliyobaki ni zaidi oksijeni (21%), ambayo ni muhimu kwa biolojia yetu. Bila kupata Oksijeni, tungekufa haraka sana. Sehemu ndogo ya hewa (1%) ina athari ya karibu kila kitu kingine.

FUNCTIONAL PARTS

The outside is simple; let's see what is going on inside. There are only a few critical parts to an O2 concentrator: A motor/compressor assembly, some valves to direct the gas, two *zeolite*[7] chambers and some electronics to control all the bits.

SEHEMU ZA KAZI

Nje ni rahisi; wacha tuone kinachoendelea ndani. Kuna sehemu chache tu muhimu kwa mkusanyiko wa O2: Kusanyiko la motor / compressor, valves kadhaa kuelekeza gesi, vyumba viwili vya zeolite na vifaa vya elektroniki kudhibiti bits zote.

[7] Zeolite is made of fine beads of Aluminium Silicate. It looks like sand or brownish-glass. Its main trick is to absorb nitrogen from the air, but only at high-pressure. At low pressure, the nitrogen is released from the beads again.

The basic function goes like this:

1. Pressurised air enters one zeolite chamber
2. Nitrogen soaks into the zeolite
3. Nitrogen-free gas is delivered to the patient
4. Nitrogen is released from the zeolite
5. Chamber is vented to the atmosphere

Most of these steps take time, so two chambers are operated in parallel such that when one chamber is being pressurised, the other is emptying. The supply to the patient is relatively continuous, if not somewhat pulsatile.

What you end up with is ideally about 94% Oxygen, 1% Nitrogen and 5% everything else[8].

Kazi ya msingi huenda kama hii:

1. Hewa iliyo na shinikizo huingia kwenye chumba kimoja cha zeolite
2. Nitrojeni huingia ndani ya zeolite
3. Gesi isiyo na nitrojeni hutolewa kwa mgonjwa
4. Nitrogeni hutolewa kutoka zeolite
5. Chumba kimewekwa kwa anga

Zaidi ya hatua hizi huchukua muda, kwa hivyo vyumba viwili vinaendeshwa sambamba ili wakati chumba kimoja kinashinikizwa, kingine kinakera. Ugavi kwa mgonjwa ni wa kuendelea, ikiwa sio kiasi kidogo.

Unachovumilia ni kweli juu ya oksijeni 94%, 1% Nitrojeni na 5% kila kitu kingine.

[8] If you think of the original mix of gases in the air, we had about 21% O2 and 1% trace gases. This makes the trace gas about 5% of the non-Nitrogen content of the air. This same proportion is what we see in the concentrated output of this device.

PROBLEMS

The first problem is that the zeolite wears out. Most Oxygen concentrators have a counter that measures hours of operation. The zeolite needs to be replaced after about 20,000 hours of use. This sounds like a long time, but for a device in daily use, this is only about six years or so. In Australia, we estimate the life of clinical equipment to be about seven to ten years, so we would expect the zeolite to be replace about once in the life of the equipment. In developing countries, the expected life may be much longer, or it could be that the device is donated at the end of its life with most of its productive capacity already consumed.

If the zeolite is OK, that leaves the motors, valves and filters, and of course, the controlling electronics. In Tanzania we saw many concentrators with similar failures[9]: electronic controllers that would not start; motors that would not run; pumps with missing or broken valves. The best you can hope for is to find a couple of machines with different problems and try and get enough good parts out of them to get one machine to work.

SHIDA

Shida ya kwanza ni kwamba zeolite huvaa. Vipimo vingi vya oksijeni vina counter ambayo hupima masaa ya kazi. Zeolite inahitaji kubadilishwa baada ya matumizi ya masaa 20,000. Hii inasikika kama muda mrefu, lakini kwa kifaa katika utumiaji wa kila siku, hii ni karibu miaka sita au zaidi. Huko Australia, tunakadiria maisha ya vifaa vya kliniki kuwa karibu miaka saba hadi kumi, kwa hivyo tunatarajia zeolite kubadilishwa karibu mara moja katika maisha ya vifaa. Katika nchi zinazoendelea, maisha yanayotarajiwa yanaweza kuwa ya muda mrefu zaidi, au inaweza kuwa kwamba kifaa hiki hutolewa mwishoni mwa maisha yake na uwezo wake mwingi wa uzalishaji tayari umetumiwa.

Ikiwa zeolite ni sawa, ambayo inaacha motors, valves na vichungi, na kwa kweli, vifaa vya elektroniki vinavyodhibiti. Huko Tanzania tuliona wakimbizi wengi wakiwa na mapungufu sawa: watawala wa elektroniki ambao hawakuanza; motors ambazo hazingeendesha; pampu zilizo na valves zilizopotea au zilizovunjika. Bora unayotumaini ni kupata mashine kadhaa zilizo na shida tofauti na jaribu na pata sehemu nzuri za kutosha kutoka kwao kupata mashine moja ya kufanya kazi.

[9] This happens for many kinds of medical devices - after long-term use, they usually fail at the weakest point and in the same way.

TESTING

To test an Oxygen concentrator, you need only pay attention to two parameters: *flow* and *concentration*. Most concentrators have a built-in mechanical flow-meter (see *flow-meters* from the previous lecture) which will be as accurate as any reference that you may have access to.

The more critical parameter is *concentration*, which is quite difficult to measure. We will talk about finding and making reference gauges next week, but you essentially must get hold of an O2 sensor of some kind[10]. There are a couple of brilliant *EWH* projects in this space, including a zinc-air battery sensor and a low-cost analyser that uses an off-the-shelf sensor.

UPIMAJI

Ili kujaribu kujilimbikizia oksijeni, unahitaji tu kuzingatia vigezo viwili: mtiririko na mkusanyiko. Vipimo zaidi vina mita ya mtiririko wa mitambo (angalia mita za mtiririko kutoka kwa hotuba iliyopita) ambayo itakuwa sahihi kama kumbukumbu yoyote ambayo unaweza kupata.

Param muhimu zaidi ni mkusanyiko, ambayo ni ngumu sana kupima. Tutazungumza juu ya kutafuta na kufanya chachi za kumbukumbu wiki ijayo, lakini kimsingi lazima uweze kupata sensor ya O2 ya aina fulani. Kuna miradi kadhaa ya maridadi ya EWH katika nafasi hii, pamoja na sensor ya betri ya hewa-zinc na mchambuzi wa bei ya chini anayetumia sensor ya rafu.

A NOTE ABOUT EXPIRED AIR

You may remember having heard that people “breathe in Oxygen and breath out Carbon-Dioxide”. It is worth noting that humans normally only consume a few percent (5%) of the Oxygen that they breathe in, and replace that percentage with CO2 (5%) when they breathe out. This means that *expired* air is still safe to breathe, being about 16% O2. This matters when performing *expired-air-resuscitation* (“Mouth-to-mouth”) whereby a healthy person can help an unconscious casualty to breathe by using their own expired air.

UJUMBE JUU YA HEWA ILIYOMALIZIKA MUDA

Unaweza kukumbuka kusikia kuwa watu "wanapumua oksijeni na kupumua Carbon-Dioxide". Inafaa kumbuka kuwa wanadamu kwa kawaida hutumia asilimia chache (5%) ya Oksijeni ambayo wanapumua, na badala ya asilimia hiyo na CO2 (5%) wakati wanapumua. Hii inamaanisha kuwa hewa iliyomaliza muda wake bado ni salama kupumua, kuwa karibu 16% O2. Hii inajali wakati wa kutekeleza roho-kufufua kumalizika ("Mdomoni hadi kwa kinywa") ambayo mtu mwenye afya anaweza kusaidia jeraha kukosa fahamu kupumua kwa kutumia hewa yao wenyewe.

[10] Dr Malkin’s text suggests using a candle and measuring the burn-time of a sample to estimate oxygen concentration. We found this method to produce wildly varying estimates and difficult to calibrate against any concentration other than atmostpheric Oxygen (21%). It is also dangerous to play with open flames around high Oxygen concentrations.

OXYGEN CONCENTRATOR MOTORS

CAPACITOR-RUN SINGLE-PHASE AC

The motor in our example Oxygen concentrator is a capacitor-run single-phase AC motor. This means its rotor is built around a squirrel-cage, it has a single mains supply and a large capacitor. A motor of this size is designed to do real work - this one is rated at 350 W. Lets look at what's going on inside.

The main challenge with an AC source is that a single AC sine-wave has no inherent direction. You can energise a motor's field windings with a single phase and watch the magnetic field simply go back and forth across the armature without causing it to turn. This is less of a problem once the armature is spinning, as the single-phase field in the stator will push the armature along as it rotates, and its momentum will carry it around[11].

MOTORS ZA KUZINGATIA OKSIJENI

CAPACITOR -ENDESHA MOJA YA AWAMU YA AC

Motor katika mfano wetu oksijeni Oksijeni ni capacitor-moja ya awamu ya AC motor. Hii inamaanisha kuwa rotor yake imejengwa karibu na ngome ya squirrel, ina usambazaji wa mains moja na capacitor kubwa. Gari ya ukubwa huu imeundwa kufanya kazi halisi - hii imekadiriwa kwa 350 W. Lets tuangalie kinachoendelea ndani.

Changamoto kuu na chanzo cha AC ni kwamba wimbi moja la AC halina mwelekeo wa asili. Unaweza kuwezesha upenyo wa uwanja wa motor na sehemu moja na kutazama shamba la magneti kwenda tu na kurudi katika kituo cha mikono bila kuifanya igeuke. Hili ni chini ya shida mara tu armature inazunguka, kama uwanja wa sehemu moja kwenye stator utasukuma armature kama inavyozunguka, na kasi yake itaibeba kuzunguka.

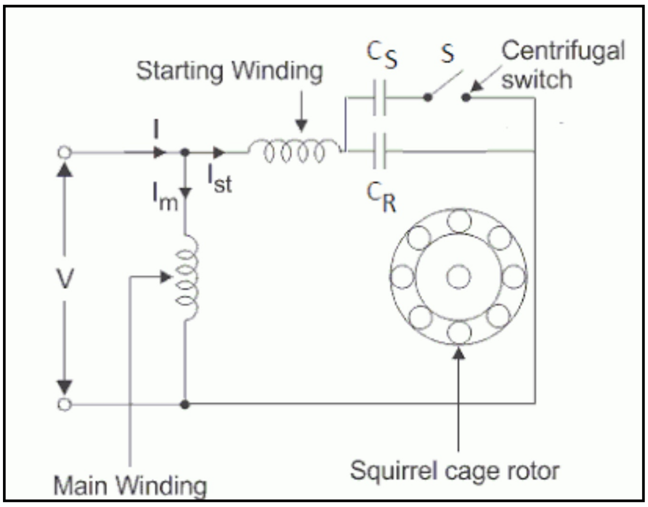
[11] In theory, if you pushed the armature backwards it would also continue to spin in reverse. In practice, this won't happen as you'll see here.

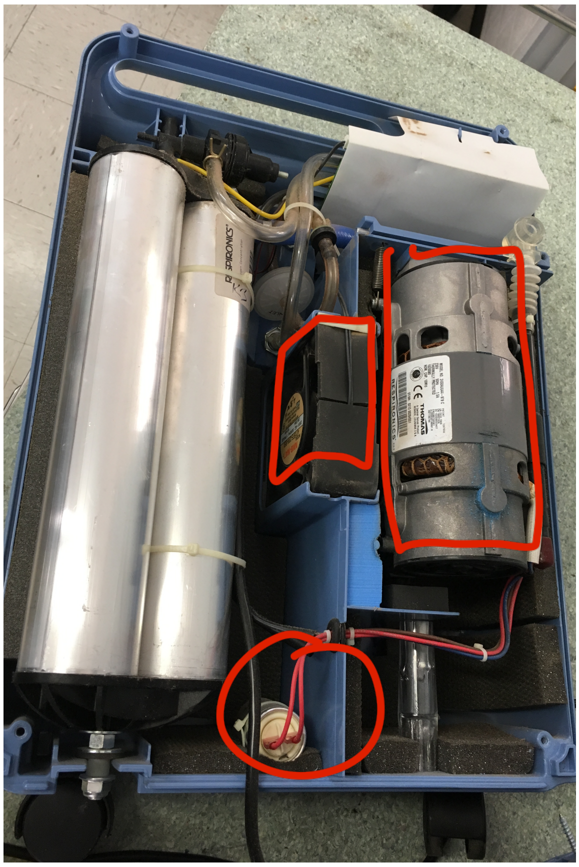
The trick to starting and running this motor is to create a rotation in the magnetic field to give the motor some direction. This is done by adding a second field winding that is about 90 degrees out-of-phase with the main field winding, both electrically and mechanically. The mechanical phase-shift is done by physically locating the windings away from the main windings in the motor casing. The electrical phase-shift is done with a large capacitor.

You may see a second capacitor in use to give the motor an extra push around during startup. This is then switched-out by a centrifugal switch once the motor is running. You can hear a loud *clack* when this spring-loaded clutch re-engages when the motor is slowing down.

Ujanja wa kuanza na kuendesha motor hii ni kuunda mzunguko katika uwanja wa sumaku ili kuwapa motor mwelekeo. Hii inafanywa kwa kuongeza shamba ya pili ikizunguka ambayo ni nyuzi 90 kutoka nje na shamba kuu, kwa umeme na kwa utaratibu. Mabadiliko ya awamu ya mitambo hufanywa na kupata eneo la mwili kwa vilima mbali na vilima kuu kwenye casing ya gari. Kuhama kwa awamu ya umeme hufanywa na capacitor kubwa.

Unaweza kuona capacitor ya pili katika matumizi ya kuwapa motor kushinikiza zaidi wakati wa kuanza. Hii hubadilishwa na swichi ya centrifugal mara gari inapoendesha. Unaweza kusikia kufurika kwa sauti wakati clutch hii ya kubeba mzigo inapoingia tena wakati gari linapungua.





STEPPER-MOTOR COOLING FAN

There is a second motor sitting in the casing of this example Oxygen concentrator - the stepper motor driving this small cooling fan. You may have seen similar fans in PCs for cooling CPUs and graphics cards. They are not designed to do a lot of work - this one is rated at 15 W.

These little stepper motors are inscrutable - they usually have an electronic front-end (usually hidden under that sticker) that creates a set of artificial phased waveforms to be fed to each of several stepped phases. From the user's point of view, they take a general input power and convert it as required. They are difficult to examine or service, but for the most part they are relatively inexpensive to source and replace. A similarly rated PC fan can do the job, and PC fans are available all over the world.

MOTOR SHABIKI WA BARIDI-WA BARIDI

Kuna gari la pili limeketi kwenye casing ya mfano huu Mzingatiaji wa oksijeni - dereva wa mwendo wa kasi anayeendesha hii shabiki mdogo wa baridi. Inawezekana umeona mashabiki kama hao kwenye PC kwa PC za baridi na kadi za picha. Hazijapangwa kufanya kazi nyingi - hii inakadiriwa saa 15 W.

Motors hizi kidogo za mwendo hazieleweki - kawaida huwa na mwisho wa umeme (kawaida hufichwa chini ya stika hiyo) ambayo huunda seti ya muundo wa bandia wa kulishwa kwa kila moja ya hatua kadhaa zilizopitiwa. Kwa mtazamo wa mtumiaji, wanachukua nguvu ya jumla ya uingizaji na kuibadilisha kama inavyotakiwa. Ni ngumu kuchunguza au huduma, lakini kwa sehemu kubwa ni rahisi kutoa chanzo na kuchukua nafasi yake. Shabiki wa PC aliyekadiriwa sawa anaweza kufanya kazi hiyo, na mashabiki wa PC wanapatikana kote ulimwenguni.

Nebulisers

WHAT ARE THEY FOR?

Nebulisers do one job: They break up a liquid sample into a mist of tiny droplets that make the sample easy to inhale. There are various ways to do this, but the most common is to generate a jet of compressed air and use it to aerosolise a liquid medicine in a small disposable set.

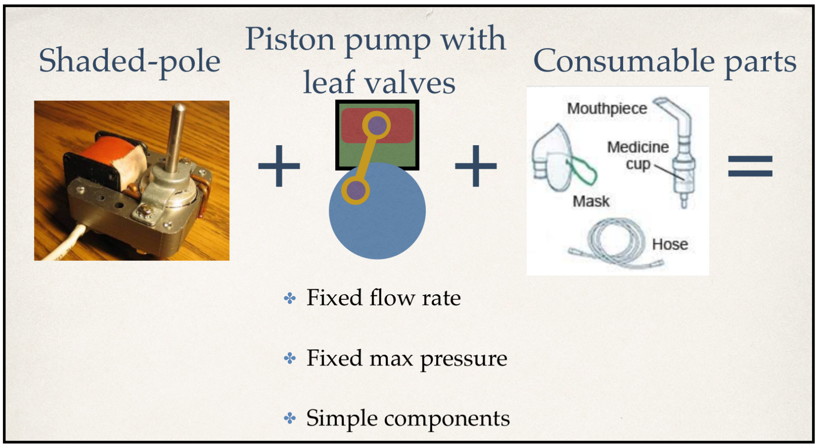
For biomedical technicians, most of your efforts will be focused on maintaining the air compressor section. The users will have to find and maintain stock of single-use sets[12].

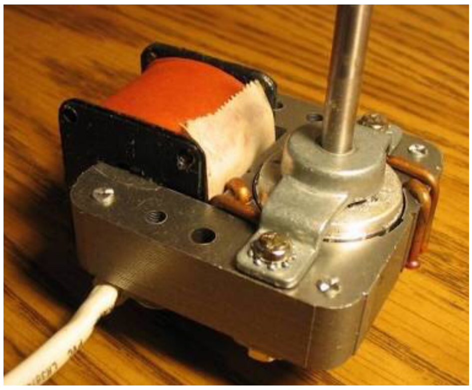
Nebulisers

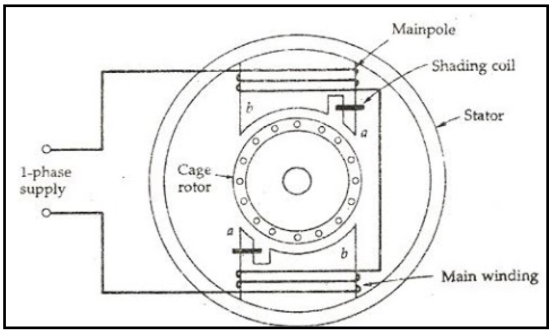
JE! NI NINI?

Nebulisers hufanya kazi moja: Wao hutengeneza sampuli kioevu kuwa ukungu wa matone madogo ambayo hufanya sampuli iwe rahisi kuvuta. Kuna njia nyingi za kufanya hivyo, lakini cha kawaida ni kutengeneza ndege ya hewa iliyoshinikizwa na kuitumia kwa aerosolise dawa ya kioevu katika seti ndogo inayoweza kutolewa.

Kwa wataalam wa biomedical, juhudi zako nyingi zitalenga kutunza sehemu ya compressor hewa. Watumiaji watalazimika kupata na kuhifadhi hisa za matumizi ya moja.



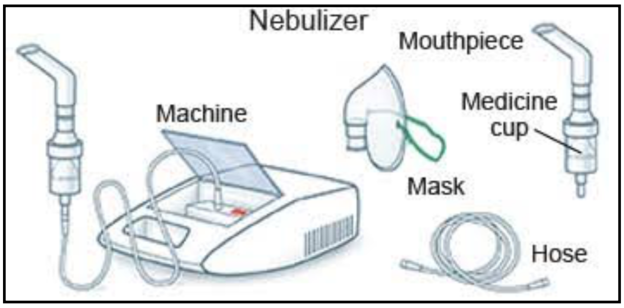




[12] There is plenty to be said about the cost and supply of single-use medical equipment in the developing world. Unfortunately it is beyond the scope of this text.

NEBULISER MOTOR: SHADED-POLE SINGLE-PHASE AC

Once again, we meet the problem of trying to get a magnetic field to rotate while only using a single phase. For this motor, the solution is inductive rather than capacitive. Have a look at this motor - you will see that the main windings are built into a solenoid with a magnetic circuit carrying the field around to the squirrel-cage armature. Close to the armature you can see a fat copper wire, This is the *shading* on the magnetic pole-pieces. You can imagine that iron core carrying a changing magnetic field. This changing field induces a current in those two copper loops (they are closed, conductive loops, usually of two turns).

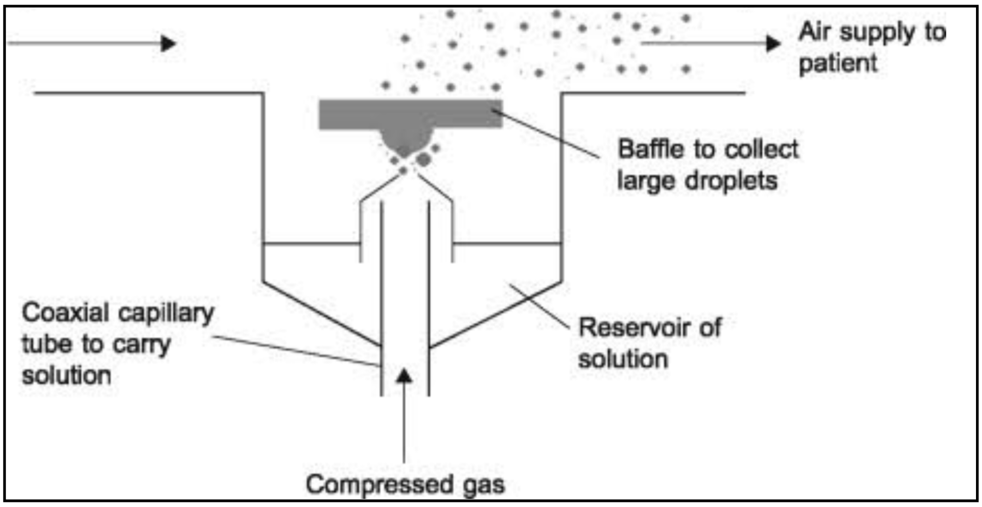


The current can be quite large and will generate its own magnetic field, opposing the generated field. This opposing field adds to the generated field resulting in a dark or *shady* spot in the magnetic field, where it is not so strong. The trick is: this secondary field takes time to develop and so lags the changes in the generated field. Since this lagging sinusoid is also phase-shifted mechanically, the net affect is a rotating magnetic field with a small amount of direction. The shaded-pole single-phase AC motor is one of the cheapest ways to turn mains power into rotation. Such motors are usually used for low-torque, low-energy applications.

GARI LA NEBULISER: SHADED-POLE SINGLE-PHASE AC

Kwa mara nyingine tena, tunakutana na shida ya kujaribu kupata shamba la sumaku kuzunguka wakati wa kutumia tu sehemu moja. Kwa motor hii, suluhisho ni la kufata badala ya uwezo. Angalia motor hii - utaona kwamba vilima vikuu vimejengwa ndani ya solenoid na mzunguko wa sumaku ukibeba shamba kuzunguka kwa armature ya ngome ya squirrel. Karibu na armature unaweza kuona waya ya shaba ya mafuta, Hii ni kivuli kwenye vipande vya pole. Unaweza kufikiria msingi wa chuma umebeba shamba ya sumaku inayobadilika. Shamba hili linalobadilisha hali ya sasa katika hizo logi mbili za shaba (zimefungwa, vitanzi vya kufurahisha, kawaida ya zamu mbili).

Ya sasa inaweza kuwa kubwa kabisa na itazalisha shamba lake lenye nguvu, inapingana na shamba linalotokana. Sehemu hii ya kupinga inaongeza kwenye shamba linalotokana kusababisha gizani au kivuli kwenye uwanja wa sumaku, ambapo sio nguvu sana. Ujanja ni: uwanja huu wa sekondari huchukua muda kukuza na kwa hivyo hubadilisha mabadiliko kwenye uwanja uliotengenezwa. Kwa kuwa sinusoid hii inayowaka pia imebadilishwa kwa mitambo, kuathiriwa ni uwanja unaovutia wa magnetic na kiwango kidogo cha mwelekeo. Gari lenye umeme la awamu moja ya AC ni moja ya njia rahisi zaidi za kugeuza nguvu za mains kuwa mzunguko. Motors kama kawaida hutumiwa kwa matumizi ya chini-torque, matumizi ya nishati ya chini.



Medical Suction

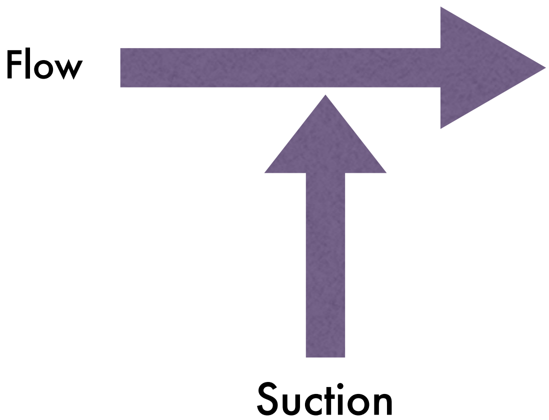
Medical suction is low-tech, commonplace and life-saving. The most common use is to extract fluid from a patient's mouth and airway so that they can breathe during resuscitation or some other life-saving procedure. There are two halves to this problem: Making a source of suction and dealing with the collected fluid.

We'll talk soon about making vacuum and suction devices, but for now we'll look at the gas-appliance side of things. Let's start by looking at the simplest way of generating suction, with a device called a *Venturi*.

Uzalishaji wa Matibabu

Suala ya matibabu ni ya chini-tech, mahali pa kawaida na kuokoa maisha. Matumizi ya kawaida ni kutoa maji kutoka kwa mdomo na njia ya hewa ili waweze kupumua wakati wa kufufua upya au utaratibu mwingine wa kuokoa maisha. Kuna nusu mbili kwa shida hii: Kufanya chanzo cha kuvuta na kushughulika na maji yaliyokusanywa.

Tutazungumza hivi karibuni juu ya kutengeneza vifaa vya utupu na vya kuulia, lakini kwa sasa tutaangalia upande wa vifaa vya gesi. Wacha tuanze kwa kutazama njia rahisi zaidi ya kutengeneza suction, na kifaa kinachoitwa *Venturi*.



Venturi suction is simple: You get a high-speed flow going through a tube, and then, by adding an inlet on the side of that tube, you get suction in the inlet. You can imagine the molecules of the supply gas flying past the side-inlet, grabbing molecules from the inlet tube as they go. In any case, you may see these around, where there is an abundant gas supply (usually medical air or oxygen), which is fed through the Venturi tube, after which suction appears at the inlet. Once you have a source of suction or vacuum, it is another step to do something useful with it.

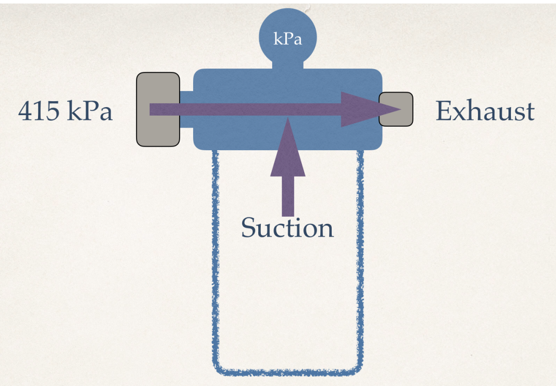
Venturi ya suction ni rahisi: Unapata mtiririko wa kasi ya kupita kwa njia ya bomba, na kisha, kwa kuongeza kidonge kwenye upande wa bomba hilo, unapata kizuizi. Unaweza kufikiria molekuli za gesi ya usambazaji zikiruka nyuma ya inchi ya nyuma, ikinyakua molekuli kutoka kwenye bomba la kuingilia wakati zinapita. Kwa hali yoyote, unaweza kuona hizi karibu, ambapo kuna usambazaji wa gesi nyingi (kawaida hewa ya oksijeni au oksijeni), ambayo hulishwa kupitia bomba la Venturi, baada ya suction inaonekana kwenye gombo. Mara tu ukiwa na chanzo cha kuvuta au utupu, ni hatua nyingine kufanya kitu muhimu nayo.

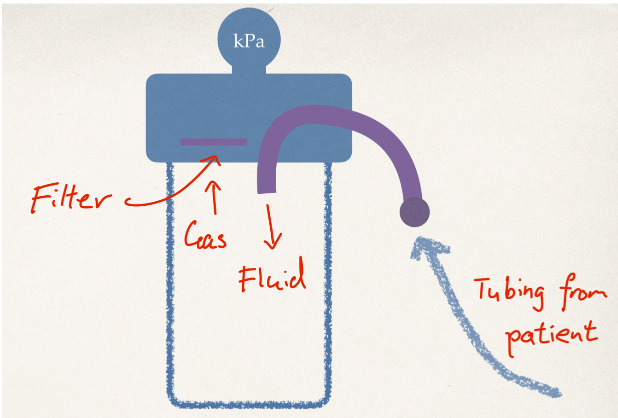
SUCTION JARS AND APPLIANCES

So, lets take our Venturi tube but instead of having a simple gas opening, lets put that opening over a jar. When we turn on the supply gas, we will be effectively evacuating gas out of the jar, creating a partial vacuum.[13] Now if we add a tube to the jar, we can draw fluid from the patient up the tube and into the vacuum jar. This works fine in principle but is terrible in practice. Why? Because in a clinical emergency, all the focus is on the patient and never on the suction jar, which will eventually overflow. If we just used our simple Venturi/ vacuum jar, we would swiftly contaminate our Venturi tube with patient fluid which, aside from ruining the vacuum, would be become very difficult to clean.

MITUNGI YA SHUGHULI NA VIFAA

Kwa hivyo, lets kuchukua tube yetu ya Venturi lakini badala ya kuwa na ufunguzi rahisi wa gesi, inaruhusu kuweka ufunguzi huo juu ya jar. Tunapowasha gesi ya ugavi, tutakuwa tukiondoa kwa ufanisi gesi kutoka kwenye jar, na kutengeneza sehemu ya utupu. Sasa ikiwa tunaongeza tube kwenye jar, tunaweza kuchota maji kutoka kwa mgonjwa hadi kwenye bomba na ndani ya jarida la utupu. Hii inafanya kazi vizuri katika kanuni lakini ni mbaya katika mazoezi. Kwa nini? Kwa sababu katika dharura ya kliniki, lengo lote ni juu ya mgonjwa na kamwe sio kwenye jar ya suction, ambayo baadaye itafurika. Ikiwa tungetumia jar yetu rahisi ya Venturi / utupu, tunaweza kuchafua damu yetu ya Venturi haraka na giligili ya mgonjwa ambayo kando ya kuharibu utupu, itakuwa ngumu sana kusafisha.

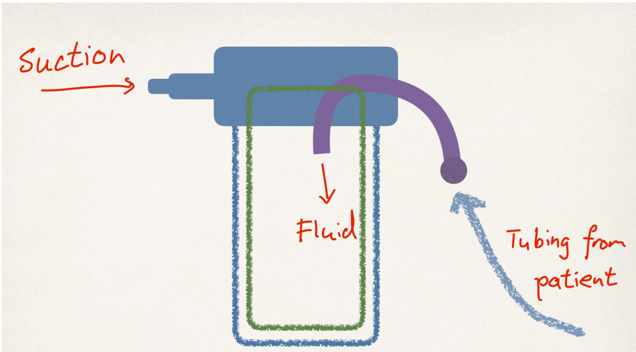


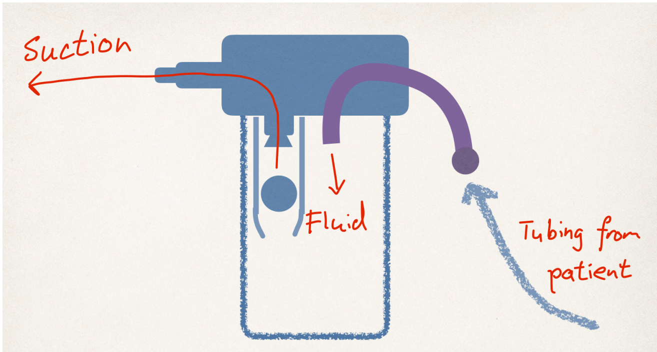


[13] There's no such thing as a perfect vacuum, of course. Venturi devices have their limits too, where eventually the vacuum wins over the atmostpheric vent and sucks the supply gas into the chamber, ruining the vacuum.

There are roughly three ways to solve this problem. The first way is to have some kind of float valve that will cut off the vacuum when the jar is full. The second way is to put a flexible liner inside the jar and apply the vacuum *outside* the liner, while keeping the patient fluid *inside* the liner. When the liner is full the jar can be opened and the liner replaced with an empty and clean one. The third way is to have the entire jar disposable and have the suction/vacuum source separate to the jar entirely.

Kuna njia takriban tatu za kutatua tatizo hili. Njia ya kwanza ni kuwa na aina fulani ya vifuniko vya kuelea ambavyo vitakata utupu wakati jaramu limejaa. Njia ya pili ni kuweka mjengo rahisi ndani ya jar na kutumia utupu nje ya mjengo, wakati wa kuweka maji ya mgonjwa ndani ya mjengo. Wakati mjengo umejaa jar inaweza kufunguliwa na mjengo ubadilishwe na moja tupu na safi. Njia ya tatu ni kuwa na jarida lote la ziada na uwe na chanzo cha utupu / utupu uliotengwa kwa jar kabisa.





SUCTION PUMPS

If you have abundant electricity and no centralised gas supply, you can generate suction with a pump, instead of using a Venturi. From a clinical point of view, the suction effect is similar regardless of how it is generated.

SUCTION PAMPU ZA MAJI

Ikiwa una umeme mwingi na hakuna usambazaji wa gesi ya kati, unaweza kutoa shida na pampu, badala ya kutumia Venturi. Kutoka kwa mtazamo wa kliniki, athari ya kunyonya ni sawa bila kujali ni jinsi gani hutolewa.

TESTING SUCTION PUMPS...

- Put your finger over the intake...
- Does the vacuum level pull down to <-70 kPa?
- Does the bleed valve open and close OK?
- Is the gauge OK?
- Any internal leaks?
- Is the leaf valve dirty/corroded?

INAPIMA PAMPU ZA KUVUTA...

- Weka kidole chako juu ya ulaji ...
- Je! Kiwango cha utupu kinashuka hadi <-70 kPa?
- Je, damu inayofungwa damu inafunguliwa na inafungwa sawa?
- Je! Kipimo ni sawa?
- Uvujaji wowote wa ndani?
- Je! Wizi wa majani ni chafu / umetapeliwa?

SUCTION PUMP INTERFACE

Let's have a closer look at what the device user sees. We have:

1. A suction gauge showing the level of vacuum applied

2. A suction intake that can be connected to a suitable suction canister (See above)

3. A bleed valve that essentially vents the internal vacuum line to atmosphere through a variable orifice, allowing the applied suction to be varied

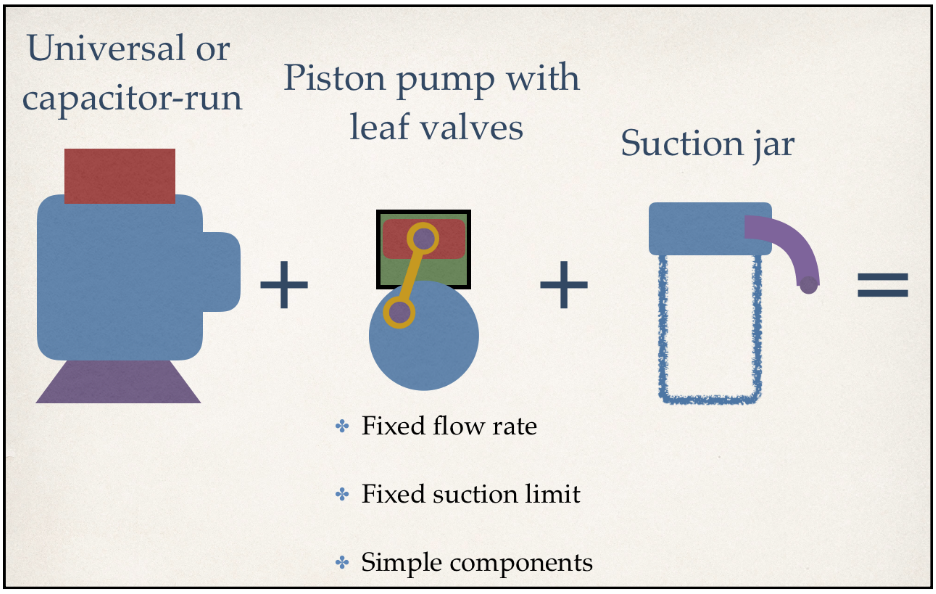
UBUNIFU WA PAMPU YA UZALISHAJI

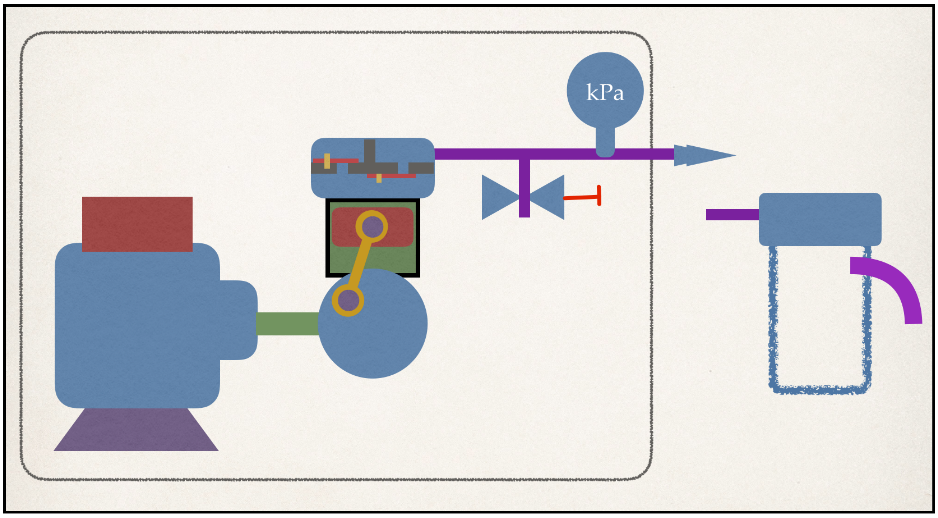
Wacha tuangalie kwa karibu kile mtumiaji wa kifaa anaona. Tuna:

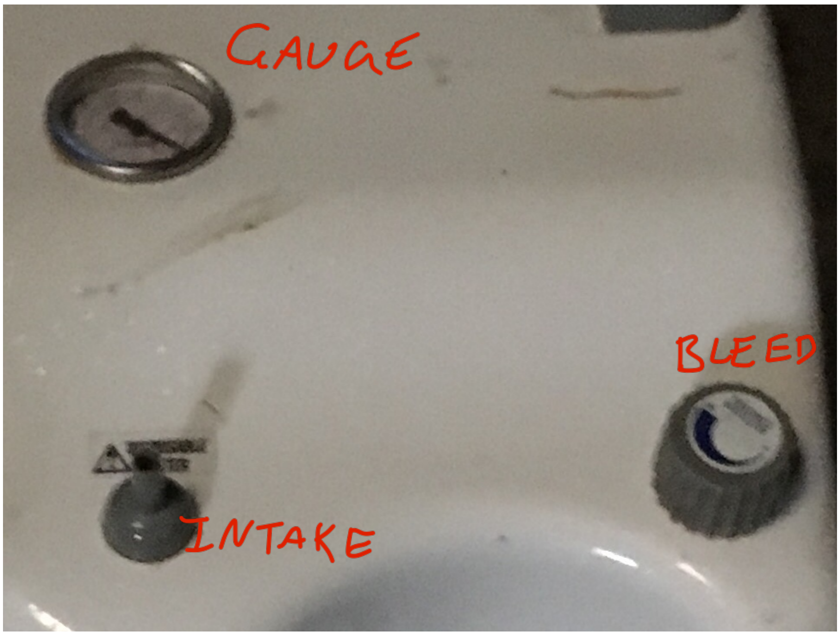
4. Chaji ya kufyatua inaonyesha kiwango cha utupu uliotumika

5. Ulaji wa kufyonzwa ambao unaweza kushikamana na kichungi kinachofaa cha kufyatua (Tazama hapo juu)

6. Valve iliyomwagika ambayo kimsingi hutumia mstari wa utupu wa ndani kwa anga kupitia orifice inayotofautishwa, ikiruhusu suction iliyotumiwa iwe tofauti.







DANGER! NOT TO BE CONNECTED DIRECTLY TO A PATIENT!

It is quite common to find suction pumps contaminated and corroded with bodily fluids. This is usually due to nurses having connected the pump directly to a suction tube that is then applied to a patient.

Suction pumps are designed to be connected to a jar or canister that has some protection against fluid egress.

HATARI! ILI ISIUNGANISHWE MOJA KWA MOJA NA MGONJWA!

Ni kawaida kabisa kupata pampu za kuvuta zilizochafuliwa na kuharibiwa na maji ya mwili. Hii kawaida ni kwa sababu wauguzi wameunganisha pampu moja kwa moja kwenye bomba la kunyonya ambalo hutumika kwa mgonjwa.

Pampu za uzalishaji zimetengenezwa kuunganishwa na jar au kabichi ambayo ina kinga fulani dhidi ya egress ya maji.

SUCTION PUMP INTERNAL FUNCTION/

If you look inside a suction pump, you will see a few, very simple components. There is usually:

1. A motor of some type, usually capacitor-run universal motor or similar
2. A pump assembly - usually a piston-pump
3. A valve assembly to direct the flow of gas

The suction output can be directed to any suitable appliance, but usually this is a suction canister of some kind.

SUCTION STUFF IS HAZARDOUS!

You will see terrible things! Whenever a suction machine fails, it will inevitably contaminate the internal works with bodily fluids. Most nursing staff are trained to clean medical equipment on the *outside*, but never on the inside. This means the first person who has to deal with contaminated equipment is usually the technician. As soon as you see or smell contamination, put on some gloves. And think about other personal-protective-equipment (PPE)[14]. It is very difficult to clean up the mess inside a machine. The best idea may be to bury the thing in landfill and move on.

SUCTION PAMPU KAZI YA NDANI

Ikiwa utaangalia ndani ya pampu ya kuvuta, utaona vifaa vichache, rahisi sana. Kawaida kuna:

1. Motor ya aina fulani, kawaida capacitor kukimbia zima zima au sawa
2. Mkutano wa pampu - kawaida pistoni-pampu
3. Mkutano wa valve kuelekeza mtiririko wa gesi

Pato la suction linaweza kuelekezwa kwa vifaa vyovyote vya kufaa, lakini kawaida hii ni kifaa cha kughushi cha aina fulani.

KUFYONZA MAMBO NI MADHARA!

Utaona vitu vya kutisha! Wakati wowote mashine ya kunyonya inaposhindwa, itaweza kuchafua kazi za ndani na maji ya mwili. Wafanyikazi wengi wa uuguzi hufunzwa kusafisha vifaa vya matibabu nje, lakini kamwe ndani. Hii inamaanisha kuwa mtu wa kwanza anayeshughulika na vifaa vyenye uchafu mara nyingi ni fundi. Mara tu unapoona au harufu ya uchafu, weka glavu kadhaa. Na fikiria juu ya vifaa vingine vya kinga-kibinafsi (PPE). Ni ngumu sana kusafisha fujo ndani ya mashine. Wazo bora linaweza kuwa kuzika kitu hicho kwa kuteleza na kuendelea mbele.

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[14] I have a tendency to avoid gloves myself; it requires real practice to work aseptically while wearing gloves without contaminating yourself, your face, your clothes and other people while putting-on, wearing, using and removing gloves.

PROBLEMS FOR ENGINEERS

Suction pumps have relatively simple components and are therefore relatively easy to troubleshoot. Most failures we have seen in the developing world have been due to either one of two problems:

1. Electric motors that are old and worn and lack sufficient torque to drive the pistons in the pump assembly

2. Pump assemblies with leaf valves that are broken or missing

SHIDA KWA WAHANDISI

Mabomba ya uzalishaji yana vifaa rahisi na kwa hivyo ni rahisi kutatuliwa. Mapungufu mengi ambayo tumeona katika ulimwengu unaoendelea yametokana na moja ya shida mbili:

1. Motors za umeme ambazo ni za zamani na huvaliwa na hazina torque ya kutosha kuendesha bastola kwenye mkutano wa pampu

2. Mkusanyiko wa pampu na valves za majani ambazo zimevunjwa au hazipo

SUCTION PUMP/PAMPU MOTOR: CAPACITOR-RUN, SINGLE-PHASE AC

This one is similar to the motor installed in our Oxygen concentrator[15]. It is rated at 200 W and you can see the large running-capacitor along side.

In the following example from Meru District Hospital, Tengeru[16], we can see what the leaf valves look like.

SUCTION PAMPU MOTOR: CAPACITOR-RUN, AC NA AWAMU MOJA

Hii ni sawa na motor iliyosanikishwa kwa kiini chako cha oksijeni. Imekadiriwa kwa 200 W na unaweza kuona kubwa-capacitor kando kando.

Katika mfano ufuatao kutoka Hospitali ya Wilaya ya Meru, Tengeru, tunaweza kuona jinsi valves za jani zinaonekana.

---

[15] You may be able to salvage a motor from one machine to operate in another.

[16] The hospital is affectionately known as, “Little Mt Meru Hospital.”

CASE STUDY: SUCTION PUMP AT MERU DISTRICT HOSPITAL, TENGERU

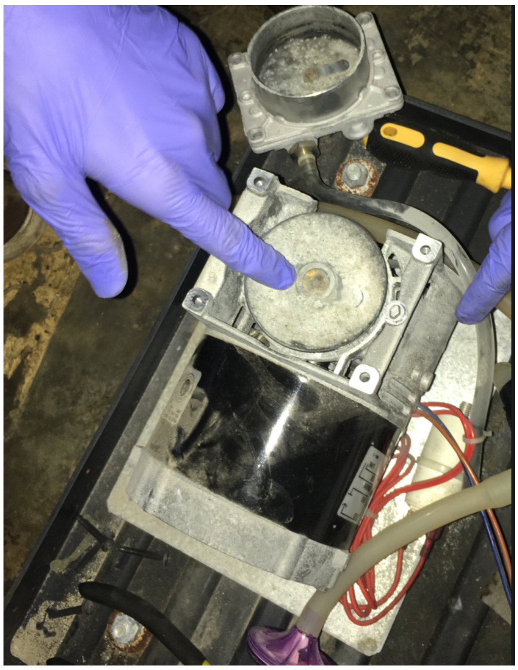
You can clearly see here a capacitor-run motor (the capacitor is white; its cables are red; the motor specification plate is visible on the side of the main casing). On the top of the motor you can see the piston from the pump. The pump cylinder head has been removed. If you look closely at it, you can see one leaf valve - the second leaf is missing.

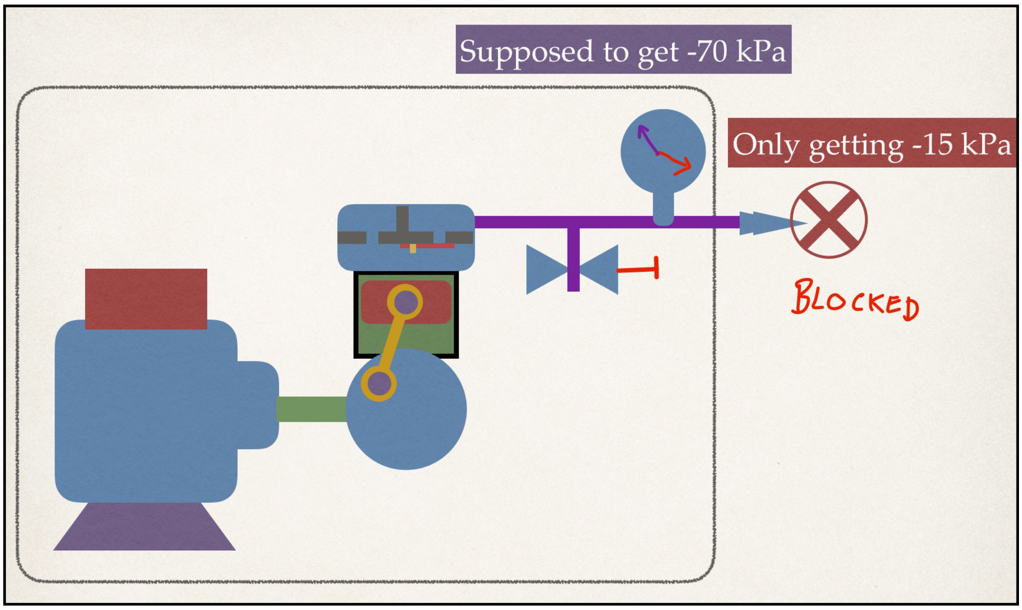
When operating, the suction pump was found to be ineffective. With one leaf-valve missing, the pump is only marginally effective. It may be possible to improvise a replacement leaf-valve - it is really just a thin piece of metal sheet. Steel is probably a good choice if available - Copper or Aluminium will probably fracture with metal-fatigue after a short period of operation.

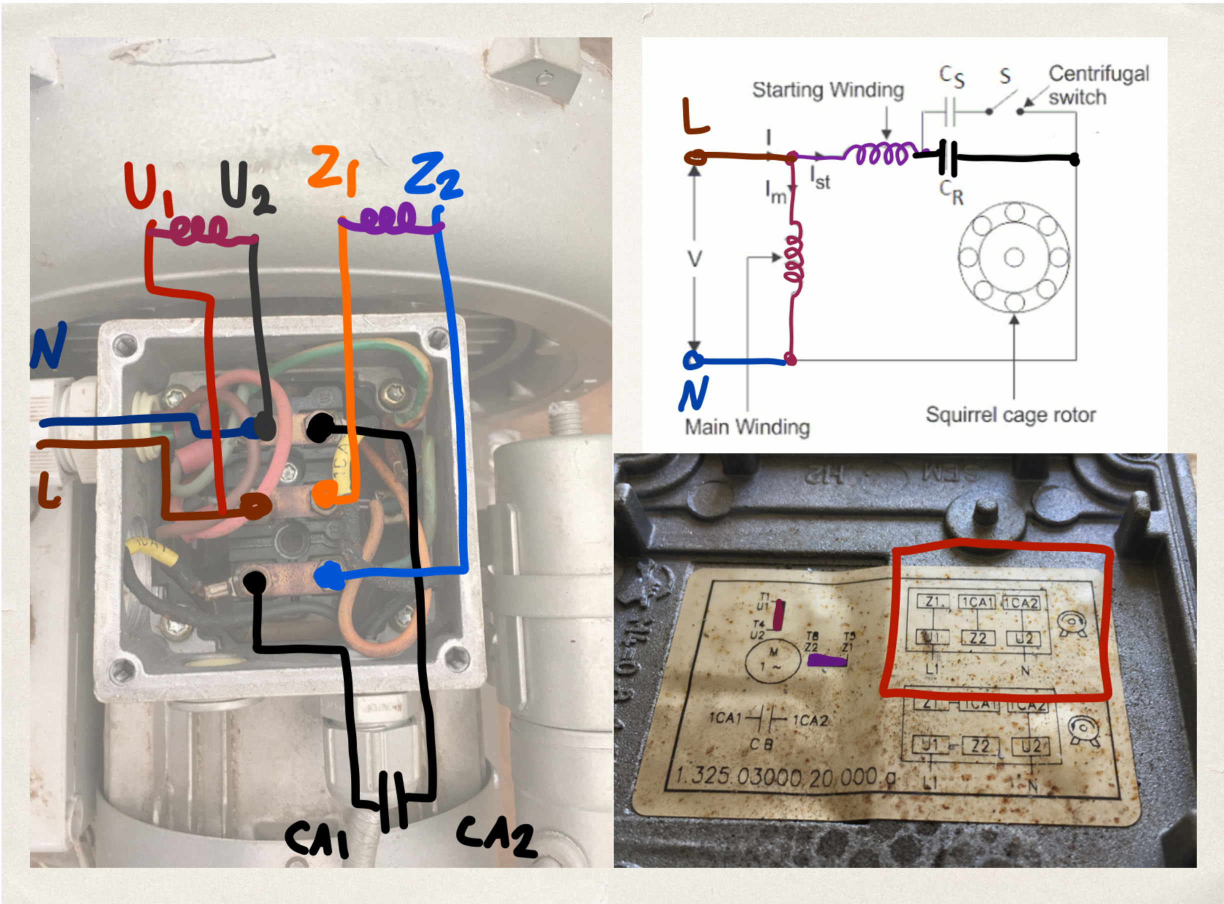
UCHUNGUZI-KIFANI: PAMPU YA UZALISHAJI KATIKA HOSPITALI YA WILAYA YA MERU, TENGERU

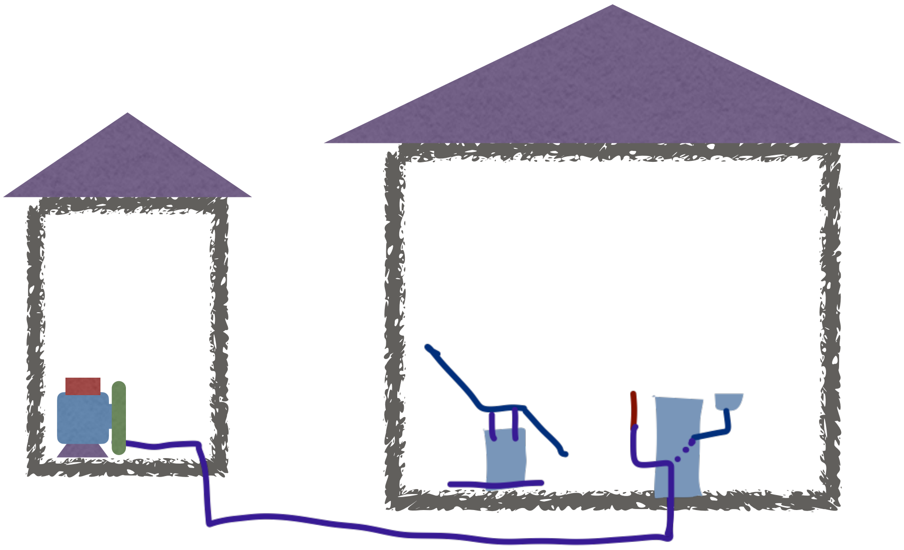
Unaweza kuona wazi hapa gari inayoendesha capacitor (capacitor ni nyeupe; nyaya zake ni nyekundu; sahani ya maelezo ya gari inayoonekana kwenye upande wa casing kuu). Juu ya gari unaweza kuona pistoni kutoka kwa pampu. Kichwa cha silinda ya pampu kimeondolewa. Ikiwa ukiitazama kwa karibu, unaweza kuona valve moja ya jani - jani la pili linakosekana.

Wakati wa kufanya kazi, pampu ya kuvuta iligunduliwa kuwa haifai. Kukiwa na jani-valve moja ya jani, pampu inafanikiwa tu. Inawezekana kufanyiza badala ya jani-valve - ni kipande nyembamba tu cha karatasi ya chuma. Chuma labda ni chaguo nzuri ikiwa inapatikana - Shaba au Aluminium itakumbwa na uchovu wa chuma baada ya kipindi kifupi cha kufanya kazi.




Supposed to get -70 kPa
Only getting -15 kPa
BLOCKED


U1
U2
Z1
Z2
N
L
CA1
CA2
Starting Winding
CS
S
Centrifugal switch
I
Ist
Im
CR
V
Main Winding
Squirrel cage rotor



CASE STUDY: DENTAL SUCTION MOTOR PAIR AT MT MERU HOSPITAL/

UCHUNGUZI-KIFANI: DAKTARI WA MENO ANAYEJIFUNGA KWA HOSPITALI YA MT MERU

The primary complaint from the dentist was simple, “No suction.” We had a look at the setup and found it to be arranged somewhat like this: The main building had two dental rooms, each containing a dental chair and cart, with the various building services[17] entering the cart from below the floor. The source of the suction for each was located in a separate outbuilding: there we found two high-powered electric motors bolted to sheets of plywood, resting on the concrete floor, with their suction lines attached to PVC pipe that were designed to provide suction to the main building.

Each motor was controlled by a relay that was in-turn controlled by a pair of switch contacts driven by a low-voltage control within the dental cart.

Malalamiko ya msingi kutoka kwa daktari wa meno yalikuwa rahisi, "Hakuna suction." Tulikuwa na uangalizi wa usanidi na tukapata ikipangwa kama hivi: Jengo kuu lilikuwa na vyumba viwili vya meno, kila moja iliyo na kiti cha meno na gari, na huduma mbali mbali za ujenzi zinazoingia ndani ya gari kutoka chini ya sakafu. Chanzo cha mashtaka kwa kila mmoja kilikuwa katika ujenzi tofauti: hapo tulipata motors mbili za umeme zilizo na sakafu kubwa iliyowekwa kwenye shuka ya plywood, ikipumzika kwenye sakafu ya saruji, na mistari yao ya kushonwa iliyowekwa kwenye bomba la PVC ambayo ilibuniwa kutoa shida jengo kuu.

Kila gari liladhibitiwa na relay ambayo ilibadilishwa na jozi ya anwani za kubadili zinazoendeshwa na udhibiti wa chini-voltage ndani ya gari la meno.

[17] Dental machines use up to five services: compressed air, potable water, drainage, suction and electricity.

Each motor had its own wiring box so that the various phases could be arranged to control the direction of rotation. We found that these particular motors were wired to rotate *clockwise*.

Kila gari lilikuwa na sanduku lake la wiring ili awamu kadhaa ziweze kupangwa kudhibiti mwelekeo wa mzunguko. Tuligundua kuwa motors hizi maalum zilikuwa za waya ili kuzunguka kwa saa.

Comparing the wiring diagrams with the actual wiring, we were able to figure out how exactly the setup was supposed to work.

Kwa kulinganisha michoro za wiring na wiring halisi, tuliweza kugundua ni jinsi gani usanidi huo unastahili kufanya kazi.

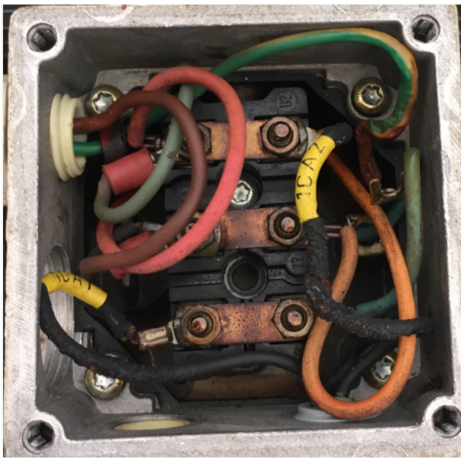
We tried various approaches:

- We gave up on burnt motor 1
- Tried to swap capacitors + control box
- Found a broken Z2 wire - fixed
- Still smokes, still won't turn

- Tulijaribu njia mbali mbali:
- Tukajitolea kwenye motor ya kuteketezwa 1
- Ilijaribu kubadilishana capacitors + sanduku la kudhibiti
- Pata waya iliyovunjika ya Z2 - iliyowekwa
- Bado huvuta, bado haitageuka

MOTOR 1

- Burnt windings/Windings iliyochomwa
- Burnt block/Kuzuia moto
- Mis-wired/wiring mbaya
- Control box stuck ON/ Sanduku la kudhibiti limekwama ON

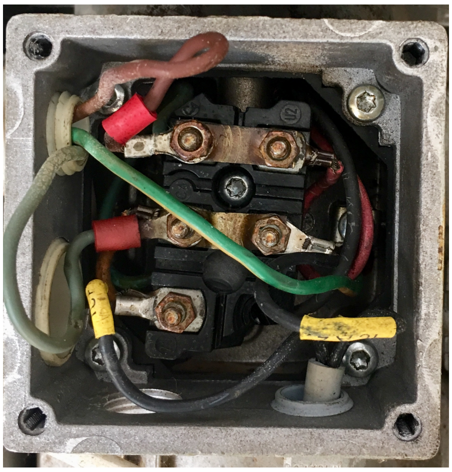


Having spent about half a day on the two motors, we discussed the situation with the hospital Matron and left the problem. Sometimes you lose.

Baada ya kukaa karibu nusu ya siku kwenye motors hizo mbili, tulijadili hali hiyo na Matron wa hospitali na kuacha shida. Wakati mwingine unapoteza.

MOTOR 2

- Block broken/Vitalu vimevunjika
- Rebuilt more than once/Kuijenga tena zaidi ya mara moja
- Humming, smoking/humming na moshi
- Stalled/kukwama bila kusonga mbele



WHAT DO THESE DEVICES HAVE IN COMMON?

These are all simple devices driven by simple electric motors. In the developing world, electric motors play a fairly significant role in medical equipment. This seems to be because elsewhere there are centralised gas supplies. Where these are not available, clinical staff must compress gases on demand, and produce suction via local vacuum pumps. Both types of device require small electric motors. If we add nebulisers, centrifuges and fluid pumps, then there is a fair amount of equipment that needs knowledge of electric motors to understand, repair and service.

JE! VIFAA HIVI VINAFANANAJE?

Zote ni vifaa rahisi zinazoendeshwa na motors rahisi za umeme. Katika ulimwengu unaoendelea, motors za umeme zina jukumu muhimu katika vifaa vya matibabu. Hii inaonekana kuwa kwa sababu mahali pengine kuna vifaa vya gesi vya kati. Ambapo haya hayapatikani, wafanyikazi wa kliniki lazima walazimishe gesi juu ya mahitaji, na kuzalisha suction kupitia pampu za utupu za mitaa. Aina zote mbili za kifaa zinahitaji motors ndogo za umeme. Ikiwa tunaongeza nebulisers, centrifuges na pampu za maji, basi kuna kiwango sawa cha vifaa ambavyo vinahitaji ujuzi wa motors za umeme kuelewa, kukarabati na huduma.

There are various types of motors in-use in medical devices. The basic physics and principles of electric motors are assumed knowledge for these lectures. Recall that all rotating electric motors are essentially doing the same thing: they are using a rotating magnetic field to drag an armature around by its own magnetic field. What varies between designs is how the two interacting fields are generated. Let's look at a few common *devices* and explore the motors within.

What do these devices all have in common? From a technical point of view, they are all relatively simple and use similar motors, pumps and concepts. Once you have grown familiar with some of the more common types of motors, you will find that you can work on any of these machines without great difficulty.

Now we will move to some machines that require a lot more skill, care and test equipment: ventilators.

Kuna aina anuwai ya matumizi ya motors katika vifaa vya matibabu. Fizikia ya msingi na kanuni za motors za umeme ni wazo linalodhaniwa kwa mihadhara hii. Kumbuka kwamba motors zote za umeme zinazozunguka kimsingi zinafanya jambo lile lile: zinatumia uwanja unaozunguka wa sumaku ili kuvuta kiwanja karibu na nguvu yake mwenyewe ya sumaku. Kinacho tofautisha kati ya miundo ni jinsi shamba hizo mbili zinazoingiliana hutolewa. Wacha tuangalie vifaa vichache vya kawaida na tuchunguze motors za ndani.

Je! Vifaa hivi vina uhusiano gani wote? Kwa mtazamo wa kiufundi, wote ni rahisi na hutumia motors sawa, pampu na dhana. Mara tu umezoea aina zingine za kawaida za motors, utaona kuwa unaweza kufanya kazi kwenye mashine yoyote hii bila shida kubwa.

Sasa tutaenda kwa mashine kadhaa ambazo zinahitaji ustadi zaidi, utunzaji na vifaa vya mtihani: viingilishi.

Ventilators

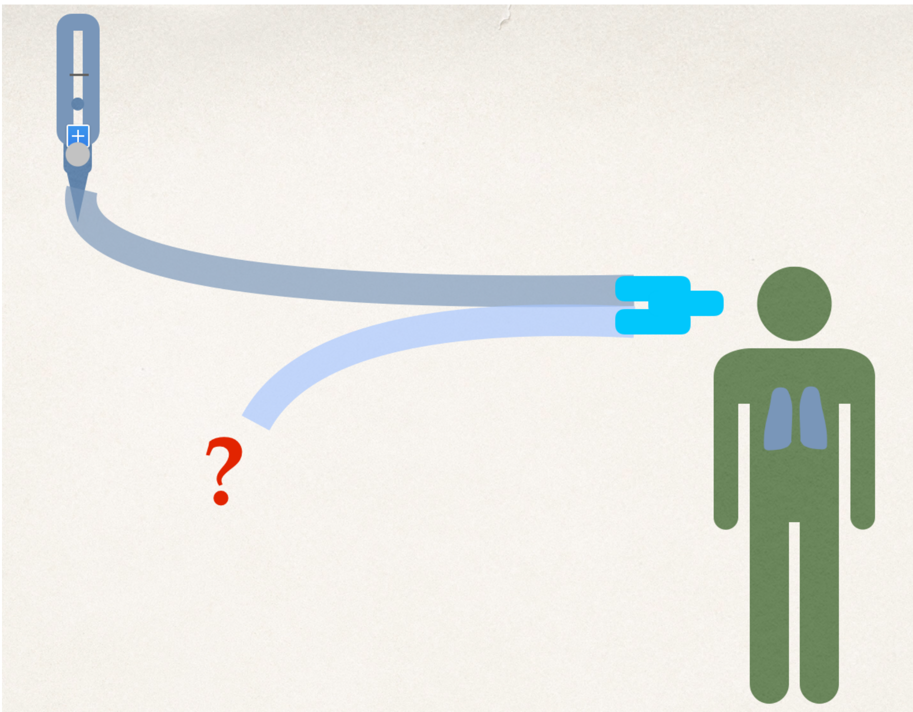
VENTILATORS ARE HIGH-RISK DEVICES

They are not for amateurs to service and they need to be handled with care. The main risk of ventilation is that a wrongly assembled or calibrated machine can over-pressurise a patient's lungs, resulting in serious injury or death. With a lot of medical equipment, you can proceed by trial and error, but with ventilation, there is little room for error. The purpose of this lecture is not to tell you how to fix or build a machine, but rather to show you the basic concepts of mechanical ventilation, such that when you look inside one, you may know what it is that you are looking at.

Ventilators

VIKOSI NI VIFAA VYENYE HATARI KUBWA

Sio kwa amateurs kwa huduma na wanahitaji kushughulikiwa kwa uangalifu. Hatari kuu ya uingizaji hewa ni kwamba mashine iliyokusanyika vibaya au iliyo na hesabu inaweza kushinikiza mapafu ya mgonjwa, kusababisha kuumia sana au kufa. Ukiwa na vifaa vingi vya matibabu, unaweza kuendelea na jaribio na kosa, lakini kwa uingizaji hewa, kuna nafasi ndogo ya kosa. Madhumuni ya hotuba hii sio kukuambia jinsi ya kurekebisha au kujenga mashine, lakini badala ya kukuonyesha dhana za msingi za uingizaji hewa wa mitambo, kwamba wakati unapoangalia ndani ya moja, unaweza kujua ni nini unaangalia.



So, what I'm going to do here is build a ventilator conceptually, so that you may understand the basic principles that are common to all mechanical ventilators.

Kwa hivyo, nitakachofanya hapa ni kujenga kiboreshaji cha uingizaji hewa, ili upate kuelewa kanuni za msingi ambazo zinajulikana kwa uingizaji hewa wote wa mitambo.

BASIC CONCEPTS

DHANA ZA KIMSINGI

Lets start with the machine-end and develop the simplest possible ventilator. You will remember learning about flow-meters from the earlier medical gas lectures. So a ventilator has two fundamental parts: a fresh gas source and an expiratory valve. That's it: it's that simple. Let's take that flow-meter and connect to to a patient's mouth by a tube[18]. The tube in this case is the *inspiratory limb* of the ventilator *circuit*. It is a gas circuit, not an electrical one.

Now imagine: a flow-meter connected directly to a patient would fill their lungs until they burst[19]. So we need some way to allow the flow to fill the lungs to just the right amount, then allow the lungs to empty as required. Most ventilators have a separate tube to allow expired air to flow away from the patient; this tube is called the *expiratory* limb. The *inspiratory* and *expiratory* limbs meet at a Y-piece (or "wye"), which connects the two limbs to the patient tube.

Inaweza kuanza na kumaliza-kwa mashine na kukuza kiingilishi rahisi zaidi. Utakumbuka ujifunze kuhusu mita za mtiririko kutoka mihadhara ya gesi ya matibabu ya hapo awali. Kwa hivyo ventilator ina sehemu mbili za msingi: chanzo safi ya gesi na valve ya nje. Hiyo ni: ni rahisi. Wacha tuchukue mita ya mtiririko na tuunganishe kwa mdomo wa mgonjwa na bomba. Chuburi katika kesi hii ni mguu wa kuhamasisha wa mzunguko wa uingizaji hewa. Ni mzunguko wa gesi, sio umeme.

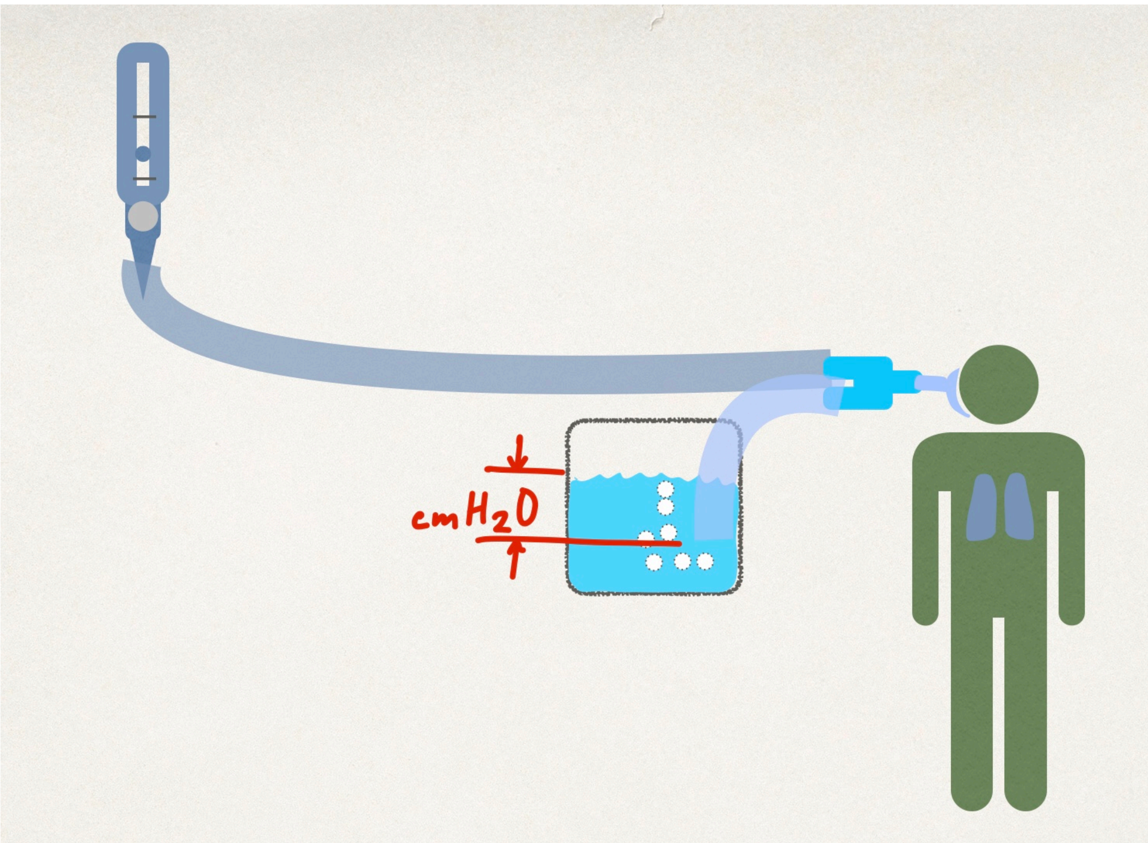
Sasa fikiria: mita ya mtiririko iliyounganika moja kwa moja na mgonjwa ingejaza mapafu yao hadi itakapopasuka. Kwa hivyo tunahitaji njia fulani ya kuruhusu mtiririko wa kujaza mapafu kwa kiwango sahihi tu, kisha upe mapafu tupu kama inavyotakiwa. Vigingi vingi vina bomba tofauti ili kuruhusu hewa iliyomalizika kutoka kwake kwa mgonjwa; bomba hili linaitwa kiungo cha nje. Viungo vya kuhamasisha na vya kuhamasisha vinakutana kwenye kipande cha Y (au "wye"), ambacho huunganisha viungo viwili na bomba la mgonjwa.

[18] There are different ways to interface a ventilator with a patient. The most common ways are either with an endo-tracheal tube - a tube that is physcially inserted into a patient's airway, or with a face mask that seals over the patient's nose and mouth. These are both usually single-use (disposable) and they both present various problems. They are not discussed at length here, as we are mainly concerned with the technical side, which is usually about the machine, and less concerned about the *clinical*, which concerns the selection and application of consumables.

[19] This is the fundamental risk of ventilator failure.

So now we have: A flow-meter, a tube connecting the flow-meter to the patient (*inspiratory limb*), a tube carrying expired air away (*expiratory*) and a Y-piece connecting both limbs to the patient. If the flow-meter's needle valve is opened, what will happen? Well, probably nothing. As there is very little resistance to flow throughout the ventilator circuit, there is no substatial pressure at the Y-piece, and therefore the patient can breathe normally (or not at all if they are incapacitated) regardless of the rate of flow. To inflate the lugs, we must briefly block the expiratory limb to allow pressure to develop in the circuit. Let's look at the simplest way to achieve this: *Continuous Positive Airway Pressure* (CPAP).

Kwa hivyo sasa tunayo: Mita ya mtiririko, bomba inayounganisha mita ya mtiririko kwa mgonjwa (mguu wa kuhamasisha), bomba iliyobeba hewa iliyomalizika mbali (msaidizi) na kipande cha Y kinachounganisha viungo vyote kwa mgonjwa. Ikiwa sindano ya sindano ya mita ya mtiririko imefunguliwa, nini kitatokea? Kweli, labda hakuna chochote. Kwa kuwa kuna upinzani mdogo sana wa mtiririko katika mzunguko wa uingizaji hewa, hakuna shinikizo la kuingiliana kwenye kipande cha Y, na kwa hivyo mgonjwa anaweza kupumua kawaida (au sivyo ikiwa haifai) bila kujali kiwango cha mtiririko. Ili kuingiza lugs, lazima tuzuie kwa kifupi kiungo cha nje ili kuruhusu shinikizo kukuza katika mzunguko. Wacha tuangalie njia rahisi zaidi ya kufanikisha hii: Shinikiza inayoendelea ya Away Airway (CPAP).



CPAP

Imagine that you take the expiratory limb and immerse its free end into a container of water. If the pressure in the circuit were to rise, gas would bubble out of the immersed end and rise to the surface. The maximum pressure developed in the circuit would be limited by the height of water above the end of the expiratory limb. This setup is called *bubble CPAP*. It is commonly used for infant ventilation and is one of the simplest possible ventilation arrangements. Provided that the water contained sits well below the patient (usually on the lower shelf of a trolley near the floor) there is no chance of the patient accidentally inhaling the water. There is also very little chance of accidentally overpressurising the patient's lungs and it requires very little technology.

From the patient's perspective, they experience only constant, positive pressure that they must breathe out against, which can be hard work. Furthermore, if the patient needs extra support while breathing in, there is no way to increase the pressure or flow into the lungs to provide extra support. To overcome these limitations, we need a mechanical valve.

CPAP

Fikiria kwamba unachukua kiungo cha nje na kumwaga mwisho wake wa bure ndani ya chombo cha maji. Ikiwa shinikizo katika mzunguko lingeongezeka, gesi ingekuwa nje ya mwisho wa kuzamishwa na kupanda juu ya uso. Shinikiza kubwa inayokuzwa katika mzunguko itapunguzwa na urefu wa maji juu ya mwisho wa kiungo cha mwili. Usanidi huu unaitwa Bubble CPAP. Inatumika kawaida kwa uingizaji hewa wa watoto wachanga na ni moja ya mpangilio rahisi wa uingizaji hewa. Ikizingatiwa kuwa maji yaliyomo hukaa chini ya mgonjwa (kawaida kwenye rafu ya chini ya troli karibu na sakafu) hakuna nafasi ya mgonjwa kuvuta pumzi kwa bahati mbaya. Kuna nafasi ndogo sana ya kuzidisha kwa uvimbe kwa shida mapafu ya mgonjwa na inahitaji teknolojia ndogo sana.

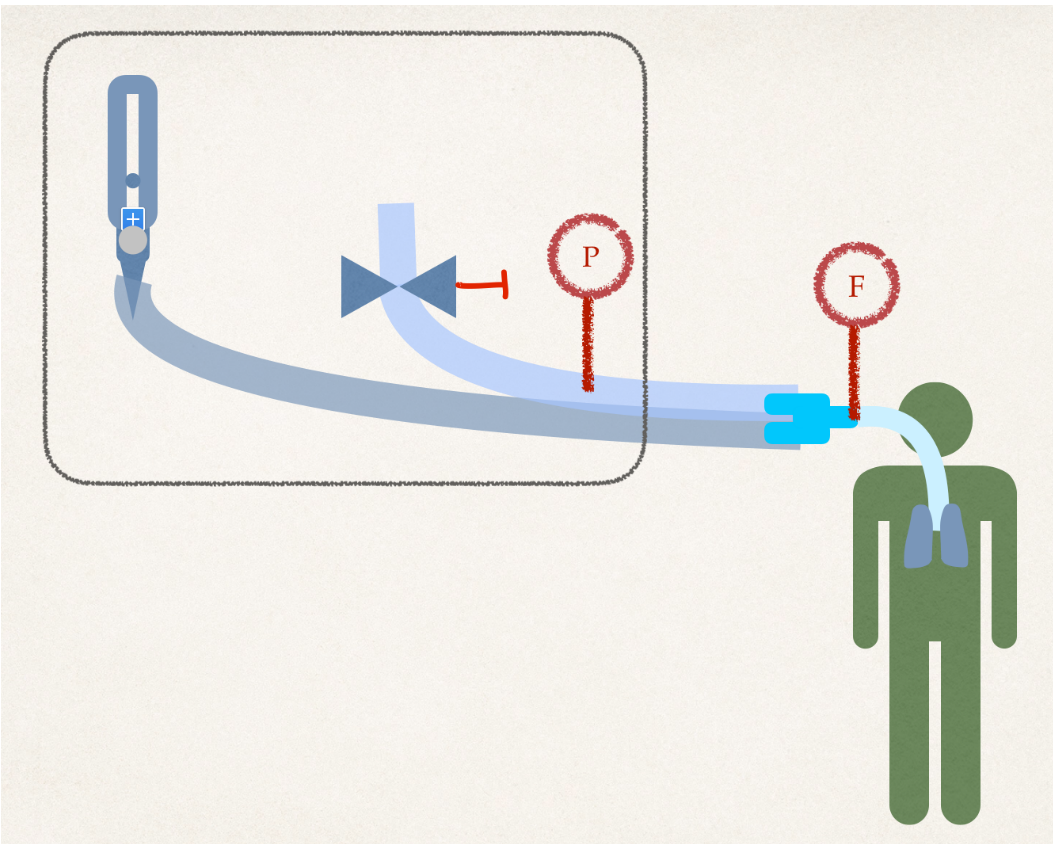
Kwa mtazamo wa mgonjwa, wanapata shinikizo za mara kwa mara, chanya ambazo lazima zipumue dhidi yake, ambayo inaweza kuwa kazi ngumu. Kwa kuongezea, ikiwa mgonjwa anahitaji msaada zaidi wakati akipumua, hakuna njia ya kuongeza shinikizo au kupita ndani ya mapafu ili kutoa msaada wa ziada. Ili kuondokana na mapungufu haya, tunahitaji valve ya mitambo.

AUTOMATIC MECHANICAL VENTILATION

If we add a mechanical valve to the free end of the expiratory limb, we can close the valve and develop pressure within the ventilator circuit and the patient lungs, provided we open the valve before the lungs are overpressurised. If a pressure sensor ("P") is added, the circuit pressure can be monitored and controlled. By adding a timer, an incapacitated patient can be made to breathe regularly by simply closing the valve to inflate the lungs, and opening it again to allow the patient to breathe out. Lastly, if the circuit pressure is known, the expiratory valve can be a proportional solenoid valve or adjustable regulator, so that the pressure can be *controlled* throughout each breath cycle.

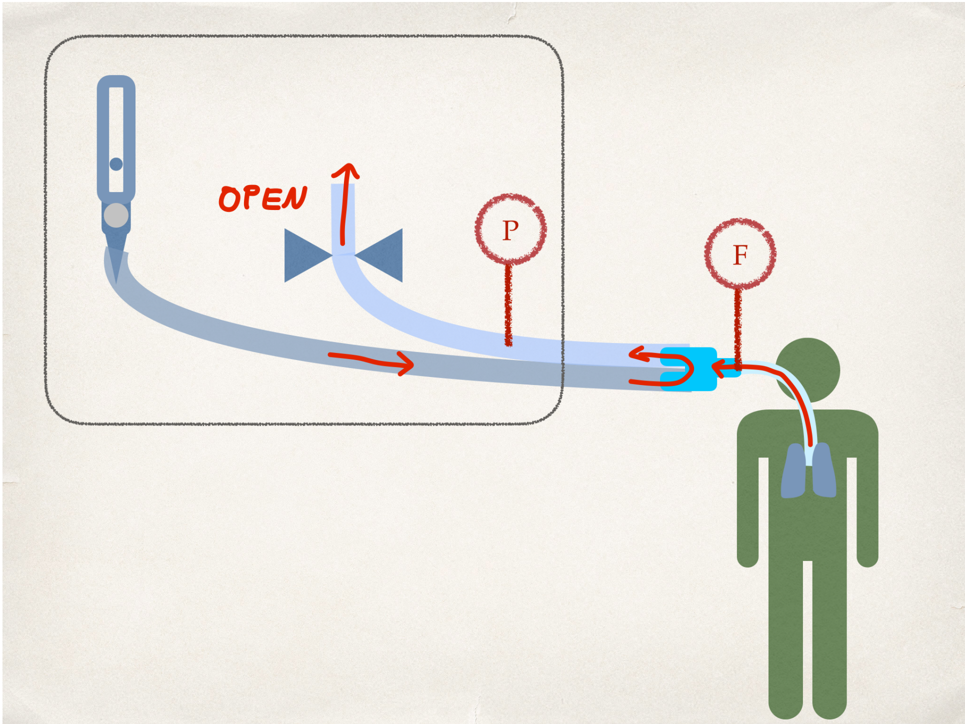
UINGIZAJI HEWA WA MITAMBO MOJA KWA MOJA

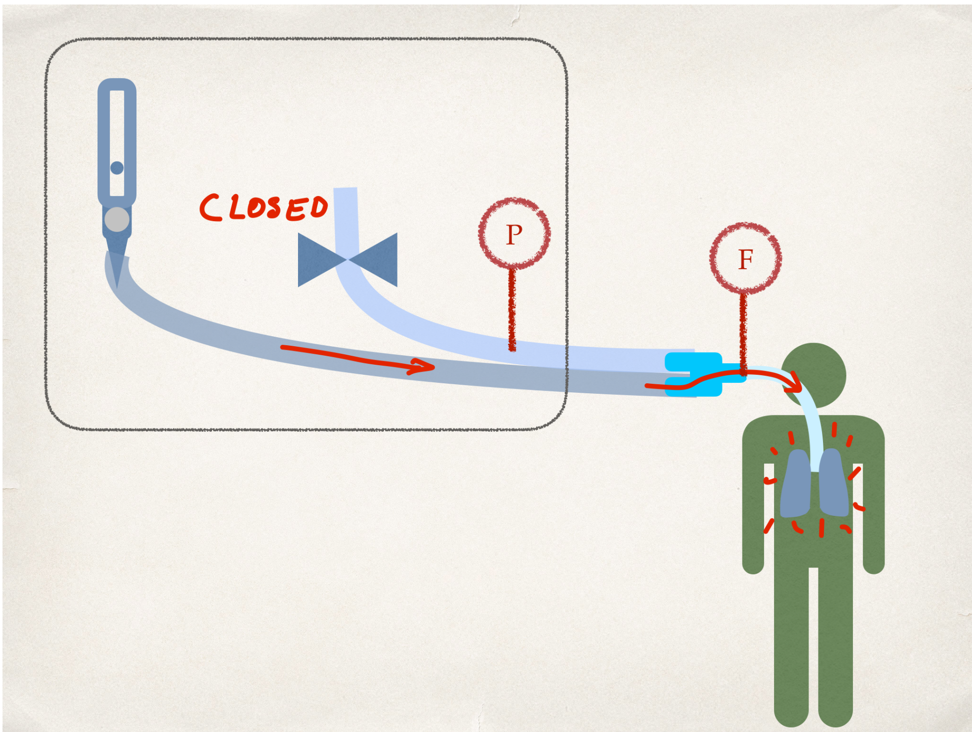
Ikiwa tunaongeza valve ya mitambo kwa mwisho wa bure wa kiungo cha nje, tunaweza kufunga valve na kuendeleza shinikizo ndani ya mzunguko wa uingizaji hewa na mapafu ya mgonjwa, mradi tu tutafungua valve kabla ya mapafu kuzidiwa. Ikiwa sensor ya shinikizo ("P") imeongezwa, shinikizo ya mzunguko inaweza kufuatiliwa na kudhibitiwa. Kwa kuongeza timer, mgonjwa asiyeweza kufanikiwa anaweza kufanywa kupumua mara kwa mara kwa kufunga tu valve kuingiza mapafu, na kuifungua tena kumruhusu mgonjwa kupumua. Mwishowe, ikiwa shinikizo la mzunguko linajulikana, valve inayoweza kutolewa inaweza kuwa sarafu ya kuogelea au mdhibiti anayeweza kubadilishwa, ili shinikizo liweze kudhibitiwa kwa kila mzunguko wa pumzi.



By watching the circuit pressure, this simple ventilator can be made to do various useful things. For instance, if the patient is *not* incapacitated, the ventilator may notice when a connected patient attempts to breathe in, and provide breath support.

Kwa kutazama shinikizo la mzunguko, kiingilishi hiki rahisi kinaweza kufanywa kufanya vitu vingi muhimu. Kwa mfano, ikiwa mgonjwa hajafanikiwa, kiyoyozi kinaweza kugundua wakati mgonjwa aliyeunganishwa anajaribu kupumua, na kutoa msaada wa pumzi.





VOLUME-CONTROLLED VENTILATION

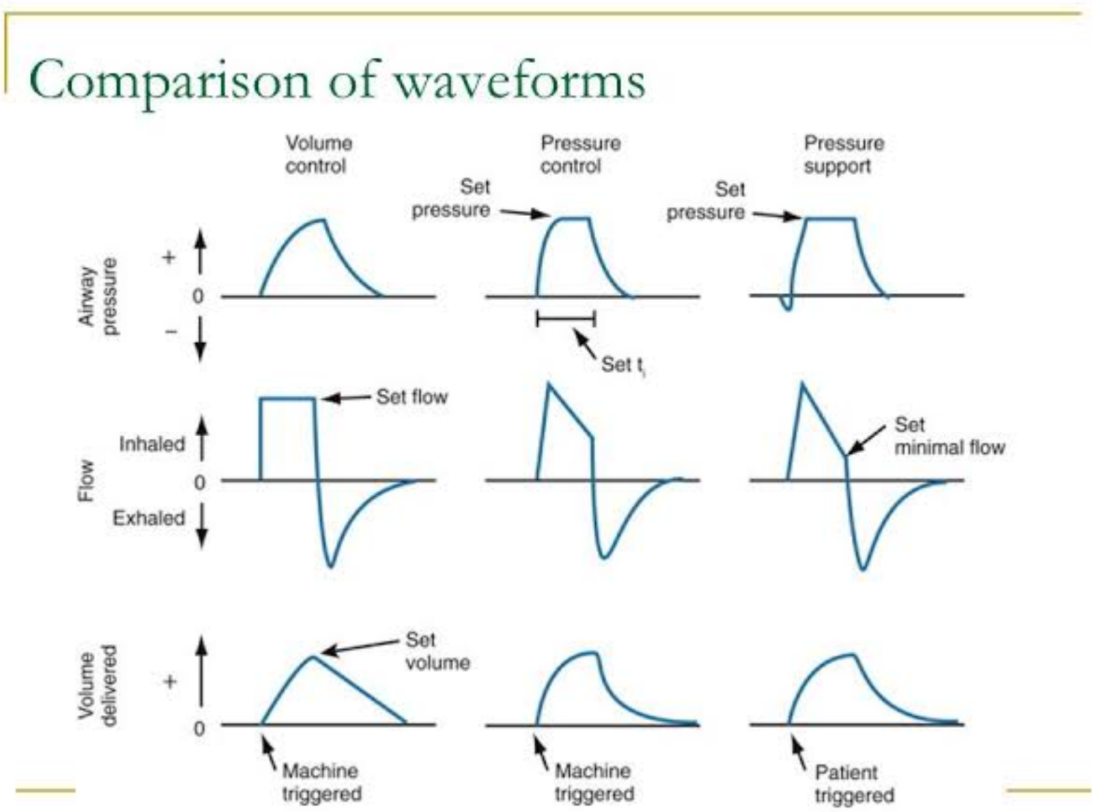
Pressure-controlled ventilation is not often the most suitable mode for therapy. Most of the time, a ventilator is working to ensure a certain *volume* of gas is delivered to the patient. This is usually specified as the *minute volume*, or the total volume delivered over an average minute. If you consider that a patient, at rest, may breathe around 12 breaths per minute, you can see that the minute volume is similar to a volume that is 12 times the *tidal* volume, or the volume delivered in any given breath.

An intelligent ventilator can sense when a patient is trying to breathe and give them extra support, then if they are not breathing frequently enough to maintain the desired minute volume, the ventilator itself can trigger extra breaths.

KUDHIBITI KIASI UINGIZAJI HEWA

Uingizaji hewa unaodhibitiwa na shinikizo mara nyingi sio njia inayofaa zaidi kwa matibabu. Wakati mwingi, kiyoyozi kinafanya kazi ili kuhakikisha kwamba kiwango fulani cha gesi huletwa kwa mgonjwa. Hii kawaida huainishwa kama kiasi cha dakika, au jumla ya jumla kutolewa kwa dakika wastani. Ikiwa unazingatia kuwa mgonjwa, wakati wa kupumzika, anaweza kupumua karibu 12 pumzi kwa dakika, unaweza kuona kwamba kiasi cha dakika ni sawa na kipimo ambacho ni mara 12 ya kiwango cha jumla, au kiasi kinachotolewa kwa pumzi yoyote.

Kwa hivyo kiingilizi chenye akili anaweza kuhisi wakati mgonjwa anajaribu kupumua na kuwapa msaada wa ziada, basi ikiwa sio kupumua mara kwa mara vya kutosha kutunza kiasi cha dakika inayotaka, kiingilizi yenyewe kinaweza kusababisha pumzi za ziada.



Marx: Rosen's Emergency Medicine, 7th ed.2009.

TRIGGERED AND MANDATORY BREATHS

There are various combinations of triggered and supported breaths, as well as *mandatory* breaths determined by the ventilator's internal calculations that combine to provide various kinds of therapy.

YALISABABISHA NA PUMZI LAZIMA

Kuna mchanganyiko anuwai wa pumzi zilizosababishwa na zilizoungwa mkono, na pumzi za lazima zilizowekwa na mahesabu ya ndani ya kiingilizi ambayo huchanganyika ili kutoa aina tofauti za matibabu.

FLOW MEASUREMENT

To determine whether ventilation is adequate, a *flow sensor* ("F") is needed. By integrating flow measurements over time, *volume* measurements become available. There are two basic approaches to flow-measurement. We'll call them *hot-wire anemometry* and the *orifice plate* method.

KIPIMO CHA MTIRIRIKO

Ili kuamua ikiwa uingizaji hewa ni wa kutosha, sensor ya mtiririko ("F") inahitajika. Kwa kuunganisha vipimo vya mtiririko kwa wakati, vipimo vya kiasi vinapatikana. Kuna njia mbili za msingi za kipimo cha mtiririko. Tutawaita anemometry-waya na njia ya sahani ya orifice.

HOT WIRE FLOW MEASUREMENT

If you look near the Y-piece of a ventilator set, you may see a small gadget that looks a bit like a lamp with a filament. It will be connected to the main controller of the ventilator by an electrical cable. The basic idea is this: electric current is used to heat the filament, while gas flows past the filament and cools it down on the way to the patient. The rate of cooling is related to the flow-rate and the heat generated is related to the current. Unfortunately, this is not a simple relationship and produces highly non-linear results. In most practical devices, the temperature of the filament is servo-controlled by varying the current, making it easier to estimate the fresh-gas flow.

KIPIMO CHA MTIRIRIKO WA WAYA MOTO

Ikiwa utatazama karibu na kipande cha Y kipya cha seti ya uingizaji hewa, unaweza kuona gadget ndogo ambayo inaonekana kidogo kama taa na filamenti. Itaunganishwa na mtawala mkuu wa uingizaji hewa na kebo ya umeme. Wazo la msingi ni hili: umeme wa sasa hutumiwa kuwasha joto, wakati gesi inapita kupita kwenye filimbi na kuipasha joto njiani kwenda kwa mgonjwa. Kiwango cha baridi huhusiana na kiwango cha mtiririko na joto linalotokana linahusiana na ya sasa. Kwa bahati mbaya, huu sio uhusiano rahisi na hutoa matokeo yasiyokuwa ya mstari. Katika vifaa vya vitendo zaidi, hali ya joto ya filimbi inadhibitiwa na kutofautisha sasa, na inafanya iwe rahisi kukadiria mtiririko wa gesi-safi.

HOT-WIRE FLOW SENSOR FAILURE

Hot-wire flow sensors are a common source of failure, as the filaments tend to break when the sensor is dropped. As they are relatively expensive, they are reusable and are typically sterilised by autoclave, which puts more stress on the sensors.

You can check the continuity of a hot-wire sensor using a multimeter or continuity tester. If it is open-circuit, throw it away. They cannot be repaired.

KUSHINDWA KWA SENSOR YA WAYA YA MOTO

Sensorer za waya-moto ni chanzo cha kawaida cha kutofaulu, kwani vichungi huwa huvunjika wakati sensor imeshuka. Kwa kuwa ni bei ghali, zinarekebishwa tena na kawaida husafishwa na autoclave, ambayo inaweka mkazo zaidi kwa sensorer.

Unaweza kuangalia mwendelezo wa sensor ya waya-moto ukitumia multimeter au tester mwendelezo. Ikiwa ni mzunguko wazi, uitupe mbali. Hawawezi kurekebishwa.

HOT-WIRE FLOW SENSOR CALIBRATION

Hot-wire sensors usually need calibration before use. A two-point calibration may be done by an automated self-test during ventilator setup, or during operation. A single-point calibration requires no reference gauges: the ventilator is set to calibration mode and the sensor briefly blocked by hand.

CALIBRATION SENSOR MTIRIRIKO WA WAYA

Sensorer za waya za moto kawaida zinahitaji calibration kabla ya matumizi. Urekebishaji wa nukta mbili unaweza kufanywa na jaribio la kibinafsi wakati wa usanidi wa uingizaji hewa, au wakati wa operesheni. Urekebishaji wa nukta moja hauhitaji viwango vya kumbukumbu: kiingilio kimewekwa kwa hali ya calibration na sensor imefungwa kwa mkono.

ORIFICE PLATE MEASUREMENT

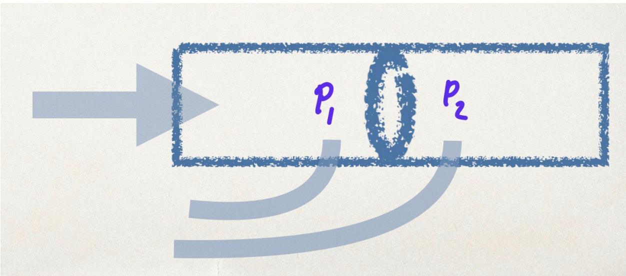
Instead of depending on a resusable filament for flow sensing, a disposable ventilator circuit may have two fine tubes connected close to the Y-piece. These will be sitting on either side of a plastic orifice plate. The pressure developed across the plate is related to the square of the flow-rate. To measure flow reliably, the ventilator must have two extra pressure sensors monitoring the pressure in these fine measurement tubes.

Before we go any further, we need to introduce some safety features. All ventilators have these two features: An *overpressure relief* valve and an *emergency inspiration* valve.

VIPIMO VYA SAHANI YA ORIFICE

Badala ya kutegemea filament inayoweza kusisishwa kwa kuhisi mtiririko, mzunguko wa uingizaji hewa wa ziada unaweza kuwa na zilizopo mbili nzuri zilizounganishwa karibu na kipande cha Y. Hizi zitakuwa zimekaa pande zote za sahani ya mapambo ya plastiki. Shinisho iliyoandaliwa katika sahani inahusiana na mraba ya kiwango cha mtiririko. Ili kupima mtiririko kwa uhakika, kiingilizi lazima kiwe na sensorer mbili za ziada zinazofuatilia shinikizo kwenye zilizopo za kipimo nzuri.

Kabla hatujaenda mbali zaidi, tunahitaji kuanzisha huduma zingine za usalama. Vivinjari vyote vina sifa hizi mbili: valve ya misaada ya kupita kiasi na valve ya msukumo wa dharura.



$$q_m = \frac{C_d}{\sqrt{1-\beta^4}}\, \epsilon\, \frac{\pi}{4}\, d^2 \sqrt{2\, \rho_1 \Delta p}$$ [3]

EMERGENCY VALVES

Test the two emergency valves. The anti-asphyxia valve should open at about 2-3 cmH2O below atmospheric pressure. The pressure-relief valve should open between 40-100 cmH2O.

VALVES ZA DHARURA

Pima valves mbili za dharura. Valve ya kupambana na asphyxia inapaswa kufunguliwa karibu 2-3 cmH2O chini ya shinikizo la anga. Valve-unafuu wa shinikizo inapaswa kufungua kati ya 40-100 cmH2O.

EMERGENCY RELIEF VALVES

OVERPRESSURE RELIEF VALVE

This valve is built somewhere into the ventilator circuit to make sure that in *any* circumstances, the circuit pressure never gets higher than a safe level. The valve should open if an over-pressure event occurs whether due to ventilator failure, patient effort, kinked tubing, power failure or combination of the above.

ANTI-ASPHYXIA VALVE

This valve is critical to ensure that a patient will *always* be able to breathe in while attached to a ventilator, regardless of the state of the ventilator. This is usually done with a mechanical valve somewhere in the gas circuit, usually in or near the expiratory block. The valve may be a simple weighted or spring-loaded check-valve that only opens when the circuit pressure drops below a certain level.

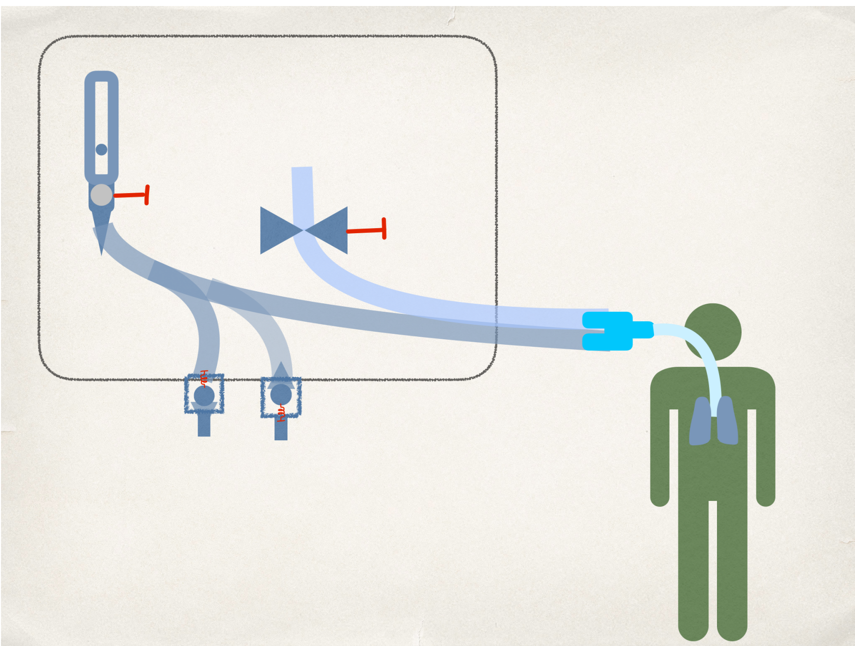
VALVES ZA DHARURA

SHINIKIZO UNAFUU

Valve hii imejengwa mahali pengine ndani ya mzunguko wa uingizaji hewa ili kuhakikisha kuwa katika hali yoyote, shinikizo la mzunguko kamwe huwa juu kuliko kiwango salama. Valve inapaswa kuwa wazi ikiwa tukio la shinikizo kubwa linatokea ikiwa ni kwa sababu ya kushindwa kwa uingizaji hewa, bidii ya mgonjwa, neli iliyokatwa, kushindwa kwa nguvu au mchanganyiko wa hayo hapo juu.

VALVE KUPAMBANA NA ASPHYXIA

Valve hii ni muhimu ili kuhakikisha kuwa mgonjwa ataweza kupumua kila wakati akiwa ambatanishwa na uingizaji hewa, bila kujali hali ya uingizaji hewa. Hii kawaida hufanywa na valve ya mitambo mahali pengine kwenye mzunguko wa gesi, kawaida ndani au karibu na kizuizi. Valve inaweza kuwa kipimo rahisi cha kupima au cha kubeba kilicho na mzigo wa spring ambacho hufungua tu wakati shinikizo la mzunguko linapoanguka chini ya kiwango fulani.



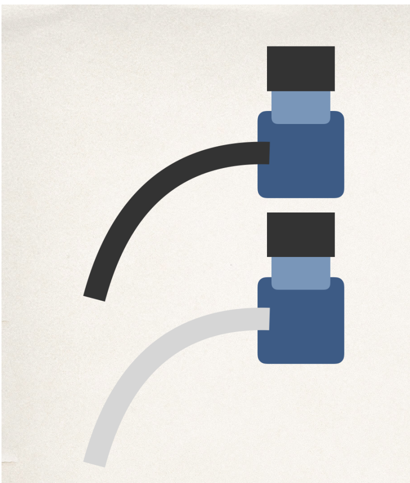
So by adding all these valves, we can paint a picture of the basic concepts of mechanical ventilation.

Kwa hivyo kwa kuongeza valves hizi zote, tunaweza kuchora picha ya dhana za msingi za uingizaji hewa wa mitambo.

FRESH-GAS SUPPLY

In building our conceptual ventilator, we started with a medical flow-meter. In practice, most ventilators depend on having at least a pressurised O2 source. Sometimes medical-grade compressed air can be generated on demand by means of an impeller, which entrains filtered air from the environment and adds it to a compressed O2 stream. O2 is not always necessary, but is commonly blended with medical air so as to create a range of therapeutic air/O2 proportions that can be selected on-demand. As such, the back-end of a ventilator contains various regulators, impellers, gas blenders and flow-metering systems for one purpose: to produce a controlled stream of fresh medical gas at a desired proportion of air and O2.

The back-end regulators themselves may need to be calibrated to ensure that they are operating at their target pressure. Downstream metering devices may depend on these pressures being accurate. You may recall regulator form and function from a previous lecture.



USAMBAZAJI WA GESI SAFI

Katika kujenga kiingilishi cha dhana yetu, tulianza na mita ya mtiririko wa matibabu. Kwa mazoezi, waingizaji hewa wengi hutegemea kuwa na angalau chanzo cha nguvu cha O2. Wakati mwingine matibabu daraja USITUMIE hewa inaweza kuzalishwa kwa mahitaji kwa njia ya impela, ambayo entrains kuchujwa hewa kutokana na mazingira na kuuongeza kwenye USITUMIE O2 mkondo. O2 sio lazima kila wakati, lakini inaunganishwa kawaida na hewa ya matibabu ili kuunda anuwai ya matibabu ya hewa / O2 ambayo inaweza kuchaguliwa kwa mahitaji. Kama hivyo, mwisho wa mwisho wa uingizaji hewa una wasanifu mbalimbali, wauzaji, mchanganyiko wa gesi na mifumo ya kutiririka kwa kusudi moja: kutoa mtiririko wa gesi safi ya matibabu kwa sehemu inayotaka ya hewa na O2.

Wasanidi wa-mwisho wenyewe wanaweza kuhitaji kupimwa ili kuhakikisha kuwa wanafanya kazi kwa shinikizo lao. Vifaa vya metering chini ya maji vinaweza kutegemea shinikizo hizi kuwa sahihi. Unaweza kukumbuka fomu ya mdhibiti na kazi kutoka kwa hotuba iliyopita.

HUMIDIFICATION

Imagine that you have clean gas coming out of a flow source: it is really really dry. Zero moisture content. As it flows into a patient's airway, it dries it out, leading to tissue damage, cracking, pain, infection and all manner of related problems. For long-term[20] ventilation, moisture must be added to the air with a humidifier.

A humidifier is essentially a hotplate with a container of water sitting on it, such that the gas from the ventilator's inspiratory limb passes across the fluid surface. The hotplate temperature must be carefully controlled so as not to overheat the water; usually its setpoint is at body temperature (about 36-37 C). This should be a simple-enough concept, but, like most medical equipment, the design effort goes into the safety features. There must be:

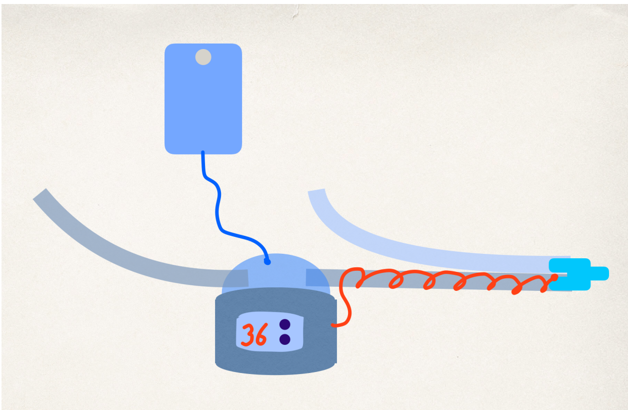
1. A controller to closely regulate the water temperature
2. A sensor to detect the air temperature
3. A heated wire to keep the moist air from condensing water as it cools down while passing through the rest of the inspiratory limb to the patient

HUMIDIZATION

Fikiria kuwa una gesi safi kutoka kwa chanzo cha mtiririko: kwa kweli kavu kabisa. Vitu vya unyevu vya sifuri. Wakati unapita ndani ya barabara ya mgonjwa, huitia nje, na kusababisha uharibifu wa tishu, ngozi, maumivu, maambukizi na kila aina ya shida zinazohusiana. Kwa uingizaji hewa wa muda mrefu, unyevu lazima uongezwe hewani na unyevu.

Kiwango cha unyevu kimsingi ni moto moto na kontena la maji limeketi juu yake, ili gesi kutoka kwa kiungo cha kuhamasisha cha mvuke ipite kwenye uso wa maji. Joto la hotplate lazima litadhibitiwe kwa uangalifu ili usizidishe maji; kawaida kawaida yake ni kwa joto la mwili (karibu 36-37 C). Hii inapaswa kuwa dhana rahisi-ya kutosha, lakini, kama vifaa vingi vya matibabu, juhudi za kubuni zinaingia kwenye sifa za usalama. Lazima kuwe na:

1. Mdhibiti kudhibiti kwa undani joto la maji
2. Sensorer ya kugundua joto la hewa
3. Waya wenye joto ili kuzuia hewa yenye unyevu kutoka kwa maji kufurika wakati inapopanda chini wakati unapita katikati ya sehemu ya kutia moyo kwa mgonjwa



[20] "Long term" means more than an hour or so. Humidification is less important for emergency ventilation but essential for therapeutic or ICU ventilation.

The other problem created by having moist air at body temperature is that it greatly increases the chances of bacteria growing in the circuit. For this reason, ventilator circuits must be changed regularly to prevent bacteria from compromising patient's lungs. More importantly, the water and its container must be sterile. Usually, the container is closed to the outside environment and the water level is maintained by using a bag a sterile water, similar to that used for intravenous injection. By keeping the water and the humidifer container sterile, the patient and the circuit remain bacteria-free for longer.

Shida nyingine inayoundwa na kuwa na hewa unyevu kwenye joto la mwili ni kwamba huongeza sana nafasi za bakteria kukua katika mzunguko. Kwa sababu hii, mizunguko ya uingizaji hewa lazima ibadilishwe mara kwa mara ili kuzuia bakteria wasiingie mapafu ya mgonjwa. Muhimu zaidi, maji na kontena yake lazima iwe na mchanga. Kawaida, chombo hicho kimefungwa kwa mazingira ya nje na kiwango cha maji kinadumishwa kwa kutumia begi maji yenye kuzaa, sawa na ile inayotumika kwa sindano ya ndani. Kwa kuweka maji na chombo cha unyevu wa humidiferi, mgonjwa na mzunguko hubaki bila bakteria kwa muda mrefu.

#VENTILATORHACKS

Coronavirus around the world in 2020

In late 2019, a novel coronavirus was found in Wuhan province in China. Over the next few months it spread around the world. At present (April 2020), it has become a global pandemic and killed thousands of people.

Those infected with the virus develop COVID-19, which is essentially a flu-like illness that in some cases becomes deadly. For those severely-affected patients, the disease progresses towards Acute-Respiratory-Distress-Syndrome - an illness that requires patients to have their respiration assisted by a ventilator. As you can see from the diagram below, as the disease gets worse, more sophisticated ventilation is required. Meanwhile, the pandemic itself is such that there is a global shortage of ventilator-beds and staff trained to operate them. There is also a shortage of PPE, and one can only imagine that it is hard to get hold of disposable and reusable ventilator circuits.

#JENGA MASHINE YA UINGIZAJI HEWA

Coronavirus kote ulimwenguni mnamo 2020

Mwishoni mwa mwaka wa 2019, nadharia ya riwaya ilipatikana katika mkoa wa Wuhan nchini China. Kwa miezi michache ijayo ilienea ulimwenguni kote. Kwa sasa (Aprili 2020), imekuwa janga la ulimwengu na kuwauwa maelfu ya watu.

Wale walioambukizwa na virusi huendeleza COVID-19, ambayo kimsingi ni ugonjwa kama mafua ambayo kwa nyakati zingine huwa ya kufa. Kwa wagonjwa walioathiriwa sana, ugonjwa unaendelea kuelekea Sifa ya Papo hapo-ya Kujishughulisha-Shaka - ugonjwa ambao unahitaji wagonjwa kupumua kwao kusaidiwa na uingizaji hewa. Kama unavyoona kutoka mchoro hapa chini, ugonjwa unapozidi, uingizaji hewa wa hali ya juu inahitajika. Wakati huo huo, janga lenyewe ni kwamba kuna upungufu wa vitanda vya uingizaji hewa na wafanyikazi waliofunzwa kuzishughulikia. Pia kuna uhaba wa PPE, na mtu anaweza kufikiria tu kuwa ni ngumu kupata duru za uingizaji hewa zenyewe na zinazoweza kutumika tena.

BUILD YOUR OWN?

In this context, there has been some discussion about how to build or hack your own ventilator. As an engineer, I always find it hard to "place" these concepts. We are trained to design for context, which means that a ventilator is not only a machine, it is also a set of concepts and people that all must interact in order for that machine to be useful. For instance, a ventilated patient is also a monitored patient, a sedated patient, typically in an intensive care unit. A ventilator needs medical gas supplies, patient-circuits, a sterilising department (for reusable circuits), not to mention skills in setup, operation, testing and calibration, and technical support. On a good day it is difficult to get device design right, even when the context is well known. To design *any* medical device without context is almost meaningless, and may be unhelpful.

Nevertheless, you may find yourself with a ventilator that doesn't work properly, but everything else is available (i.e. the medical gases, the expertise etc) and you want to hack some other devices together to save a sick patient[21]. By looking at the ventilator usage guidance in the diagram, and by referring to the notes above, you may be able to get simple ventilation going with what you have and at least facilitate the treatment of the least-worst cases.

Good luck, Bahati njema!

- M. Smith, Central Australia 2020

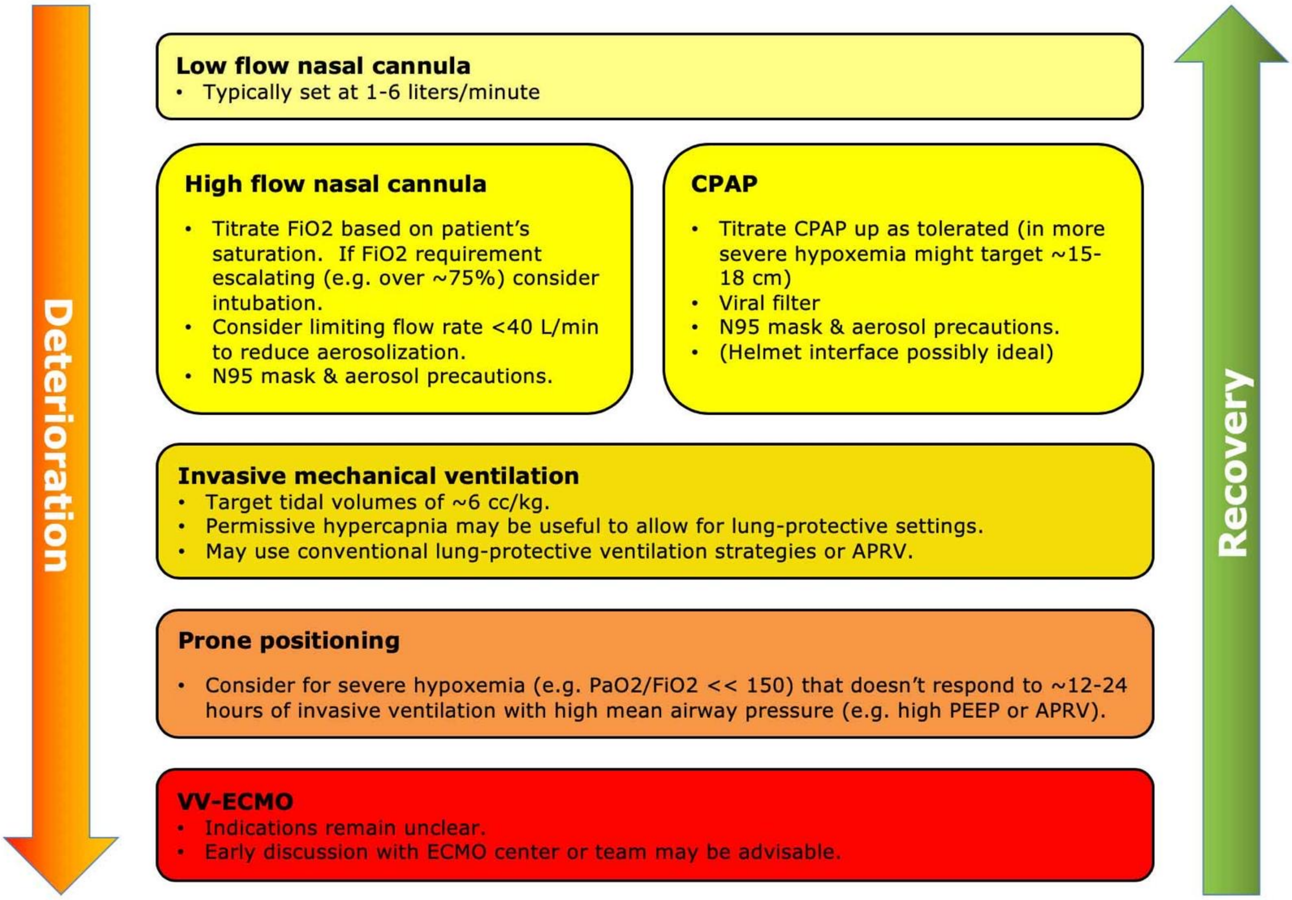
JENGA YAKO MWENYEWE?

Katika muktadha huu, kumekuwa na majadiliano juu ya jinsi ya kujenga au kuvinjari kiwanda chako mwenyewe. Kama mhandisi, mimi hupata shida kuweka "dhana hizi" kila wakati. Tumefundishwa kubuni kwa muktadha, ambayo inamaanisha kuwa kiingilio sio mashine tu, pia ni seti ya dhana na watu ambao wote lazima waingiliane ili mashine hiyo iweze kuwa na maana. Kwa mfano, mgonjwa aliye na hewa safi pia ni mgonjwa anayesimamiwa, mgonjwa aliyekaa, kawaida katika kitengo cha utunzaji mkubwa. Inafungia mahitaji ya vifaa vya gesi ya matibabu, mizunguko ya wagonjwa, idara ya steri (kwa mizunguko inayorekebishwa tena), bila kutaja ujuzi katika usanidi, operesheni, upimaji na hesabu, na msaada wa kiufundi. Katika siku nzuri ni ngumu kupata muundo wa kifaa kulia, hata wakati muktadha unajulikana. Kubuni kifaa chochote cha matibabu bila muktadha karibu haina maana, na inaweza kuwa isiyo na maana.

Walakini, unaweza kujikuta na kiingilio ambacho haifanyi kazi vizuri, lakini kila kitu kingine kinapatikana (kwa mfano, gesi za matibabu, utaalam n.k.) na unataka kubonyeza vifaa vingine pamoja ili kumwokoa mgonjwa mgonjwa. Kwa kuangalia mwongozo wa matumizi ya uingizaji hewa kwenye mchoro, na kwa kurejelea maelezo hapo juu, unaweza kupata uingizaji hewa rahisi kwenda na kile ulicho nacho na angalau kuwezesha matibabu ya kesi mbaya zaidi.

[21] By the way, you can use a ventilator to ventilate multiple patients at once. See, for example: https://emcrit.org/pulmcrit/split-ventilators/

General schema for respiratory support in patients with COVID-19



The optimal strategy for respiratory support in COVID-19 remains unknown. Patients with more complex respiratory disease (e.g. COPD plus COVID-19) might benefit from BiPAP. Choice of CPAP vs. HFNC may vary depending to resources and patient preference. ANZICS guidelines recommend HFNC rather than noninvasive ventilation.

-The Internet Book of Critical Care, by @PulmCrit