

15 Years, 4 Cycles

The Changes in Medical Gas and Vacuum Systems Requirements in NFPA 99 from the 1999 to 2012 Editions and Changes from the 2012 to 2015 Edition.

Mark Allen

Notes on Using this Pamphlet:

This pamphlet is presented as a service to users of the National Fire Protection Association's Healthcare Facilities Code, the NFPA 99. The pamphlet seeks to simplify understanding the changes with respect to medical gas and vacuum requirements which have occurred between the document as published in 1999 and the document as published in 2012. In addition, the pamphlet details the changes to the document between the 2012 and 2015 versions (see starting page 11)

Users are cautioned that this pamphlet is intended to be used in conjunction with the several standards, which should be obtained from:

National Fire Protection Association
1 Batterymarch Park
Quincy, MA 02269-9101
Phone 1-800-344-3555
Internet www.NFPA.org

This pamphlet is not intended to be exhaustive and there may be changes of significance omitted from this document. Our concentration is on Category 1 and 2 systems. Users particularly interested in Category 3 should consult other authorities in addition to this document.

This pamphlet is not a publication of the National Fire Protection Association. Any opinions expressed and/or interpretations given or implied are the sole responsibility of BeaconMedæS and the author, and should not be relied upon without reference to the standard.

First Edition October 2014

Comments on this booklet or on any aspect of medical gases are welcome and encouraged. Please send to mark.allen@beaconmedaes.com

This Pamphlet in both print and electronic versions is Copyright 2014 BeaconMedæS and Mark Allen. All Rights are Reserved, and no reproduction may be made of the whole or any part without permission in writing. Distribution of the Electronic version is permitted only where the whole is transmitted without alteration, including this notice.

Contents & Introduction

Contents

Introduction	4
The Reorganizations	6
How Chapter 5 was reorganized in 2002, and the rest in 2012.	
Levels to Categories and the Fundamentals Chapter ...	7
The influence of “Fundamentals”	
Levels of Anesthesia	9
An essential concept since 2012.	
Defining an Occupancy	10
The owners new role and responsibilities.	
Promotion and Extinction	10
Standard to Code, and the end of NFPA 99 C	
Changes, 2012 to 2015	12
Summary of the Changes in the most recent revision.	
Annex A: Alarms and Computers	19
The allowance to substitute an alarm panel with a computer can get you in trouble - here’s why.	
Annex B: Alarms and “Communication”	21
An allowance, first appearing in the 2012, that needs to be understood if it is to work effectively	

Introduction

This may seem a strange booklet to offer. What possible value can there be in a book that talks over four revisions of a standard? Everyone should have been following along, no?

Most of the engineering and verification community *have* kept pace with NFPA, and thus it is common to see later editions enforced on the ground. However, at the State and Federal level and at the Centers for Medicare and Medicaid Services, they enforce the NFPA Life Safety Code (NFPA 101) and only by reference through the 101, do they enforce the NFPA 99. The edition they’ve been stuck on has been the Life Safety Code, 2000 edition, which in turn referenced the NFPA 99, 1999 edition. A CMS inspector would therefore show up at the facility with the 1999 standard in hand and in mind.

There are several difficulties posed here, but the most problematic is that there are many changes to the standard over these three editions where the newer version contains allowances which were explicitly prohibited by earlier editions. To take advantage of that allowance was to put yourself at risk of a rejection. One of the most glaring examples is an allowance for computers to substitute for one of the mandatory master alarms under certain circumstances. This allowance appears first in the 2005 edition, and has been requested often enough that CMS has been granting waivers to use it.

CMS has stated their interest in moving forward and redrawing their rules to enforce the 2012. When this happens, facilities will be faced with conforming to the 2012 standard over whatever grace period CMS permits. It will suddenly be important to know what all the changes have been so the facility can assess their position and their need for updates. That is the motivation for this pamphlet.

We will take up the subject topically, detailing the major changes one by one and talking through the change, its likely effect and also giving some guidance where appropriate on the implementation of the change. These of course will only involve the more significant changes. To understand the smaller changes, or to delve into the details, the reader is referred to each of the “Changes” pamphlets published by BeaconMedæx at the issuance of each new edition. Thus these three pamphlets are relevant:

NFPA 99, HealthCare Facilities - The Changes in Medical Gas and Vacuum Systems from the 1999 to 2002 Editions
BeaconMedæx, February 2003

NFPA 99, HealthCare Facilities - The Changes in Medical Gas and Vacuum Systems from the 2002 to 2005 Editions
BeaconMedæS, June 2005

NFPA 99, HealthCare Facilities - The Changes in Medical Gas and Vacuum Systems from the 2005 to 2012 Editions
BeaconMedæS, October 2012

The present pamphlet will focus only on the changes to medical gas and vacuum systems (PMGVS) (Chapter 4 in 1999, Chapter 5 thereafter) respecting PMGVS, and within that, primarily Category 1 and 2 systems (Level 1 and 2 in the 1999 version - an important change in itself).

While we concentrate here on PMGVS, the reader would be well advised to closely examine the other chapters of the NFPA 99 as well. The 1999 to 2002 revisions and the 2002 to 2005 revisions bearing on PMGVS are massive, but the changes in PMGVS from 2005 to 2012 were relatively few, and from 2012 to 2015 fewer yet. On the other hand, the changes in other chapters from 1999 to 2005 were limited, but in the 2005 to 2012 cycle the changes in the document outside of Chapter 5 are sweeping.

As a very general statement with innumerable exceptions, the NFPA has been moving from a prescriptive to a more performance based format. In doing so, many decisions that the standard once offered guidance on or even formulas to help with are now cast onto the responsibility of the facility. The standard is therefore more flexible but the facility is expected to call the shots and bear the liability.

In the construction environment, particularly with engineers, this has not been particularly popular. Answers to essential questions are often difficult to obtain and the issues are often poorly understood by the people NFPA now expects to decide. Engineers like their answers crisp and quick, and the structure of the latest document editions is not necessarily optimized to provide that.

The first part of our discussion will review some of these major philosophic changes in the documents over the four cycles.

Changes in Philosophy and Organization

The Reorganizations

Comparing the 1999 and 2015 documents is a difficult challenge. Aside from the many technical changes made between these two editions, the document has undergone two root and branch reorganizations of primary significance to the medical gas user.

2002 : Medical Gases takes it's turn

The 2002 NFPA 99, Chapter 5 deserves to be viewed as a watershed in the history of the NFPA medical gas chapter. From the ground up - every word, every figure, every table - was redone. The document became, in format at least, entirely new.

Without a doubt, the chapter had become more cumbersome and harder and harder to understand with each revision cycle since its origin with the 99 in 1986. As one example, the document contained paragraphs with vast numbers of requirements all choked together in a single paragraph. As a random example, here's 4-3.1.1.9 (g) from the 1999 version:

“(g) Accessories. Compressor systems for medical air shall be equipped with intake filter-mufflers of the dry type, aftercoolers or air dryers, or both, line filter(s) appropriate for the intake air conditions and compressor type, pressure regulators, and a pressure relief valve set at 50 percent above nominal line pressure to ensure the delivery of medical air (see definition of Medical Air in Section 2-2).

The medical air receiver shall be provided with a three-valve bypass to permit service to this device without shutting down the medical air system.

Dryer systems shall be, at a minimum, duplexed and valved to permit isolation of individual components to allow for maintenance or repair in the event of failure, while still continuing to adequately treat the flow of air. Under normal operation, only one dryer shall be open to airflow with the other dryer valved off. Each dryer system shall be designed to provide air at a maximum dew point of 35°F (1.7°C) at the peak calculated demand of the system. [See 4-3.1.2.2(b)3g.] System design shall preclude formation of liquid water in the air line.

Aftercoolers, where required, shall be duplexed and provided with individual condensate traps. The receiver shall not be used as an aftercooler or aftercooler trap.

Where more than two devices are provided, the peak calculated demand shall be met with the largest single unit out of service.

1999 to 2012 - Changes in Philosophy and Organization

Final line filters located upstream of the final line regulators shall be duplexed with appropriate valves to permit service to these devices without shutting down the medical air system. Each of the filters shall be sized for 100 percent of the system peak calculated demand at design conditions and shall be rated for a minimum of 98 percent efficiency at 1 micron. These filters shall be equipped with a continuous visual indicator showing the status of the filter element life.

All final line regulators shall be multiplexed with isolating valves to permit service to the regulator without completely shutting down the gas piping system. Each of the regulators shall be sized for 100 percent of the system peak calculated demand at design condition."

Other problems also existed and needed attention. The figures were out of sync with the text and antique in presentation. Beyond that, there was a large amount of invalid appendix material which needed combing through.

It is impossible to overstate the value of this cycle's Chair of the Committee, Mr. Doug Erickson. Although Mr. Erickson has been a member of the committee for many years as alternate for ASHE, he was placed into the chair by a conspiracy of events late in the life of the 1999 edition. As the 2002 revision cycle kicked into high gear, it was Doug who received NFPA's demand for a rewrite.

A crucial limitation of the rewrite was to reformat the text for clarity but ensure that no technical changes were made which were not otherwise intended by proposals received. The process required a chair with sufficient command of the process to ensure the work was done and thoroughly done, and enough presence with NFPA to ensure the task force was allowed the time and staff support to do it. The committee was exceedingly fortunate in their Chair.

The significant requirements of the rewrite which are reflected in the final document include:

- A document must be written to be convenient for and comprehensible to enforcers.
- Each numbered paragraph has one requirement or at most a very limited number of very tightly related requirements.
- The NFPA went metric (english) versus english (metric).
- The definitions no longer could contain enforcement

criteria as such - an innocuous sounding change with important consequences.

- There is nothing in the body of the chapter which is not enforceable. The Annex therefore had to contain most of the Tables and all of the Figures. Conversely, everything in the Annexes became non-mandatory and is only to be explanatory or to expand on the text. Nothing in an Annex is enforceable.

Compare the section of the 2002 which is roughly equivalent to the 1999 version section shown on page 5 & 6:

"5.1.3.6.3.5 Aftercoolers.

(A) Aftercoolers, where required, shall be provided with individual condensate traps.

(B) The receiver shall not be used as an aftercooler or aftercooler trap.

(C) Aftercoolers shall be constructed of materials deemed suitable by the manufacturer.

(D) Antivibration mountings shall be installed for aftercoolers as required by equipment dynamics or location and in accordance with the manufacturer's recommendations.

5.1.3.6.3.6 Medical Air Receivers. Receivers for medical air shall meet the following requirements:

(1) They shall be made of corrosion-resistant materials or otherwise be made corrosion resistant.

(2) They shall comply with Section VIII, "Unfired Pressure Vessels," of the ASME Boiler and Pressure Vessel Code.

(3) They shall be equipped with a pressure relief valve, automatic drain, manual drain, sight glass, and pressure indicator.

(4) They shall be of a capacity sufficient to prevent the compressors from short-cycling.

5.1.3.6.3.7 Medical Air Dryers. Medical air dryers shall meet the following requirements:

(1) They shall be designed to provide air at a maximum dew point that is below the frost point [0°C (32°F)] at 345 kPa to 380 kPa (50 psi to 55 psi) at any level of demand.

(2) They shall be sized for 100 percent of the system peak calculated demand at design conditions.

(3) They shall be constructed of materials deemed suitable by the manufacturer.

(4) They shall be provided with antivibration mountings installed as required by equipment dynamics or location and in accordance with the manufacturer's recommendations.

5.1.3.6.3.8 Medical Air Filters. Medical air filters shall meet the following requirements:

(1) They shall be appropriate for the intake air conditions.

(2) They shall be located upstream (source side) of

the final line regulators.

(3) They shall be sized for 100 percent of the system peak calculated demand at design conditions and be rated for a minimum

of 98 percent efficiency at 1 micron or greater.

(4) They shall be equipped with a continuous visual indicator showing the status of the filter element life.

(5) They shall be constructed of materials deemed suitable by the manufacturer.”

You will quickly see that the resulting rewrite of the 99 is vastly more clear and leaves many fewer ambiguities. While it can never be without “room for interpretation” and there undoubtedly remain loopholes and flaws, the general feeling is that the document is vastly easier to understand and apply.

Most significantly, this chapter became as “enforcer friendly” as a specialist document is ever likely to be. That means that even an enforcer who is not especially expert in medical gas should generally be able to read and understand the requirements. Since they are now arranged one paragraph, one requirement, there is less of the “three paragraphs and a figure that bear” problem which plagued earlier versions.

2012 : Everything else goes through the mill

In the revision for the 2012 edition, the basic structure of the document was redone. Chapters were renamed, moved, and new chapters and subjects were added. A rewrite process like the medical gases rewrite was also carried through for other chapters. So while the 2012 revisions were significant in the medical gas chapter, they were nothing like the changes that occurred in the other chapters of the document.

Finding your way in the 2012 and 2015:

- Look for the definitions in Chapter 3 instead of 2.
- Look for the medical gas section in Chapter 5 instead of Chapter 4.
- The Occupancy Chapters (formerly 12 for Hospitals, 13 for “Other” Health care Facilities, 16 for Nursing Homes, 17 for Limited Care Facilities and 20 for Freestanding Birthing Centers are entirely gone.
- Don’t look for any Appendix - they’re renamed “Annexes”.
- Don’t look for a separate vacuum section. Vacuum and pressure gases are tightly integrated on the premise that they’ve more in common than they have differences.

- To find Level 1 requirements (Now Category 1), look in sections numbered 5.1. Level 2 (Now Category 2) will be found in 5.2, and Level 3 (Now Category 3) in 5.3. Similar requirements across levels will generally be found in similarly numbered paragraphs, so for example, to find outlets requirements for Level 1 application, look in 5.1.5. For Level 2, go to 5.2.5 and Level 3 go to 5.3.5.

- Requirements previously in the medical gases chapter have been moved. A new chapter on HVAC systems (now Chapter 9), a substantially different chapter on Gas Equipment (now Chapter 11), and even the NFPA 55 (successor to the NFPA 50) all contain relevant information moved out of Chapter 5.

While it has never been desirable to use Chapter 5 in isolation, it is outright risky to do so now. The reader must attend to the removals and relocations from Chapter 5 as well as the additions and changes.

2015 : The process completes

Some parts of the 99, as conceived as part of the 2012 rewrite did not actually appear. They were controversial, and NFPA chose to sacrifice them in order to get the document out in 2012 at all. (This is in part at least is the reason for the seven years between editions from 2005 to 2012).

Thus, the Chapter 8 and Chapter 9 “stubs” that appear in the 2012 are only the minimum material which was required to hold together other chapters. In 2015, they appear entire.

Levels to Categories and The Fundamentals Chapter

Perhaps the most important change is not in the medical gases chapter at all. Rather it is the development of the Fundamentals chapter, Chapter 4.

The underlying concept, that a facility should be able to match their medical gases to the acuity of the patient population they expect to serve, appeared in rudimentary form with the original NFPA 99 in 1987. In the medical gas requirements in that edition there were Type I and Type II systems. Type II was essentially for dental facilities, and was written around a one or two operatory dental practice, Type I covered all others.

As recast in 1993, “Types” became “Levels”, and two “Types” went to four “Levels”. The Levels roughly

1999 to 2012 - Changes in Philosophy and Organization

corresponded to:

- Hospitals (level 1),
- Dental facilities (level 3),
- Laboratories (level 4),
- Less-than-a-hospital-but-more-than-a-dental-facility (level 2).

When it came time to define the technical requirements in each of these, the committee essentially separated the existing Type I and Type II requirements, assigning them to Level 1 and Level 3 respectively. Level 2 was new, and was simply a very slightly watered down version of Level 1. Level 4 was also new, but the requirements were not, as the Level became the custodian of the three or so paragraphs already in the standard which applied to laboratories.

The Levels were tied to the occupancy chapters (12-20) in the back of the standard. These were the chapters which dealt with which requirements applied to a hospital, a clinic, an office, a nursing home, etc. In theory, to determine one's level, you went to the appropriate occupancy chapter, followed the decision tree in that chapter and were directed to the appropriate Level for the medical gases found in Chapter 4.

This basic structure runs through the 1999, 2002 and the 2005 editions. In 2002 for the first time, it was explicitly permitted to mix Levels within a single facility. Thus, as an example, a hospital with Level 1 systems could contain a separate stand alone sleep lab with Level 3 systems.

Also in 2002, level 4 disappeared, its function being absorbed into a rewritten chapter 11 on labs.

While the Levels were initially a medical gas chapter construct, in 2012 every chapter across the document was restructured to contain its own version of the "levels". They are now retitled as "categories" but they are the same idea. Now in effect, there are Category 1, 2, 3 and 4 electrical systems, medical gas systems, plumbing systems, and so forth.

The occupancy chapters and decision tree concept also disappears in 2012, and is replaced by Chapter 4, the new "Fundamentals" chapter, which now takes on the role of defining the appropriate category(ies) for a facility.

The new chapter 4 is extraordinarily short, and the important sections for medical gases are reproduced in part below (the requirement for Category 4 is not included, since by definition there is no Category 4 medical gas). This is the text from 2015:

"4.1.1 Category 1. Activities, systems or equipment whose

failure is likely to cause major injury or death of patients, staff or visitors shall be designed to meet system Category 1 requirements.

4.1.2 Category 2. Activities, systems or equipment whose failure is likely to cause minor injury of patients, staff or visitors shall be designed to meet system Category 2 requirements.

4.1.3 Category 3. Activities, systems or equipment whose failure is not likely to cause injury to patients, staff or visitors but can cause discomfort shall be designed to meet system Category 3 requirements.

In summary, there are three relevant categories for medical gases, and the essential criteria that defines the three categories is:

Category 1 : Death or major injury.

Category 2 : Minor Injury.

Category 3 : Discomfort.

The devil is in the detail. One man's "discomfort" is another's "minor injury", and what the doctor may see as a "minor injury", the sufferer may view with the utmost gravity as pretty "major". These terms are appallingly imprecise and are likely to be defined one way if you are the person lying on the O.R. table and another if you are the medical staff standing over it.

Death might seem pretty easy to achieve consensus about, but remember the criteria is "likely". Suppose I ask any doctor or nurse: "do you agree that if the medical gas systems completely failed during your procedure, you would, by heroic measures if necessary, keep your patient alive?". No clinical professional worth their license would ever answer "no". Therefore I can conclude that in the opinion of the clinical professionals you are not "likely" to die or suffer death in the event of loss of medical gas.

Therefore, we can suppose this facility can be piped Category 2.

Suppose then, Doctor: If the medical gas systems completely shut down during your procedure, would you not, by heroic measures if necessary, keep your patient from serious injury? Of course, Doctor will emphatically answer "yes". To do otherwise would be a frank admission of incompetence or indifference. Therefore it can be concluded that in the Doctor's opinion you are no longer "likely" to suffer major injury. Therefore, this Doctor's facility can be piped Category 3. The only medical facilities therefore which will need to

be properly piped will be the happy few with cowardly medical staffs unwilling to “do what it takes” to keep you alive ...

Clearly this is an exaggeration, but that it is plausible to reach such interpretations within the rule as written is unnerving. Since there is a clear first-cost advantage to the owner in reducing the systems to this minimum, there will be a standing temptation to do so. We have already seen how rules can be creatively interpreted for financial reasons - the “23 hour facility” being the best known example.

The guidance for applying these rules is contained in one additional paragraph of this brief chapter:

“4.2 Risk Assessment. Categories shall be determined by following and documenting a defined risk assessment procedure

A documented risk assessment shall not be required for Category 1”

The idea of course is that the facility should, through a documented and recognizable risk management process (of which there are many models, the most widely cited of which is probably the ISO 31000) determine the Category for the systems. Properly followed, these risk management processes should expose the risks that patients will be under in the event of a failure of the systems during their procedure. Each system should be independantly considered: the consequence of medical gas failure may not be the same for an electrical or telecommunication failure, and the category that applies to each may be different.

Because the process and it’s conclusions must be documented, the facility management is in theory entirely exposed. It will not be possible for them to blame their engineer, contractor or anyone else because they will now have to state up front that they have conducted the required risk assessment and that they have concluded that they can install the Category of system they chose.

However, some old ghosts that were laid to rest in

the evolution of the 2002 and 2005 versions are likely to return as the 2012 is used more often. One is the question of mixed systems. It was unclear in the 1999 whether systems of various Levels can be “mixed” within a single facility. In 2002, this allowance became explicit so that a facility with all Category 1 systems could have a standalone Category 3 system provided that the area(s) served were distinct and the systems were entirely independant. This explicit allowance disappeared in 2012, so the question will undoubtedly re-surface.

for more:
See Chapter 4 in NFPA 99 2015

Levels Of Anesthesia

Another area in which the code has moved in it’s effort to avoid over specification is into Levels of Anesthesia. In the 2012 edition for the first time, four Levels of Anesthesia are defined (3.3.61 in the 2015). In order of “depth of anesthesia”, they are be:

- I. Minimal Sedation
- II. Moderate Sedation
- III. Deep Sedation/Analgesia
- IV. General Anesthesia

These should properly be bookended by two other “states of consciousness”, “Normal” and “Dead” (see Detail 9). This is to emphasize that the lefthand five are not exactly defined states, but merely waypoints on a continuum. Only the one is ultimately indisputable.

There are various tests that the doctor can use to approximately determine the state of a patient, but there are few absolutes, and the level of anesthesia a patient is currently under is constantly in flux throughout a procedure, which is why anesthesiologists sometimes use the analogy of “flying” the patient through the procedure.

This is impossible for the design engineer, as they have neither the training nor the intimate understanding of the various medical and surgical procedures which would be required. That makes the inclusion of these



Detail 9: The Levels of Anesthesia

1999 to 2012 - Defining an Occupancy

Levels in the standard very problematic. One important bit of help is offered: under 1.3.4 it is now clearly defined that it is the responsibility of the “governing body of the health care facility” to designate the Category of all patient care spaces and all anesthetizing locations. What the designer must appreciate is that they must go one step further than this to make the designations useful ~ the “governing body” must not only say that it is an anesthetizing location, they must also designate the maximum level of anesthesia intended to be used therein.

The level of anesthesia effects two crucial design decisions. First, under NFPA 99 2015, 5.1.4.6.8, Zone valves are required “immediately outside each ... anesthetizing location of moderate sedation, deep sedation or general anesthesia”. Thus, a zone valve would not be required for an anesthetizing location which will only administer anesthesia to the minimal sedation level. This is an important change, because under earlier versions, a valve would have been required there.

There is another clause however which will prevent these areas from having NO valve - it's 5.1.4.6.1, which requires that no outlets or inlets can exist without an intervening zone valve on that floor. Since the 5.1.4.6.1 valve might combine several rooms together, it could combine anesthetizing locations if those locations were limited to Minimal Sedation.

Second, under 5.1.9.4, area alarms must be furnished for all “anesthetizing locations where moderate sedation, deep sedation or general anesthesia is administered”. Again, as with valves, an anesthetizing location exclusively for Minimal Sedation will be excluded, but unlike with zone valves there is no other clause to consider, so such areas might now have no alarm at all.

In the general hospital, there are many areas in which minimal sedation is administered, but very few of those areas will be affected by this. That is because in our own way we have been applying this rule without knowing we were doing it. The areas where minimal sedation is likely to be administered are simply given unique names ~ exam room, treatment room, endo/cysto. We have always treated these areas separately from other areas, and many designers have coincidentally handled them exactly like the new rules would require. Now, the new rules may help eliminate the grey areas (occupancies like endoscopy, cystoscopy, trauma) because the facility will have to designate them as “anesthetizing locations for anaesthesia level(s) X to Y”.

Where it is going to get very interesting is in places

and rooms where they do not administer general anesthesia but always work at the lower levels. In these occupancies, the fact that (an) alarm(s) and extra zone valve(s) (plus the cost of installation) may hang on the decision will act as powerful temptation.

The most notorious examples are free standing plastic surgeries and oral surgeons, but the same challenge will face some dentists, podiatric surgeries, even birthing centers, among many others.

Many of these procedures are performed in the indistinct continuum between Minimal and Moderate Sedation, and the temptation to opt for the lower level and the cheaper installation will be a constant challenge, particularly as many such facilities are single practices, and the doctor who benefits or loses is also the sole competent “governing body” who must designate the spaces.

Simply put, it will be a classic angel vs. devil struggle over the question “is it green for \$\$\$\$ or yellow for \$?”

Defining an Occupancy

In the 2012 for the first time, it is clearly stated that the facility owner must define the several occupancies. In the 1999, this definition is not required of any specific entity, and there is no criteria for making the call. Traditionally, it will have been made by reference to the plans and the name of the unit.

The facility is required to at least designate the Category of each area. These designations are essential in decisions regarding alarm and valve placement, so having responsibility for designating them clarified will simplify design.

Related to this is the addition of a new set of definitions for levels of anesthesia (3.3.61). These rules more finely gradate the levels of anesthesia recognized in the document. Through that mechanism, building requirements can also be more finely graduated. The Levels of Anesthesia are more fully discussed on page 9

for more:

See 1.3.4, 3.3.61; 5.1.4.6.8 and 5.1.9.4 in NFPA 99 2015

Promotion and Extinction

One last change is one of the more important but least clear in it's long term consequences - The NFPA 99 has been promoted from a “Standard” to a “Code” and will now be referred to as the “Health Care Facilities Code”. This raises the status of the document to equal status with documents like the NFPA 70, National

Electrical Code, the NFPA 1 Fire Code, or the NFPA 101 Life Safety Code. It also means that it is now intended for incorporation into law by itself and not simply by reference.

NFPA has discontinued the publication of the NFPA 99C, which was the extract of only the medical gases related portions of the document. Now, only the standard in its entirety will be published.

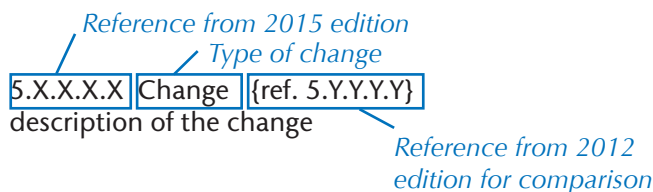
In place of the 99C, NFPA has issued a new document specifically aimed at the most numerous user of the 99C and titled the "Installation Handbook".

This should not be confused with the "NFPA 99 Handbook" which also still exists.

Users are cautioned that both of the Handbooks are only in part the Code (they do contain the text of the Code along with much else). The commentary and associated materials they contain are illustrative and hopefully instructive, but they are NOT mandatory and should never be enforced as such.

Key to the Changes (pages 12 through 17)

The references in the left column are paragraphs from the 2005 edition with a brief summary of what has changed in that paragraph, and follows the format:



New indicates a totally new requirement or allowance not in the standard previously.

Change indicates a requirement or allowance which is not the same as in the earlier edition.

Term Changed indicates a new term has been substituted for an older one. Such a change can have very wide consequences.

Deletion indicates a requirement or allowance which has been removed. In this case of course, there will only be the reference number from the old standard.

Reinforced indicates an existing requirement has been revised to be stronger or has been repeated for emphasis.

Clarification indicates a requirement or allowance which has been rewritten to make it more understandable but is not seen to change technically.

Editorial Change indicates a rewrite which is not intended to change any requirement but corrects an earlier error.

Reword indicates a requirement or allowance which has been rewritten to make it more understandable, but which may also have subtle changes in meaning.

Moved indicates a requirement or allowance which has been relocated but existed before.

Red text in the right hand column is commentary and represents opinion on the change. It is not and must not be taken as in any way the official view of NFPA or of the Technical Committee.

The Symbol 4 and text in blue indicates a provision which the user should use with care. There are two places these will be seen: first where there appear to be errors in the copy or the implementation of a particular change and second where a new allowance directly contradicts earlier versions and therefore the user should take advantage of these only with the prior agreement of local authorities.

2012 to 2105 Changes by Paragraph

NFPA 99 2012 to 2015 Significant Changes by Paragraph

Preparation of this section was greatly assisted by work previously done by Mr. Keith Ferrari of Praxair, Inc., which is gratefully acknowledged.

1.3.1 Addition 1.3.1

Veterinary has been added to the excluded facility types. (see also 3.3.67)

This reflects a failure to generate any interest in the veterinary community to add their facilities to the standard. Such facilities sometimes do follow the standard by choice, but this clarification makes that practice less likely.

1.3.4.1 Change 1.3.4

“Rooms” in the 2012 edition are “spaces” in the 2015.

This change recognizes that the term “room” can often imply doors, walls and other defining characteristics which are not necessarily present.

1.3.4.1 Change 1.3.4.1

The Governing authority of the facility must designate the Category of each area.

This completes the transfer of responsibility to the facility of this critical decision. In 2012, the facility had to name the areas, which would leave the Category to be defined. Now, they must directly designate the Category.

2.1 New

Referenced documents are not incorporated in their entirety.

4 Chapter 5 will need to catch up - the designations in Chapter 5 still refer to “critical care” (see 5.1.4.8.7 and 5.1.9.3)

3.3.5 Change 3.3.6

Ambulatory Health Care Facility becomes Ambulatory Health Care Occupancy

This change is a departure from standard practice in the writing of standards, wherein a referenced document is usually “incorporated by reference” and thus becomes enforceable in its entirety as the main document is enforceable. The language will no doubt open a mine of controversies over what is and is not incorporated from any given referenced document.

3.3.19 Editorial Change 3.3.21

Changing the wording makes this provision applicable to *portions* of a facility used for Ambulatory Healthcare.

3.3.19.3 New

The section on bulk systems has been reorganized, primarily to make the next addition fit properly.

3.3.109.1 Deletion 3.3.118.1

Oil free, dry is eliminated from Nitrogen NF

A whole set of new requirements for what are popularly known as “minibulks” and “microbulks” now have requirements defined in the 99 (see also 5.1.3.5.13)

3.3.127 Change 3.3.138

“Rooms” are now “Spaces” and the definitions for room types (e.g. “critical care room”) are gone.

Since Nitrogen NF has a specification for oil vapor and dryness, these terms were redundant.

3.3.135.5 New 3.3.147

A definition for Operating Pressure is now given. (See also Working Pressure 3.3.135.8)

See commentary for 1.3.4.1

3.3.135.8 Term Changed 3.3.147.7

The definition for Working Pressure (rated) is now more in line with classic engineering usage. (See

Operating pressure was not defined, but the term Working pressure essentially was used instead. Now the two are clearly separated.

Operating Pressure 3.3.135.5)

3.3.140 New

A definition for a Qualified Person is added.

This is not specifically intended for medical gases qualification, but will serve the purpose.

3.3.146 New (but see 4)

The risk categories are defined here. "Activities" are now added to failure of systems and equipment as defining the Risk.

This addition makes the use of the terms throughout the document more cogent. Activities is an interesting addition which will make evaluating the risks somewhat more complex.

3.3.155 New

Definition for a "space" is added.

This was necessitated by the change throughout the document from Room to Space when referring to occupancies.

4 New

"Activities" are now added to failure of systems and equipment as defining the Risk. "Patients, staff and visitors" replaces "patients and caregivers"

There is an important subtlety here in the wording which needs to be noted. The previous wording here instance was "Facility systems ... shall be designed". With this revision it is now - "Activities, systems and equipment ... shall be designed". Visitors need to be considered now. See also 3.3.146.

4.2.2 New

When a facility accepts that it is Category 1, the risk assessment required to qualify for the other Categories is not required.

This might seem commonsense, but the wording did mandate the assessment even though it would clearly have been pointless.

4.4 New

"Non combustible materials" are set out in detail.

The wording has been borrowed from other NFPA documents, and lays out what can be considered a noncombustible material. This is particularly significant in the design of gas storage facilities.

5.1.1.2 New

Each of the three applicable categories (Category 1, 2 and 3) now have a summary of the limitations at the start of the relevant section. Here, Category 1 requirements are summarized. (see also 5.2.1 and 5.3.1)

This is the reverse of the coin seen in 4.1 and ties to those risk categories.

5.1.3.2.12 Change, Moved 5.1.3.3.1.7

Cylinder storage is limited to 52°C (125°F)

This is a reduction from 54°C (130°F). This should have been changed last edition so all temperatures correlated. See 5.1.1.5 and also 5.1.3.2.13.

5.1.3.2.13 Moved 5.1.3.3.1.8

Moving this requirement places it into the operations section of the chapter and thus makes it apply to an existing facility. See 5.1.1.5 and also 5.1.3.2.12.

5.1.3.3.2(5 and 6) Changed 5.1.3.3.2(4 and 5)

The enclosure and finishes (floor, wall ceiling) must be one hour fire rated, the opening protectives and finishes (doors, etc) only 3/4 hour rated.

Changes were made to bring these requirements into correlation with the NFPA 101 and 5000.

5.1.3.3.2(4) New

A separate clause for bulk liquid systems, requiring dual egress is added.

4 It is not clear that this new paragraph was needed, as the previous paragraph 3 did include all central supply systems located outdoors.

5.1.3.3.2(13) Moved 5.1.3.3.1.5

The clause was moved from the operations section to

2012 to 2105 Changes by Paragraph

5.1.3.3.2(14) New

This is the design analogue of the operational temperature limit. (see 5.1.3.2.12)

5.1.3.3.3.1 New

Reference to 9.3.6

5.1.3.3.3.4 New

Provisions for walls which are fire barriers has been added.

5.1.3.5.7 New

An auxiliary connection for all sources has been added. It consists simply of a valved and capped connection point.

5.1.3.5.15 Clarification 5.1.3.5.13

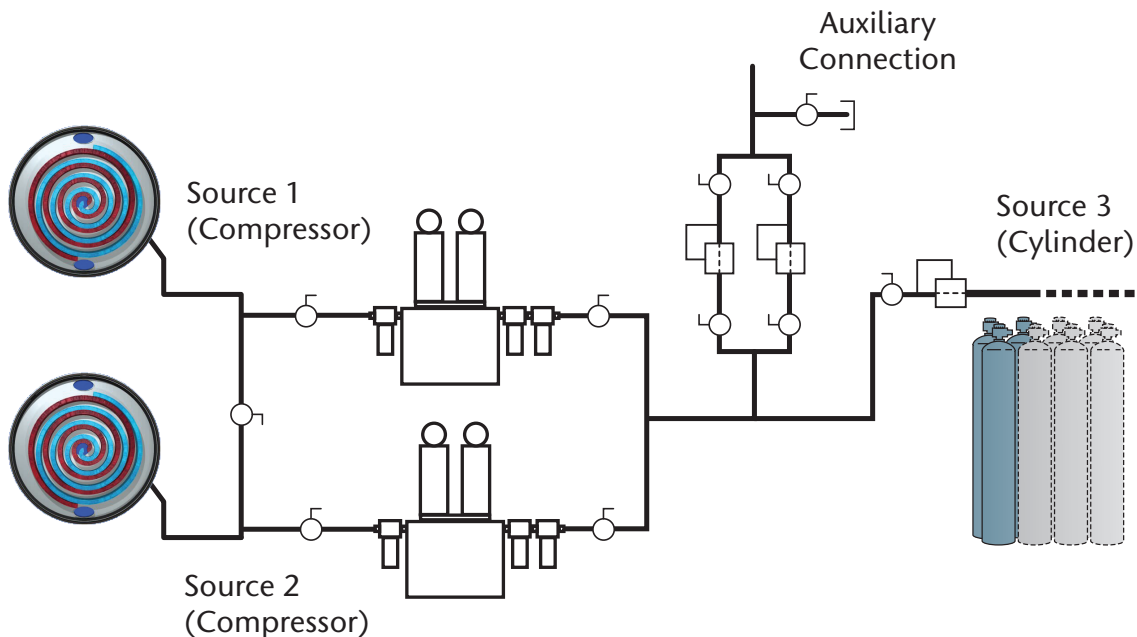
Section has been rewritten for clarity and to add the Microbulk option (see also 5.1.3.5.13)

the design and construction section. It is clearly only relevant when the enclosure is built or modified. See 5.1.3.2.12 and 13.

This paragraph is added to reference the user to the relevant material which was moved as part of the 2012 reorganization and is now found in Chapter 9.

This section was added originally for the situation where a bulk gas system or other source was enclosed in a brick or block wall. In these cases, ventilation openings in the walls are necessary. However, it is also seen that these walls are shared and are fire barriers, which must take precedence. The new language accounts for this.

The Auxiliary connection is intended to be used like the EOSC for oxygen, as a place to make a temporary connection of a supply source when the usual source must be removed from service. While the EOSC is an emergency connection, the implication is that the Auxiliary connection would be used in a more planned process.



Detail 14: The Auxiliary Connection (note that the system illustrated also shows a third source, which is NOT required)

5.1.3.5.13 New

A section defining requirements for Micro or Mini bulk systems is added.

“Mini” or “Micro” bulk systems are distinguished by being stationary (as opposed to liquid containers which are portable) and therefore filled in place, and NFPA has defined them as being under the 566 m³ (20,000 ft³) capacity line (see 3.3.19.4). Because this is also the “indoor”/ “outdoor” line, this definition opens the probability that these systems will be located indoors. It is important to remember that the indoor/outdoor rule applies to *all* supplies, so the actual bulk tank must be small enough to allow for the cylinder reserve as well, such that the *total* gas volume stored in the room is under 566 m³ (20,000 ft³).

5.1.3.7.6.6 New

Vacuum exhaust piping materials and jointing is specified.

This corrects an omission in the 2012.

5.1.4 Clarification 5.1.4

Some reorganization was done to make the section read more effectively.

5.1.4.1.6 New

(see 5.1.4.3 in 2012)

The valve section has been changed from *prescriptive* (use a full port ball valve or butterfly valve) to *performance* (use a valve with \leq a specified pressure drop at design flow).

This opens the possibility of using other valve types (which may or may not exist) so the technology choices are now more open.

The butterfly valve for vacuum is also gone, also replaced by the pressure drop at design flow.

All other requirements remain:

quarter turn to off, materials suitable to the service, tube extensions for brazing, indication of open or closed, serviceable in-line, cleaned for oxygen in pressure service.

An easy way to comply: use a full port ball valve.

5.1.4.3.1 Clarification 5.1.4.5

The rewrite of the paragraph makes it clear that where you have multiple buildings, each should be evaluated for a Main Line valve.

5.1.6.8 Clarification 5.1.6.8

Manufactured assemblies are not required to have station outlets/inlets.

The previous wording made it sound as though manufactured assemblies were required to have outlets, which of course was never true.

5.1.9.1 New

Alarms are required to indicate if there is an audio failure.

Oddly, this is a case of being required to prove a negative, and as such is impossible. All alarms have a test function which tests the audio and the lamps. The test will be the only way to comply with this rule.

5.1.9.2.3 Clarification 5.1.9.2.3

“Communication” and the rules for using it are improved.

“Communication” as an alternative to the earlier “wiring” was added in 2012 to admit emerging technologies (wireless, ethernet, fiber optic, etc.) to be used with alarms. The modifications made in 2012 left a lot to be desired in clarity, and were very hard to translate into action. 2015 has greatly improved the clarity and clearly defined the difference between systems using “communications” and those using the older “wiring”.

Most important to note is that the overweening concern is for reliability, and that intent is identical whichever

2012 to 2105 Changes by Paragraph

5.1.10.2.1 New
Specification for stainless tube and fittings are added.

5.1.10.8 Clarification 5.1.10.8
Threaded fittings in the pipeline are limited to demand checks.

5.1.10.11.7 Clarification 5.1.10.11.7
Systems containing the same gas may be interconnected.

5.1.11.3.1.1 New
Driven outlets (as used primarily in sleep labs), must be labelled. See also 5.1.12.3.10.6.

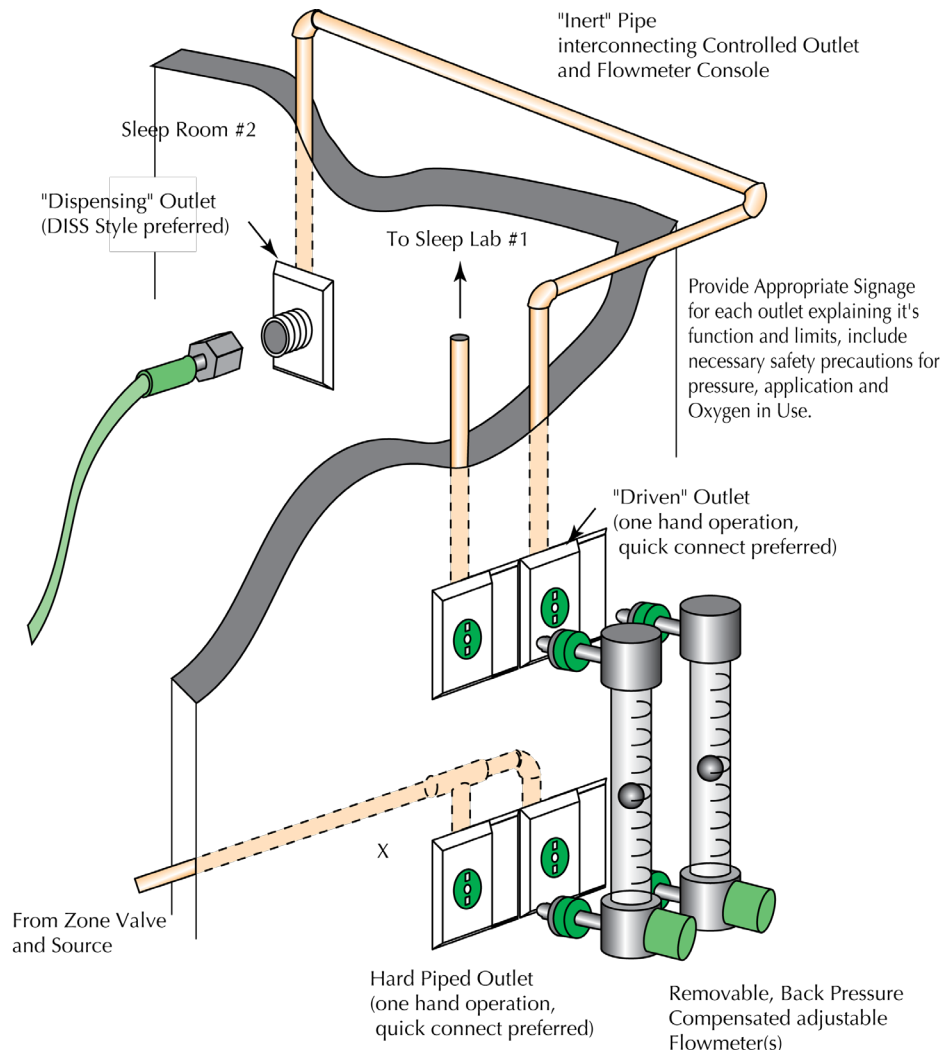
means are chosen. (See Annex A for a full discussion of this topic)

This corrects an omission where stainless was permitted, but grade and fittings were never specified.

This is companion to a change in the 2012 which eliminated the allowance for threaded check valves with the Oxygen Supply Connection.

Common sense perhaps, but the 2012 read as if two medical air systems using separate sources could not be interconnected. Never the intent (actually it is a very good practice), the 2015 clarifies that such connection is acceptable.

See Detail 16.



Detail 16: A Sleep Lab implementation using a "driven outlet" (5.1.11.3.1.1)

5.1.11.4 Reinforcement 5.1.11.4

Labelling for alarms is more clearly specified, requiring gas service, area of surveillance, and condition monitored for each indicator.

The rules are not new by intent, as these things were always expected, but the rewrite is much more clear and many will see it as new.

5.1.12.3.1.6 Deletion

The word “flexible” is removed

Using “flexible” here created a loophole for manufactured assemblies employing hard tube.

5.1.12.3.6.4 New

An odor test is added.

Highly controversial, this test is believed to be the best way to catch certain installation problems such as burnt plugs. It is also part of the USP tests for most gases. However, odor is entirely subjective, and this test is likely to be the source of many arguments between verifier and installer in the future.

5.1.12.3.10.6 New

Outlets at non-standard pressures must be labelled. (See also 5.1.11.3.1.1)

Although this is primarily intended to be the necessary companion to the requirement for sleep labs, it has some other consequences wherever outlets are used at pressures other than those in Table 5.1.11.

5.1.13 Moved 5.1.13

Instrument air systems requirements are moved to Support Gases

This is has been the intention of the Instrument air allowances since they were added to the document - IAir has always been intended to be an alternative to the use of nitrogen in support applications. Relocation should greatly assist in making this clear.

5.1.14.2.2.5 (B) (1) Clarification and New

5.1.14.2.2.5 (1)

Certification for persons qualified by in-house training has been removed. All persons must be competent on the equipment actually in that facility.

The clauses here have been rewritten, but the requirements are essentially the same, with two important changes: In house training must be “documented” but not necessarily “certified”, and all must be competent to work on the equipment in the facility. This eliminates a concern that someone could obtain a 6030 or 6040 certification and proceed to work on the equipment. Now, they must be trained on the actual equipment as well as the other qualifications the facility chooses to require.

5.1.14.3.3 and 5.1.14.3.4 New

Outlet and alarm labelling must be kept up to date.

There is an important line crossed here - 5.1.14 is in the *Maintenance* section, which indicates that it applies to existing healthcare facilities (see also 5.1.1.6). These new provisions therefore mandate that a facility must pay attention to these things on an ongoing basis, not merely at commissioning.

5.3 Reword, New and Clarification 5.3

The Category 3 requirements are entirely rewritten (again). Users are cautioned to read carefully.

11.5.2.4 New

Cylinder filling from oxygen concentrators is accepted and the rules defined.

This is not of course strictly in the medical gases section, nor is it necessarily applicable to a piped system, but it is noted here as an interesting view of the future.

Annex A : Computers as Substitute Alarms

Notes on Computers as Substitute Alarms

One of the changes to the 2005 which has been greeted with general acclaim has been the change which allows a computer to act as one of the two master alarm panels. While this is clearly a useful change and will improve the surveillance of medical gases in some facilities, it is a complex change, easily misunderstood and easy to implement badly. To assist with implementation of the change, we offer some general observations and guidance.

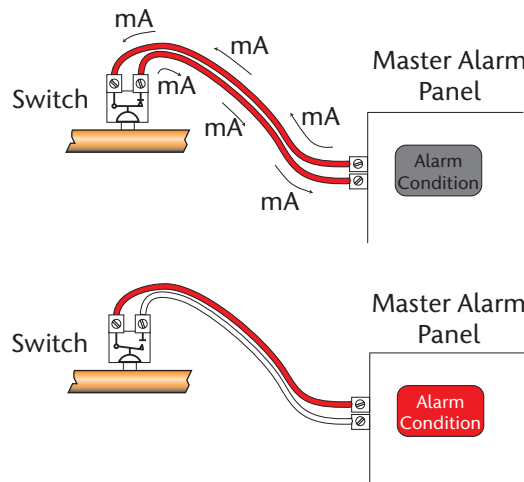
It is essential to begin with the understanding that this change is not intended to diminish in any way the ultimate level of surveillance or safety which is the role of the medical gas alarm system. In this, all the elements of the alarm system which are present when a panel is installed must be present when a computer is used, and one additional safeguard is required.

First question: Is the computer you are contemplating for this application suitable? The one requirement in which the computer must be superior to a panel is that a computer must be under continuous supervision (5.1.9.3.1 (2)). To be acceptable, the computer must be under constant observation or equipped to remotely advise the responsible person(s) through pagers, etc. An installation where this requirement may be met might be a central Building Automation System (BAS) where an attendant is present 24 hours, or which is equipped to page the engineer on duty when certain programmed events occur. An unsuitable computer would be the P.C. on the chief engineers desk, which is turned off at night and locked in the office.

Once the supervision of the computer is evaluated and agreed to be suitable, the next question is how

to get the signals into the computer and the other alarm panel. This is more tricky than it sounds, because of the way alarm panels are designed to be wired and the fact that computers work differently.

A quick brief on alarm wiring (see Detail A18.1): An alarm panel sends out a current on the wires to the switch and detects the returning current. If the switch opens or the wire is cut, the alarm detects the circuit is broken and signals the fault. (Incidentally, this is why alarms do not detect shorts in the wiring.)

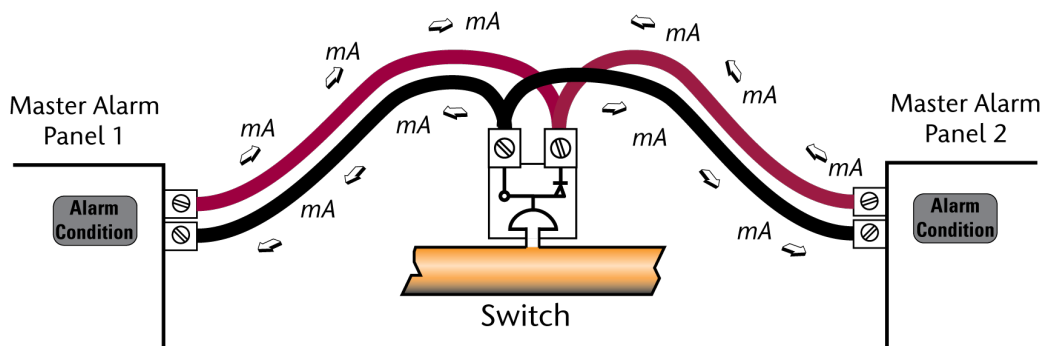


Detail A18.1: While current is flowing, the alarm is silent. when current is interrupted, the alarm is active

used for the computer's power supply (in fact, it is often difficult simply to get a computer power supply with the same voltage).

To get a computer to work with a panel, several strategies can be employed, all of which must be evaluated in light of the requirements of 5.1.9.3.1(3) through (6). This gets to be extremely tricky because there is a problem which can be created which can go undetected until a critical moment when suddenly the

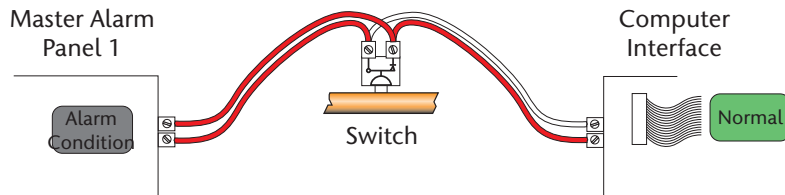
Detail A18.2. shows the switch/sensor wiring as required by 5.1.9.2.3. To make this operate, the alarms must be able to cooperate to the extent necessary to prevent the two power supplies from "bucking" one another. This is a minor trick as long as the same design has been employed for both power sources. However, a computer substituting for an alarm must also perform this trick, and it is extremely unlikely that the same design will have been



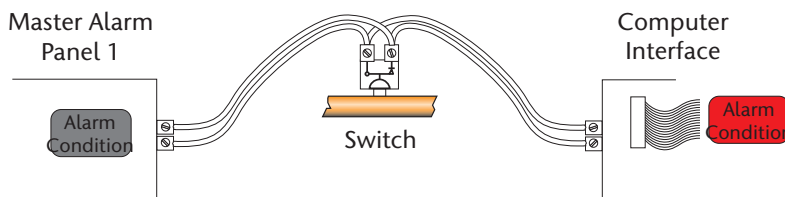
Detail A18.2: Wired to a single switch, both alarms attempt to power the switch, which they cannot do. This can lead to "bucking" between the two power supplies.

facility has no alarms.

One trick is to install a relay or a signal interface. The difficulty with these is that they are not typically arranged to power the switch but commonly only read the presence of power on the line. Essentially they will therefore depend on the other panel to power the switch and simply read the presence of the signal from that panel. Detail A19 illustrates this effect.



When operating normally, the Master alarm powers the switch, the alarm and computer read the result.



But shut off power to the panel, and the computer thinks the switch is open because it does not power the switch itself. Both alarms are now out of service.

Detail A19: The passive computer interface.

This is a subtle flaw which will be detected only when the alarm panel is shut off. Unlike two alarms, where the second alarm will simply carry on as if it had always been alone, in this case the computer will fail as well, since it will presume the switch has opened because of the absence of current.

There are other, even more subtle faults that can be created by this pairing. They are faults the verifier must test for by shutting down the alarm panel and checking that the computer continues to monitor all signals correctly, and then disconnecting the computer and ensuring the alarm panel continues to monitor all signals correctly. Such testing is well beyond normal verification practices, as is testing the computer algorithm as described in 5.1.9.3.2.

A method (often the easiest of all) to get around this is to simply install two switches. This will work in any case where this is possible (i.e. line pressure switches), but it is not a realistic option for the dew point monitor, inside the control cabinets of air or vacuum plant, etc.

where a single contact is all that is available.

It is the complexity of solving issues like this which may in fact make the elimination of an alarm so problematic that any savings from removing the panel disappears in additional interfaces, switches, wiring and programming.

There is a workaround, which has always been available to any facility under any version of the standard. The rules are that two panels are required, and the communication between them and their actuators is tightly prescribed for safety. However, it has always been true that a facility can go beyond the standard and monitor the medical gases at as many *additional* points as they desire. There are no limits on the “third panel”, “fourth panel”, etc.

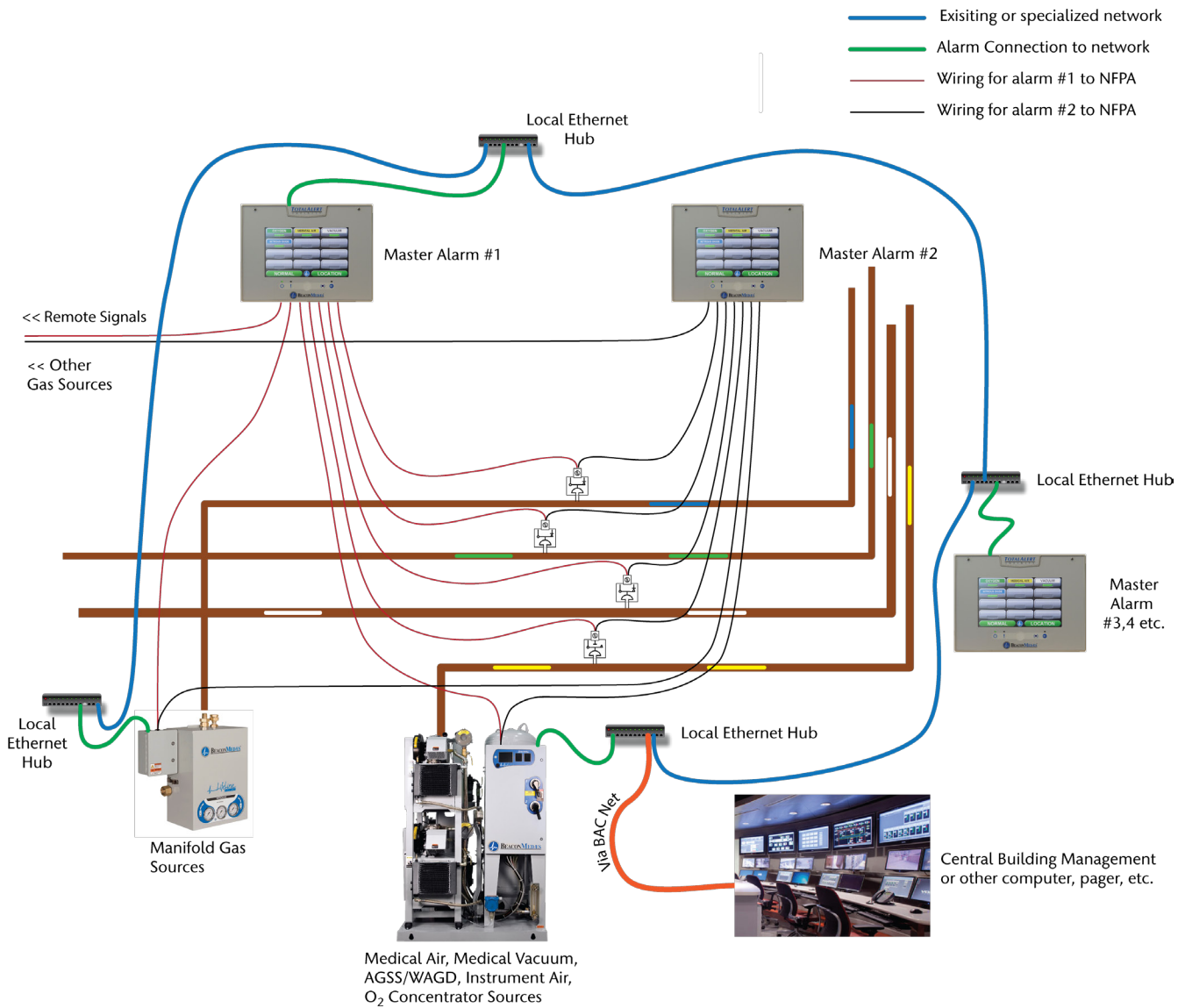
Modern alarms like the Total Alert Infinity provide a direct digital communications path which can easily be read into any computer system which is programmed to interpret the signal. If the two alarm panels are installed as required, it becomes very easy to use the digital output to read into a computer as a “third panel”. Detail A20 shows this configuration.

The beauty of this configuration is that it enables the alarm system to become a vastly more effective participant in the facility’s emergency planning and also in their Preventative Maintenance program. Alarm panels, computers, pagers, and smartphones all can be integrated together, all without sacrificing the basic requirements for alarm security as described by the standard and by good common sense.

Before letting enthusiasm for this new allowance in the standard induce you to take on a project which requires struggling with all the complexities of the wiring as described above, don’t forget that this older but proven option is still available and may in fact prove quicker, cheaper and less trouble to implement.

Annex B discusses this same topic with respect to the 2015 allowance for “communication” and which reinforces the points above.

Annex A : Computers as Substitute Alarms



Detail A20: The “third alarm” by network, a simple and powerful way to meet safety concerns and to remote monitor.

The Challenge of “Communications”

Prior to the 2012 edition, information from sensors to alarms could only be managed using wires. The word “wire” and “wired” was actually written into the standard. 2012 is the first edition where that word has been changed (in part at least) to “communications”, implying other methods might be used.

Methods which the new term makes conceivable include wires, wireless, fiber optic, and networks. (that is not to imply any limits, as there may be other usable methods beyond this list). The intent of the standard is not to prescribe the *technology* to be used, but the *result* to be achieved. Sometimes, the two are inseparable, because only one technology can achieve the required performance, but wherever possible, the idea is to stay away from imposing limits on the technology.

Although the term “communications” was inserted in the 2012 text, it was immediately clear that the result was inadequate. The intended performance was not properly outlined and thus the allowance was relatively useless. With the 2015, this weakness has been resolved, and with the appropriate performance criteria stipulated the gate is now open. So it is appropriate to explore the opportunity and the problems of “communications” with alarms.

To begin, here is the wording from the 2015 standard:

5.1.9.2.3 The master alarm panels required in 5.1.9.2.1 shall communicate directly to the alarm initiating devices that they monitor.

5.1.9.2.3.1 If communication is achieved by wires, the following shall apply:

(A) Each of the mandatory alarms shall be wired independently to the initiating device(s) for each signal.

(B) The wiring between each mandatory alarm(s) and the initiating device(s) shall not utilize common conductors that, if interrupted, would disable more than one signal.

(C) Each set of wires (in whatever number as required by the alarm) shall run to the initiating device(s) without interruption other than in-line splices necessary to complete the necessary length of wire.

(D) Where initiating devices are remote from the building and the wiring is to be run underground in compliance with NFPA 70, the following exceptions shall be permitted to be used:

(1) wiring from the initiating device and through the underground section shall be permitted to be run to a junction box located where the wiring first enters the building.

(2) A single set of wires complying with 5.1.9.2.3.1 for each signal shall be permitted to connect the initiating

device and the junction box.

(3) between the junction box and the two mandatory alarm panels, wiring shall comply with 5.1.9.3.2.1, 5.1.9.2.3.4 and 5.1.9.2.3.5 in all respects.

5.1.9.2.3.2 If communication is achieved by means other than wire, the following shall apply:

(A) Each of the mandatory alarms shall communicate independently to the initiating device(s) for each signal.

(B) The means of communication between each mandatory alarm(s) and the initiating device(s) shall not utilize a common communication device that, if interrupted, would disable more than one signal.

5.1.9.2.3.3 A single initiating device shall be permitted to activate multiple master alarms.

5.1.9.2.3.4 The mandatory master alarms shall not be arranged such that failure of either panel would disable any signal on the other panel.

5.1.9.2.3.5 Where a relay is required to ensure correct operation of an initiating device, the control power for the relay shall not be such that disabling any master alarm would disable the relay.

5.1.9.2.3.6 Master alarm signals shall not be relayed from one master alarm to another.

5.1.9.2.3.7 Where multi pole alarm relays are used to isolate the alarm initiating signals to master alarm panels, the control power for the relays shall be independent of any of the master alarm panels.

5.1.9.2.3.8 Multiple master alarms shall be permitted to monitor a single initiating device.

The Gold Standard ~ Wire.

Since the alarm requirements were originally drafted in an age of hard wiring, and wired alarms are very well proven, wired remains the point of departure. Every other technology will be expected to do as well or better.

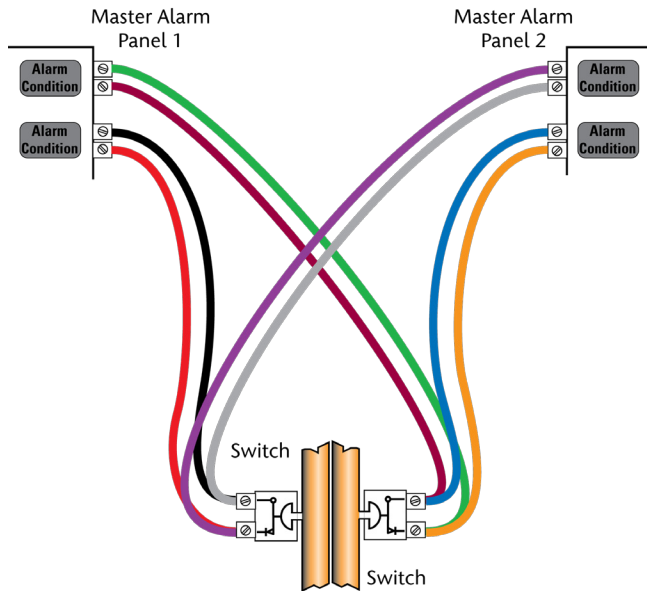
Detail 22.1 shows the classic “wired” model described by the text in NFPA. Each switch or sensor is wired to each alarm, and the wires are in parallel (Note that the switches are open with no pressure (no current), and close when under pressure (current flows). Thus, an abnormal condition opens the switch and stops the flow of current). Any wire cut or disconnected acts like an open switch, and will show an alarm. The circuit is termed “supervised”, because no failure can occur without setting off the alarm. This behavior remains in the standard and is required of any form of “communications” (see 5.1.9.1).

Emulating Wire without Any

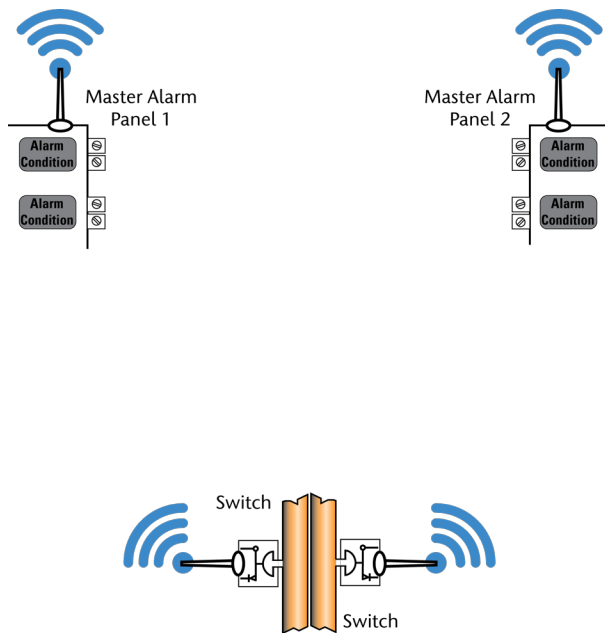
Detail 22.2 shows the communications model that is implied in the language of NFPA 5.1.9.2.3, using wireless as the example technology. When people

Annex B : The Challenge of “Communications”

think about this new allowance, this generally seems to be the image in their minds. It is immediately attractive because all the work involved in running conduit, and pulling wires, as well as the wire itself, has disappeared.



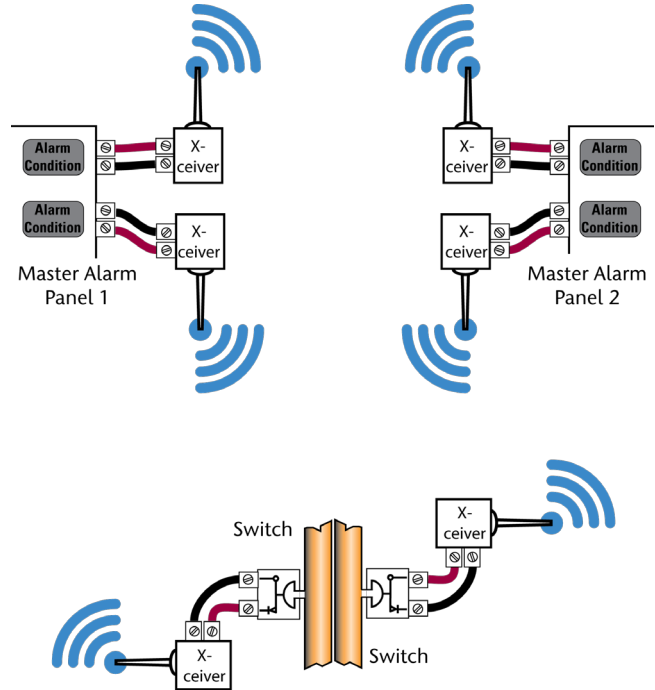
Detail 22.1: Classic “wired” switches.



Detail 22.2: The NFPA ideal of “communication”

The problem is that this is not realistic with the available technology. The first problem is that the devices for the most part do not exist in this form. The switches used on medical gas systems are standard pressure switches and such like, and of course these aren’t wireless. That is a technological

difficulty that can be gotten around. With a little creativity it is possible to do what is envisioned in Detail 22.2 using off the shelf components, with the approximate result as shown in Detail 22.3. (Although of course the 22.2 ideal could also be built using the same technologies inbuilt to the alarm circuitry).



Detail 22.3: More realistic, but still within 5.1.9.2.3

Either way, the transceivers shown here (“X-ceivers” on the details) will need power, so the first difficulty is that each device would need to be reliably powered (from the life safety branch of the emergency electrical system of course (see 5.1.9.1(9)), which is not necessarily the branch that socket where you plan to plug in the power brick is wired to!). In the wired version the panels power the switches, so this is not a consideration.

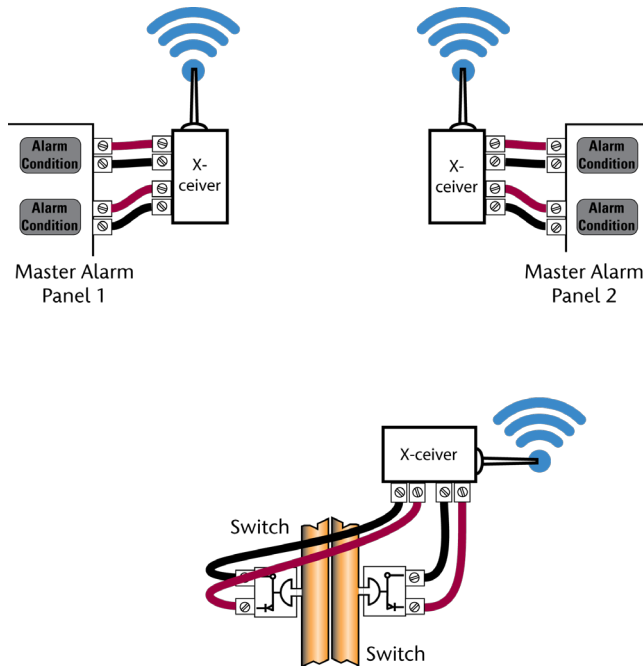
5.1.9.2.3.2 (B) is the key test of acceptability for this design. Here, given appropriate programming, each switch communicates directly to the corresponding alarm indicator. Failure of any one communications component will disable only the one signal (notice that it will disable that signal on *both* masters, so right away the system is not as robust as the wired version) but it is clear that this design meets the rules as written.

This however is really not what people want to do, because it would be undesirably expensive and clumsy to have so many transceivers. So Detail 23.1 shows the where that thinking leads us.

In this version, we have successfully reduced the six

Annex B : The Challenge of “Communications”

transceivers shown in Detail 19.3 to three. Now, when we apply the test of 5.1.9.2.3.2 (B), we have three devices, any of which would cause multiple signal failures. Probably financially attractive but clearly not acceptable under 5.1.9.2.3.



Detail 23.1: Saved some hardware, but...

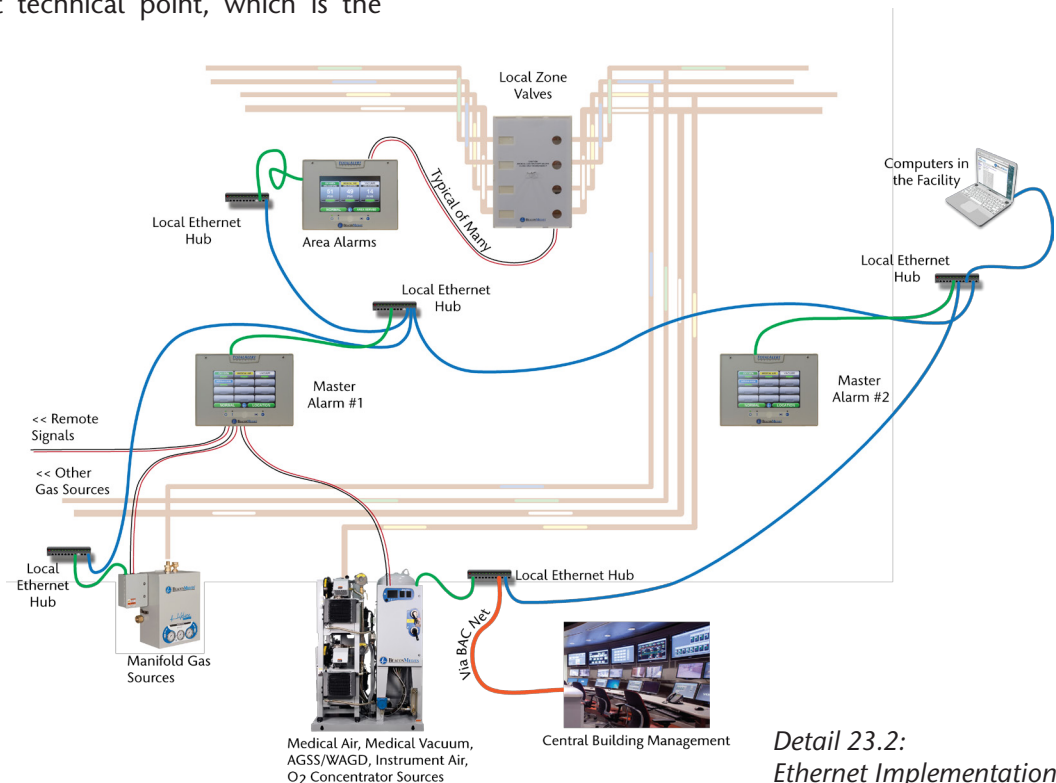
Using Wireless as available today requires consideration of another significant technical point, which is the available wireless spectrum and legal use of frequencies. To achieve what we would like to see (Details 22.2 or 22.3), with the reliability we require in medical gas alarms (and to prevent nuisance alarms under 5.1.9.1) would require a radio transceiver which will not have too limited a range or suffer from interference. That generally would mean some sort of private channel requiring an FCC licence. In absence of that, what is

available to us are the frequencies in the “Industrial, Scientific and Medical band” (ISM) which we are most familiar with as “WiFi”, “Bluetooth” and the like. Detail 24 summarizes these available techniques and gives some idea of their positives and negatives.

Because these available frequencies are limited in various ways, the actual implementation in the field often will necessitate some signal boosting, which is accomplished with repeaters at strategic locations. Immediately it will be obvious that these repeaters are flagrant violations of the rule, since loss of the repeater will cause *all* the signals to be lost.

There is another variant of these designs which is often viewed as “better”. That would use one set of wires to one of the master alarms, and then a wireless transmission to the second master. It reduces the wiring required but ensures that at least one master meets the “gold standard”. This idea runs foul of the rule in 5.1.9.2.3.4 and 5.1.9.2.3.6, which prohibit one master from controlling the signal to the other, since loss of one means loss of both.

Regrettably, the sum of all this is that while wireless can work for some places, it cannot work for all, and the user must take great care to ensure that any wireless implementation meets the rules for security and reliability. The places who most want to use wireless for the money saved are also least likely to be able to use it.



Detail 23.2: Ethernet Implementation

Detail 24
Wireless Implementations - Licence Free Methods

	802.11 B/C	Zigbee	Bluetooth	802.11 ac	900 mHz
Common application	Starbucks wireless	The “internet of things”	telephone earpieces	Relatively new - rapidly being adopted for wireless internet	industrial wireless ethernet
Frequency	2.4 GHz	2.4 GHz	2.4 Ghz	5.4 GHz	900 mHz
Speed	11 Mbps		2 Mbps	11 Mbps	claims vary - varies with signal configuration
Range (typical maximum)	150-300 ft (45-100 m) typical (1,000 ft (300m) max	60 feet (20m)	32 feet (10m)	150-300 ft (45-100 m) typical (1,000 ft (300m) max	varies - approx. 1-5 miles Interference with transmission problematic.
Power	1 watt	1 milliwatt	1 milliwatt	1 watt	1 watt
Network	point to point	mesh	point to point	point to point	point to point

Other Ideas?

NFPA chose the word “communication” with the clear intention of not limiting the technology, and there are other options beside wireless.

One option is use of the facility’s existing data network. In such an implementation a signal could be placed onto the network and read by any other alarm also on the network. Such an implementation is shown in Detail 23.2. Since the network already exists, the costs to implement this can be very small.

Naturally, any such implementation would fail the test in 5.1.9.2.3.2 (B) for multiple signals, as the network itself is fallible. If the network went down, so too would the signals.

This technique does have the advantage that the network is critical in itself, so it is unlikely to be out of operation for long if it does go down. The reliability of the network is also well demonstrated, and resources are always available to maintain it.

Use of the network also allows easy implementation of other desirable options which also use the network, such as connection to Building Management, remote access over the internet, and access to external services such as pagers, etc.

The most effective use of the network is (as Detail 23.2 shows) to dispense with the wiring to the second master. It will be readily seen this has the same disability as trying to achieve that result wirelessly. Failure of one master can cause all masters to be inoperative.

In summary, it is very possible to implement alarms using various “communications” technologies, but it is generally not possible to match the gold standard of wired alarms with them (fiber optic may be an exception, but it has no obvious advantage and no one to our knowledge has yet tried it).

Real Goals

It is very important to remember the overall objective. What we need to achieve is to

Annex B : The Challenge of “Communications”

notify the right person when the alarm goes off. The number and placement of alarms should be evaluated to facilitate that real goal more than the artificial goal of simply two master alarms.

The allowances in the 2015 become far more valuable when measured by this real objective.

If we consider that our true objective is to inform the person best positioned to correct or deal with the condition, and we consider who that might be, we begin to think about notifying those individuals in more relevant ways than the simple “idiot light” and buzzer which constitutes the mandated alarm signal.

Thinking this way, suddenly it becomes possible to use these allowances in far more creative ways. For example: it would be usual for purchasing to be responsible for reordering the gases. We traditionally would have the “Contents Low” alarm in Maintenance, and while maintenance will change the cylinders, maintenance can only advise purchasing to arrange the refill.

How much better would it be to notify Purchasing directly?

With this scenario, placing that alarm in Purchasing’s workspace would be sensible, but with the old rules doing that would be prohibitively expensive because the wiring cost would be formidable. With the new rules, alarm placement becomes vastly more flexible because the available methods for initiating the alarms open up.

This is the real benefit of the new rules. They offer no worthwhile benefit if they simply introduce additional points of failure and thereby reduce the reliability that the old “gold standard” provided. Where they increase our flexibility and allow the design of alarm systems that improve notification, speed response and thereby reduce risk, they truly are worth consideration.



1800 Overview Drive • Rock Hill, NC 29730 • Phone 1 888 4 MED GAS • Fax 1 803 817 5750
www.beaconmedæs.com