Medical Gas Industry - The Patient-Safety-Advocate Roles of Piped Anesthesia/Medical Gas Professionals

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During the piped anesthesia/medical gas distribution systems training which allows us to become third-party credentialed to ASSE/ANSI Standard Series 6000 as Installers (6010), Inspectors (6020), Verifiers (6030), Maintenance Personnel (6040) or Instructors (6050), we are taught the technicalities, according to the current edition of NFPA 99. This training guarantees proper installation, inspection, verification and maintenance of these healthcare patient life-supporting systems. This exceptional training emphasizes the proper installation or maintenance of these systems that are utilized by all ages of patients - ranging from premature neonatal infants to adults of every age. However, this training usually implies that the grouping of piped anesthesia/medical gas systems is just another piping system category utilized by the patient. This grouping seems to be classified on only the same level of importance as the health care facility’s potable water, sanitary drainage, heating and cooling and specialty piping systems.

I feel that regarding the determining of either immediate short term or extensive long term and positive or negative, patient outcomes, this extensive technical training should place much more emphasis on the intense, real-time patient life-supporting roles that piped anesthesia/medical gas distribution systems play. It should also underline the major patient-safety-advocate roles that all piped anesthesia/medical gas system professionals must envision themselves playing while performing all required installation and maintenance procedures regarding these systems.

Ironically, throughout their history to the present these complex piping systems which are designed to provide maximum reliability during medical procedures, along with utmost healthcare patient safety, have occasionally accidentally caused catastrophic patient consequences. Of all healthcare-piping systems, anesthesia/medical gas presents the largest number of latent possibilities that can unexpectedly arise and cause instantaneously, extremely negative healthcare patient outcomes. These are caused by a multitude of preventable faults that can swiftly occur from these systems’ improper installation, maintenance or operation. Unlike other malfunctioning piping systems (potable water distribution, sanitary drainage, etc.) which can cause serious healthcare patient complications that today’s modern medicine can cure before most permanent adverse complications arise - improperly installed, maintained, or operated piped anesthesia/medical gas piping systems have been known to cause immediate permanent patient injury or death before the healthcare facility’s professional staff even realizes what is happening and is able to react!

Because today’s regulations mandate exceptional training, along with incredibly reliable equipment design and gas manufacturing, these extremely serious accidents now happen more rarely than ever. However, the occurrence of even only one more catastrophic healthcare patient anesthesia/medical gas event throughout our enormous national healthcare system must still be considered totally unacceptable!

Because of these reasons, piped anesthesia/medical gas installations have effectively placed medical gas professionals directly into the loop of patient care. To guarantee patient safety, these professionals must become knowledgeable about exactly how each of these systems influence the total care of the patient - just as the hospital’s medical staff must. A good example is because the administration of various gases is directly prescribed by physicians, particularly oxygen and medical air; these gases are now legally upgraded to the level of pharmaceuticals. Because properly credentialed professionals install, inspect, verify and maintain all facets of oxygen and medical air piping distribution systems, they must all consider themselves to be of equal rank, and perform with the same level of intensity regarding knowledge, alertness and care as the hospital’s pharmacists!

To explain, one hundred percent Oxygen (O2) has always been considered the “granddaddy” of all anesthesia/medical gas piped delivery systems. Many people involved in, or out of healthcare realize the role that O2 plays in:

1. Assisting patient breathing as in the use of the low flow O2 nasal cannula,
2. Providing life-support in combating hypoxic (too low) blood O2 levels during the use of ventilators,
3. The supplying of O2 during anesthesia by using either the anesthesia or the heart-lung machines.

However, how many people, including piped medical gas systems’ professionals, realize the critical importance of medical air? Medical air is also directly breathed by patients. In reality, medical air is also prescribed by the physician.

Contrary to many people’s beliefs, straight 100% O2 is seldom administered to patients. It is usually “diluted” with medical air. An excellent example of this is the treatment of the complications of hypoxemia (seriously decreased concen-
tration of O2 levels in the patient's blood). Each patient who suffers from hypoxemia develops individual needs regarding the specific amount of O2 needed to be added to their blood. To achieve normal levels of O2 concentration, ventilators, usually found in intensive care units and directly attached to the facility's piped O2 and medical air systems, are used to provide highly oxygenated breathing air to the patient that raises the blood O2 level. Before initiating use of the ventilator, each individual patient's O2 blood percentage needs must first be determined by blood gas testing. After the testing is evaluated, each particular patient's precise ventilator O2 breathing percentage requirement is prescribed by the physician. For the respiratory therapist to be able to “fill” this prescription, a reliable piped medical air system, which supplies the breathing air that will be blended inside the ventilator to accurately dilute the 100% O2, is required. To battle his/her level of hypoxemia, this patient-specific O2/medical air “blend” is then continuously delivered directly to the patient through the trachea-tube.

In hospitals the normal source of medical air consists of a complex system of compressors, dryers, alarms and other equipment that requires a higher level of maintenance.

Regarding ventilator use, a continuous supply of O2 and medical air, supplied by piped medical gas professionals, is absolutely critical. Depending on patient needs, sudden and unplanned termination of O2 could result in, within three minutes, permanent patient injury or death!

As another example, during anesthesia, each patient's oxygen needs also vary. For anesthesia purposes as well, piped medical air and O2 are blended in either the anesthesia or heart lung machines to deliver the precise O2 percentage “blend” required by each individual patient. Other piped anesthesia/medical gases are also connected to each of these two machines.

During open heart or heart transplant surgery, this process becomes much more complicated. This is because during open heart or heart transplant surgical anesthesia, the initial portion of the procedure is performed by the anesthesiologist using the anesthesia machine. While the anesthesia machine is used, O2 and medical air are blended and then inhaled by the patient. As the procedure continues, the patient's blood circulation system is eventually connected to the heart-lung machine. Anesthesia and life support responsibilities are then transferred to and administered by this machine. The heart's beating is then stopped. While the heart is stopped, the patient's blood is circulated through the heart-lung machine. While the heart-lung machine is used, piped O2 and medical air are blended as needed and added directly to the patient's blood.

The heart-lung machine is operated by the cardiac perfusionist. While the patient is on the heart-lung machine, the perfusionist is also responsible for administering anesthesia.

What makes these surgical procedures unique and much more complicated regarding maintaining patient blood O2 level requirements, is that to reduce the patient's O2 blood level needs during longer than average procedures, the patient's blood temperature is actually cooled to as low as 50 degrees Fahrenheit!

At the Cleveland Clinic Foundation, this is accomplished by a special heat exchanger that is connected to piped, continually circulating, chilling/warming water systems. Tubing is then connected from the heat exchanger to the heart-lung machine. The blood is chilled and then reheated in the heart-lung machine. Also, the patient lies on a hypothermic mattress placed on the operating room table, which is also connected to the same piped chilling/warming systems. Both the mattress and heat exchanger are used to gradually lower, and then to elevate, the patient's blood and body temperature. The purpose is that at this lower blood temperature, hypothermia is initiated and the patient needs much less O2 to be sustained—sometimes as much as 85% less!

Until a few years ago, the blood of almost all patients undergoing these heart procedures was cooled. Recently, the time required to perform most open heart procedures has been reduced significantly. Blood chilling during these shorter duration procedures has become unnecessary. Instead, only the heart itself is cooled. Heat is still added to the patient's blood as it is circulated through the heart-lung machine and its external tubing.

Towards the completion of these procedures the patient is switched back to the anesthesia machine. During these cardiac procedures, especially during blood chilling, the patient's O2 blood percentage levels require continual adjustment. An extremely reliable medical air supply for continually adjusting “O2 dilution,” is mandatory.

Regarding 100% source O2 and medical air needs required during anesthesia, small emergency backup O2 and medical air cylinders, along with other types of gases, are attached to and directly connected to the anesthesia machine. The heart-lung machine may not have these backup cylinders attached. If the primary source gases are suddenly, accidentally interrupted, these backup cylinders will immediately supply the necessary amount of anesthesia gases for a specified period of time. However, during these highly complex cases, the severe distraction that this unnecessary event might cause to the surgeon and operating room staff could still cause a catastrophic patient injury.

Another critical use for medical air, which few people know of, is in the premature baby neonatal intensive care units (NICU). A possibly permanent neonatal eyesight complication that requires medical air utilization to address is Retinopathy of Prematurity (ROP). ROP is a potentially serious blinding condition that could permanently affect the retina of premature newborns. Today, if detected in time, ROP can almost always be cured.

One of many causes of ROP was set in motion in the early 1950's by the newly initiated, and often unknowledgeable use of extremely high levels of supplemental O2 in neonatal units— as in O2 tents. During the ROP epidemic of the 1950's, very high levels of supplemental O2 delivered to neonatals was shown to be a major cause for the development of this disease. The difficulty, it was later discovered, was that infants on higher levels of supplemental O2 were more likely to develop undetected ROP, but the same infants on lower levels of O2 were also more likely to die or have permanent systemic complications from low O2.

With today's precise arterial blood oxygen monitoring, the level of supplemental O2 can be carefully monitored. To mini-
mize the risk of excessive O2-level-related ROP, medical air is used to both dilute the neonate’s oxygen and simultaneously avoid the complications of too little O2.

Ironically, with the increasing skill and technology available in neonatal intensive care units, it has been reported that there has actually been an increase in treatable ROP that is caused by other factors. This is because more tiny babies are surviving. Although supplemental elevated levels of O2 is a significant risk factor for ROP, the careful control of O2 levels in modern NICU’s reduces this risk as low as possible without compromising the infant’s medical status.

Although no amount of time of exposure to elevated O2 levels has been discovered that absolutely determines if a particular neonatal infant will develop ROP, it is definitely known that the unexpected interruption of the medical air supply would be a definite contributor. Because elevated O2 ROP usually develops over a period of time with symptoms that do not reveal themselves immediately, not only a reliable supply of medical air; but also, reliable area and master alarms are necessities in Neonatal Intensive Care Units!

There are many other examples of why medical air is considered a pharmaceutical. I hope that these few are impressive enough to encourage all anesthesia/medical gas professionals to have much more respect for the healthcare facility’s medical air distribution system.

In talking with my peers at other hospitals, I discovered that there are still hospital maintenance personnel who maintain medical air compressors who don’t yet know that patients breathe the medical air from the compressors that they maintain! They actually thought that medical air powers surgical instruments and operating room utility arms! When they were finally informed of the actual patient breathing use of medical air, they took the compressor systems much more seriously!

Another taken-for-granted medical gas is medical vacuum. Most people think that medical vacuum is used only to suction blood from wounds, or as suction of fluids in the emergency room or operating room from severe injuries. However, for certain patients in intensive care units, medical vacuum is crucial for their survival. In hospitals, the source of medical vacuum consists of a complex system of pumps, alarms and other equipment that require higher level maintenance.

In cases where the entire chest cavity is filled with fluid, chest tubes are inserted into the patient and connected directly to the hospital’s medical vacuum system to drain this fluid. Without the negative pressure provided by a reliable medical vacuum system that evacuates this fluid from the chest cavity, this fluid will eventually collapse the patient’s lungs, and the patient will surely suffocate to death within minutes!

Also, regarding the initial use of the heart-lung machine immediately after it’s attachment to the surgical patient, medical vacuum is introduced directly into the machine. This is to cause the patient’s blood to be initially drawn out of the body to begin the circulation of blood through the heart-lung machine.

Because of these reasons, among many others, a reliable healthcare facility medical vacuum system is a necessity. Believe it or not I know of some jurisdictions in this country, for the purpose of permits and inspections, where despite the guidance of NFPA 99 and ASSE/ANSI Standard Series 6000, medical vacuum has not yet been elevated to and not yet considered to be a medical gas!

The last piped medical gas system that I will mention is carbon dioxide (CO2). Among many, two uses are for the purging of ambient air from the inside of heart-lung machines prior to open heart and heart transplant surgeries and for the inflation of body cavities during minimally invasive surgeries.

Regarding minimally invasive surgeries, it is absolutely critical that the CO2 pumped into the body cavity is 100% CO2! I recently read of a case where the CO2 introduced into a patient’s body cavity somehow contained a percentage of oxygen. The procedure went well until the surgeon, not knowing that the body cavity was oxygen enriched, inserted an electrocauterization tip. When the cauterization tip was activated, the sudden intense heat reacted with the oxygen and a brief flame ignited inside the patient’s body cavity!

These are just a few examples, mentioning only a few gases, to emphasize the critical role that piped anesthesia/medical gas systems installed throughout our nation’s healthcare facilities play in the role of patient care and safety.

I hope that I have adequately expressed the magnitude that all healthcare facilities piped anesthesia/medical gas distribution systems play in influencing patient outcomes. I also hope that I have significantly raised the level of awareness of the importance of:

1. not only instructing medical gas professionals of the proper methods of the installation, inspection, verification, and maintenance of these systems
2. but also of the importance of impressing upon them the necessity of learning exactly how each of these systems influence positive or negative patient outcomes.

To address the second issue, in conjunction with our upcoming world class prototype piped anesthesia/medical gas system maintenance program (to be discussed in an upcoming column), the Cleveland Clinic Foundation (CCF) has initiated a program consisting of a series of field trips for the apprentices and instructors of Cleveland Plumbers Union Local #55. The field trips will consist of the viewing of all of our plumbing systems throughout our central campus. Our backflow prevention program that protects our facility’s drinking water from becoming contaminated will certainly be one system that is highlighted.

Of very special interest will be our piped anesthesia/medical gas systems. To impress upon the apprentices and instructors the importance of these systems’ influences in determining the patient care outcomes listed above, they will visit surgical and intensive care units that are in actual operation. They will observe all ages of patients breathing from similar piping systems that they will install or maintain during their careers. Also, this will be the first opportunity for many of them to observe the hospital protocols expected of all workers, including construction - such as proper dress and behavior.

When I approached anesthesia, respiratory therapy, surgery and ICU departments for permission to take the ap-
prentices through their departments, and explained that these are the same professionals who will be installing the piping systems of the future that their patients will be breathing from, they expressed wholehearted excitement!

The manager of the Respiratory Therapy Department of the Heart Center immediately volunteered her education coordinator to give the apprentices an overview of both the cardiac patient’s critical medical gas needs, coupled with the importance of their installation of reliable piped medical gas delivery systems.

Besides providing educational benefits to the apprentices and instructors, these field trips will also be of benefit to CCF. This is because many will be the same apprentices – soon to become journeypersons – who will be working on our brand new, one million square foot, 13 stories, almost $400 million dollar Heart Center that is newly under construction! The construction of this magnificent building is only fitting for CCF’s Heart Center – that was recently rated #1 throughout the entire USA – for the tenth consecutive year!

Also, in a few years, after this monstrous project is completed, these same professionals will then begin the massive renovation projects that will occur in the areas that the cardiac units vacate when they move into their new complex.

As the apprentices/journeypersons install anesthesia/medical gases in our brand new Heart Center construction project that is far from the critical care patients they observed during their field trip, CCF’s benefits will be enhanced even further. This is because an indelible impression will be left on the apprentices/journeypersons’ minds of the patients that they observed during their field trip, breathing from similar systems that they are currently installing. Because of these impressions, they will exercise much more care than they may have used if it wasn’t for their observances during their field trip!

Also, because obviously all of these apprentices will not work on CCF’s heart center, but may work at other healthcare facilities, these field trips will aid most other healthcare institutions throughout the Greater Cleveland Area in enhancing their patients’ safety as well.

In these regards, I am suggesting that all apprentice training facilities throughout the USA approach their local health care facilities and arrange for similar field trips for their apprentices. I’m sure that when the patient safety enhancement benefits are explained, every facility will welcome the apprentices with open arms also!

In conclusion, I realize that during this short time I have been able to touch only the tip of the iceberg regarding the patient-safety-critical uses, and consequences, of piped anesthesia/medical gas systems. I felt that these little-known examples I chose would be of particular interest.

Of far greater importance, however, I hope that I have fully emphasized the concept that, to stay ahead of and avoid future healthcare patient medical gas accidents, all anesthesia/medical professionals must absolutely envision themselves not only as extremely capable installers, inspectors, verifiers, maintenance personnel, and instructors, but also as extremely committed patient safety advocates!

As an announcement, the recently triennially revised 2004 edition of ASSE/ANSI Series 6000 Professional Qualifications Standards for Piped Anesthesia/Medical Gas Installers, Inspectors, Verifiers, Maintenance Personnel, and Instructors is now available. Simply contact the International Office to acquire your copy of this greatly enhanced, and very valuable, document.