APPROVED BY:	RESPONSIBILITY:	EFFECTIVE DATE:	POLICY NO.:	PAGE:
Peter John Camacho, M.P.H. Hospital Administrator/CEO	Hospital-wide	April 12, 2018	A-EC900	1 of 8
TITLE: COMPRESSED GAS STORAGE AND OXYGEN USE				
LAST REVIEWED/REVISED: 12/2017				
ENDORSED: EOC 01/2018, PSC 01/2018, NM 02/2018, EMC 03/2018				

POLICY:

The Joint Commission and the Centers for Medicare and Medicaid Services require that healthcare organizations be compliant with NFPA 99-2012, 11.3 and 11.6. It is the policy of Guam Memorial Hospital Authority (GMHA) that all compressed gas cylinders, either in use or in storage (empty or full), shall be tightly secured by a strap, chain, non-tip base or other approved means.

Staff who handle medical gases shall be educated about the possible hazards associated with medical gas use. All staff concerned with the use and transport (handling) of compressed gas shall be trained in the proper handling of cylinders (vessels), cylinder trucks and supports, and cylinder-valve protection caps. All cylinder storage areas, outside and inside, shall be protected from extremes of heat and cold and from access by unauthorized individuals.

DEFINITIONS:

Compressed Gas - Any material or mixture having, when in its container, an absolute pressure exceeding 40 psia (an absolute pressure of 276 kPa) at 70° F (21.1° C) or, regardless of the pressure at 70° F (21.1° C) having an absolute pressure exceeding 104 psia (an absolute pressure of 717 kPa) at 130° F (54.4° C).

Compressed Gas Cylinder - Any portable pressure vessel of 45.4 kg (100 lb) water capacity or less designed to contain a gas or liquid that is authorized for use at gauge pressures over 276 kPa (40 psi) at 21° C (70° F) by the U. S. Department of Transportation (DOT) or Transport Canada (T.C.)

"Cracking" a Cylinder - "Crack" the valve slowly (by opening the valve slightly and then reclosing it) before attaching the regulator in order to blow out dust and debris from the opening. Note: Cylinders containing highly toxic gases should **not** be "cracked".

Cryogenic liquid: liquid with a normal boiling point below -130oF (-90oC). Common industrial gases transported, handled and stored in the liquid state at cryogenic temperatures are Argon, Helium, Hydrogen, Nitrogen, and Oxygen.

"D" sized Compressed Gas Cylinder - holds approximately 15 cu ft of gas.

"E" sized Compressed Gas Cylinder - holds approximately 25 cu ft of gas.

"H" sized Compressed Gas Cylinder - holds approximately 250 cu ft of gas.

Flammable Compressed Gas - A compressed gas which forms a flammable mixture when 13 percent or less (by volume) is mixed with air, or a compressed gas having a flammable range with air wider than 12 percent, regardless of the lower limitation. These limitations shall be determined

at atmospheric temperature and pressure. Flammable gases do not have flash points. Also: Any substance that exists in the gaseous state at normal atmospheric temperature and pressure and is capable of being ignited and burned when mixed with the proper proportions of air, oxygen or other oxidizers.

Flow-Control Valve - A valve, usually a needle valve, that precisely controls flow of gas.

Medical Air - Medical air is air supplied from cylinders, bulk containers, and medical air compressors or has been reconstituted from oxygen USP and oil free nitrogen NF.

Pressure Regulator - A device, either adjustable or nonadjustable, for controlling and maintaining, within acceptable limits, a uniform outlet pressure.

PROCEDURE:

I. GENERAL STANDARDS:

A. All staff handling medical gases shall be trained to recognize various types of medical gas labels.
   - With use of 360-degree wrap-around labels to designate medical oxygen provided on oxygen cylinders from the medical gas supplier, staff shall be trained to assure that each vessel to be connected to oxygen systems bears the 360-degree wrap-around label.

B. Cylinders must be marked clearly with the name of the contents. Cylinders with wired on tags or color codes only shall not be accepted.

C. Medical grade products such as oxygen cylinders, must be stored separately from industrial grade products. Full medical gas cylinders shall be received and stored in a clearly designated area that is clearly marked and separate from the clearly marked storage area for empty medical gas cylinders.
   Note 1: Once a medical gas cylinder valve is opened, it is considered empty, even if there is gas remaining in the cylinder.
   Note 2: All cylinders with pressures < 500 PSI are to be removed from patient use.

D. Full, partial and empty cylinders must be clearly labeled and physically separated.

E. The use of oil, grease or lubricants on valves, regulators or fittings is prohibited.

F. Plastic crush gaskets shall **never** be reused for oxygen cylinders.

G. Fittings (adapters) on medical gas cylinders shall never be changed. If a cryogenic vessel fitting does not seem to connect to the oxygen supply system fitting, immediately notify the medical gas supplier. The cylinder shall be returned to the supplier to determine the fitting or connection problem.

H. Do not attempt to repair damaged cylinders or to force frozen cylinder valves.

I. Cylinders must be secured at all times so they cannot fall.

J. Cylinders shall be transported, stored and used in an upright position.

K. Valve safety covers shall be left on until pressure regulators are attached.

L. Once an oxygen vessel is connected to the oxygen supply system, but prior to introducing the product into the system, the Power Plant Maintenance Leader, or designee, shall inspect the connection to the system to assure the correct vessel has been connected properly.

M. Any patient injury felt to be related to the use of medical gases shall be immediately reported to the Risk Management Program Officer and the manufacturer of the medical gas.

II. FLAMMABLE GASES:

A. Special care must be used when gases are used in confined spaces.

B. No more than two (2) cylinders shall be manifolded together; however, several instruments or outlets are permitted for a single cylinder.

C. Cylinders must not be stored near heat sources or combustible materials, lubricants, electrical wiring, ignition sources or other non-compatible compressed gases.
D. Storage areas must be well ventilated, well protected, dry and at least 20 feet from highly combustible materials.

III. PRESSURE REGULATORS AND NEEDLE VALVES:

A. Needle valves and regulators are designed specifically for different families of gases. Use only the properly designed fittings.
B. Always follow the regulator manufacturer's instructions for attaching the regulator to an oxygen cylinder.
C. Always use the sealing gasket specified by the regulator manufacturer.
D. Throats and surfaces must be clean and tightly fitting. Do not lubricate.
E. Always inspect the regulator and CGA 870 seal before attaching it to the valve to ensure that the regulator and seal are in good condition, and the regulator is equipped with only one (1) integral metal and rubber seal that is in good condition. Avoid plastic seals.
F. Tighten the T-handle firmly by hand, but do not use wrenches or other hand tools that may over-torque the handle.
    - Tighten regulators and valves firmly with the properly sized wrench. Do not use adjustable wrenches or pliers. Do not force tight fits.
G. Open the post valve slowly, while maintaining a grip on the valve wrench, so that it can be closed quickly if gas escapes at the juncture of the regulator and valve.
    - Do not stand directly in front of gauges (the gauge face may blow out). Do not force valves that stick.
H. Check for leaks at connections. Leaks are usually due to damaged faces at connections or improper fittings. Do not attempt to force an improper fit. (It may only damage a previously undamaged connection and compound the problem.)
I. Valve handles must be left attached to the cylinders.
J. The maximum rate of flow shall be set by the high-pressure valve on the cylinder. Fine-tuning of flow shall be regulated by the needle valve.
K. Shut off cylinder when it is not in use.

IV. LEAK TESTING:

A. Cylinders and connections shall be tested by "snoop" or a soap solution. First, test the cylinders before regulators are attached and test again after the regulators or gauges are attached.

V. EMPTY CYLINDERS:

A. Must be marked empty.
B. Empty or unused cylinders must be returned promptly to the designated empty cylinder storage area.
C. Replace valve safety caps where applicable.

VI. OXYGEN USE:

A. Oxygen and other gases are potentially dangerous. Special safety precautions shall be followed at all times while using or storing oxygen.
B. Ensure cylinders are secure on rack and never hang anything on cylinder.
C. Crack valves to clear them before bringing tank into patient care area.
D. Read labels, tags and color code before administering any compressed gas.
E. Check oxygen supply regularly.

F. Store oxygen cylinders upright and secured.
G. An individual medical gas cylinder placed in a patient room for immediate use by a patient is not required to be stored in an enclosure, as it is considered in use.
H. Ensure oxygen cylinders are secured in a dedicated carrier on a stretcher during any transport. This includes oxygen cylinders on ambulance company's rescue stretchers.

VII. CYLINDER DURATION:

Boyles law states that pressure and volume of a given amount of a confined gas are inversely proportional **(P * V = k),** whereas **P** is pressure, **V** is volume and **k** is the constant. To find the duration of a cylinder, the following formula is applied:

$$\text{Estimated Duration (in minutes)} = \frac{k * (P - R)}{F}$$

k is the tank constant ("D" cylinder is 0.16, "E" Cylinder is 0.28, "H" cylinder is 3.14)
P is the tank gauge pressure in PSI.
R is the *Safe Residual Pressure in PSI, typically 200 PSI.
F is the Flow in liters per minute.

*Safe Residual Pressure is a term that implies that it is unsafe to continue using an oxygen cylinder with a pressure of less than 200 PSI.

VIII. OPERATIONAL SUPPLY:

A. A supply of non-flammable medical gas of up to 300 cubic feet (12E-sized cylinders) associated with patient care can be located outside of enclosed locations (per smoke compartment) open to the corridor (i.e., nurse's station) in a healthcare facility.
   - This amount of medical gas is in addition to those cylinders contained in crash carts and in use on wheelchairs or gurneys.
B. Such containers shall be properly secured (i.e., in racks) to prevent tipping over or damage.
C. Operational supply of non-flammable medical gas shall be stored so as not to obstruct the use of any corridor.

REFERENCE(S):

Centers for Medicare and Medicaid Services (CMS), Life Safety Code Tag K922, K933, https://www.cms.gov/Medicare/CMS-Forms/CMS-Forms/downloads/cms2786R.pdf
NFPA 99 Healthcare Facilities, 2012 Edition at 11.3
NFPA 99 Healthcare Facilities, 2012 Edition at 11.6
NFPA Glossary of Terms, 2016 Edition
Oxygen Tank Duration, Weill Medical College of Cornell University, http://www-users.med.cornell.edu/~spon/picu/calc/o2tankd.htm

ATTACHMENT(S):

I. How to calculate cylinder duration for "d" and "e" cylinders
II. How to calculate cylinder duration for "H" cylinders
III. Formula for cylinder for cylinder duration for Crashcart attachment
IV. Oxygen Tank Badge

ATTACHMENT I

HOW TO CALCULATE CYLINDER DURATION FOR "D" AND "E" CYLINDERS

LPM	Pressure (PSI)							
	500	750	1,000	1,250	1,500	1,750	2,000	2,200
1	84	154	224	294	364	434	504	560
2	42	77	112	147	182	217	252	280
3	28	51	75	98	121	145	168	187
4	21	39	56	74	91	109	126	140
5	17	31	45	59	73	87	101	112
6	14	26	37	49	61	72	84	93
10	8	15	22	29	36	43	50	56
12	7	13	19	25	30	36	42	47
15	6	10	15	20	24	29	34	37

LPM	Pressure (PSI)							
	500	750	1,000	1,250	1,500	1,750	2,000	2,200
1	48	88	128	168	208	248	288	320
2	24	44	64	84	104	124	144	160
3	16	29	43	56	69	83	96	107
4	12	22	32	42	52	62	72	80
5	10	18	26	34	42	50	58	64
6	8	15	21	28	35	41	48	53
10	5	9	13	17	21	25	29	32
12	4	7	11	14	17	21	24	27
15	3	6	9	11	14	17	19	21

*** Consider alternate tank if calculation is ≤15 minutes**

HOW TO CALCULATE CYLINDER DURATION

$$\textbf{Estimated Duration (in minutes)} = \frac{k * (P - R)}{F}$$

k is the tank constant *(**E** cylinder is **0.28, D** cylinder is **0.16**)*
P is the tank gauge pressure in PSI
R is the Safe Residual Pressure in PSI, typically 200 PSI
F is the Flow in liters per minute

Example: RN is transporting a patient on oxygen (E cylinder) running at 4 LPM. The gauge reads 1000 PSI. With the above formula, there are 56 minutes of oxygen available.

0.28 (1000 - 200)/4
0.28 (800)/4
224/4 = 56 minutes

The tables to the left are for reference. Please note that this is the estimated time for the duration of the Oxygen tank being used.

ATTACHMENT II

HOW TO CALCULATE CYLINDER DURATION FOR "H" CYLINDERS

LPM	Pressure (PSI)							
	500	750	1,000	1,250	1,500	1,750	2,000	2,200
1	15h, 42min	1d,4h, 47min	1d,17h, 52min	2d,6h, 57min	2d,20h, 2min	3d,9h, 7min	3d,22h, 12min	4d,8h, 40min
2	7h, 51min	14h, 24min	20h, 56min	1d,3h, 29min	1d,10h, 1min	1d,16h, 34min	1d,23h, 6min	2d,4h, 20min
3	5h, 14min	9h. 36min	13h, 57min	18h, 19min	22h, 41min	1d,3h, 2min	31h, 24min	1d,10h, 53min
4	3h, 56min	7h, 12min	10h, 28min	13h, 44min	17h, 1min	20h, 17min	23h. 33min	1d,2h, 10min
5	3h, 8min	5h, 45min	8h, 22min	10h, 59min	13h, 36min	16h, 13min	18h, 50min	20h, 56min
6	2h, 37min	4h, 48min	6h, 59min	9h, 10min	11h, 20min	13h, 31min	15h, 42min	17h, 27min
10	1h, 34min	2h, 53min	4h, 11min	5h, 30min	6h, 48min	8h, 7min	9h, 25min	10h, 28min
12	1h, 19min	2h, 24min	3h, 29min	4h, 35min	5h, 40min	6h, 46min	7h, 51min	8h, 43min
15	1h, 3min	1h, 55min	2h, 47min	3h, 40min	4h, 32min	5h, 24min	6h, 17min	6h, 59min

HOW TO CALCULATE CYLINDER DURATION

$$\text{Estimated Duration (in minutes)} = \frac{k * (P - R)}{F}$$

k is the tank constant. **H** cylinder is **3.14**
P is the tank gauge pressure in PSI
R is the Safe Residual Pressure in PSI, typically 200 PSI
F is the Flow in liters per minute

Example: RN connecting a patient on oxygen (H cylinder) running at 15 LPM. The gauge reads 1000 PSI. With the above formula, there are 167 minutes of oxygen available.

3.14 (1000 - 200)/15
3.14 (800)/15
2512/15 = 167 minutes or 2h,47min

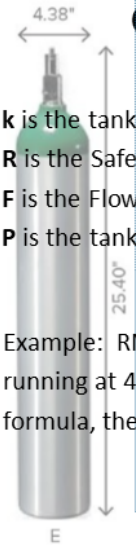
The table to the left is for reference. Please note that this is the estimated time for the duration of the Oxygen supply in the H cylinder.

ATTACHMENT III

FORMULA FOR CYLINDER DURATION FOR CRASHCART ATTACHMENT

HOW TO CALCULATE CYLINDER DURATION

Estimated Duration (in minutes) = $\frac{k * (P - R)}{F}$



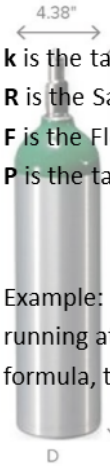
k is the tank constant. The constant for **E** cylinders is **0.28**
R is the Safe Residual Pressure in PSI, typically 200 PSI
F is the Flow in liters per minute
P is the tank gauge pressure in PSI

Example: RN transporting a patient on oxygen (E cylinder) running at 4 LPM. The gauge reads 1000 PSI. With the above formula, there are 56 minutes of oxygen available.

0.28 (1000 - 200)/4
0.28 (800)/4
224/4 = 56 minutes

HOW TO CALCULATE CYLINDER DURATION

Estimated Duration (in minutes) = $\frac{k * (P - R)}{F}$



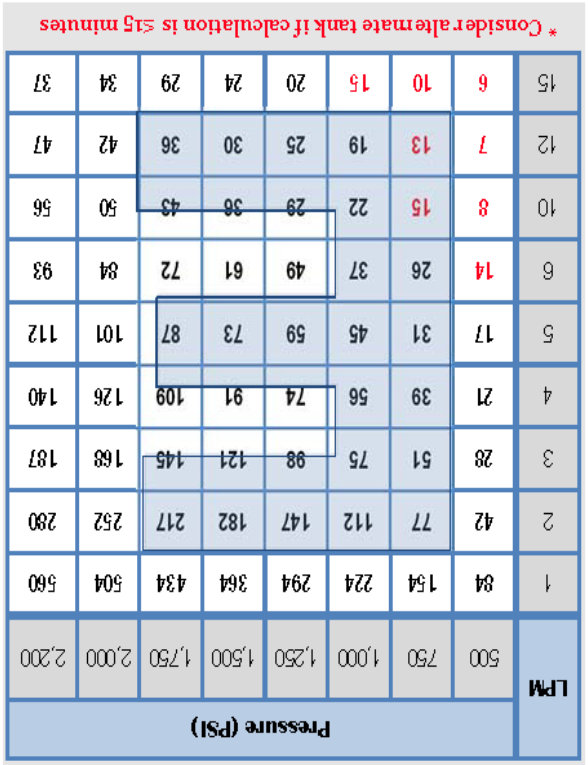
k is the tank constant. The constant for **D** cylinders is **0.16**
R is the Safe Residual Pressure in PSI, typically 200 PSI
F is the Flow in liters per minute
P is the tank gauge pressure in PSI

Example: RN transporting a patient on oxygen (D cylinder) running at 4 LPM. The gauge reads 1000 PSI. With the above formula, there are 32 minutes of oxygen available.

0.16 (1000 - 200)/4
0.16 (800)/4
128/4 = 32 minutes

ATTACHMENT IV

OXYGEN TANK BADGE



* Consider alternate tank if calculation is ≤15 minutes

LPM	Pressure (PSI)							
	500	750	1,000	1,250	1,500	1,750	2,000	2,200
1	84	154	224	294	364	434	504	560
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6	14	26	37	49	61	72	84	93
10	8	15	22	29	36	43	50	56
12	7	13	19	25	30	36	42	47
15	6	10	15	20	24	29	34	37

Estimated Duration (in minutes) = k* (P - R) / F
k is the tank constant (E cylinder is 0.28), R is the Safe Residual Pressure in PSI, typically 200 PSI, F is the Flow in liters per minute, P is the tank gauge pressure in PSI.

Estimated Duration (in minutes) = k* (P - R) / F
k is the tank constant (D cylinder is 0.16), R is the Safe Residual Pressure in PSI, typically 200 PSI, F is the Flow in liters per minute, P is the tank gauge pressure in PSI.

LPM	Pressure (PSI)							
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4	12	22	32	42	52	62	72	80
5	10	18	26	34	42	50	58	64
6	8	15	21	28	35	41	48	53
10	5	9	13	17	21	25	29	32
12	4	7	11	14	17	21	24	27
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