First Revision No. 6-NFPA 53-2019 [Global Input]

Convert equivalent units for SI/US measurements throughout the document for both the text and the figures. See attached file for reference. The following figures have been edited:

Figure C.1.2.2(a)

Figure C.1.2.2(b)

Figure E.3.2.2

Figure E.4.2.5

Figure F.2.2.2(b)

Figure F.2.2.4

Figure F.3.2.6.1.2

Figure F.3.2.6.2

Figure F.3.4.3(a)

Figure F.3.4.4

Supplemental Information

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Committee Statement

Committee Statement:	The standard needs to be updated to include SI and their equivalent US values in the diagrams and throughout the text of NFPA 53.
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A.5.2.1

Nonmetals are more susceptible to ignition than metals [most nonmetals are flammable in oxygen at 101.3 kPa (1 atm) or greater]. In many instances, failures of metallic components are caused by a polymer ignition, which provides sufficient energy for the metal to ignite.

C.1.2

The degree of fire hazard of an OEA varies with the concentration of oxygen present, the diluent gas, and the total pressure. An OEA is defined as any atmosphere in which the concentration of oxygen exceeds 21 percent by volume or the partial pressure of oxygen exceeds 21.3 kPa (160 torr). Other oxidants include nitrous oxide, nitric oxide, and chlorates. In most commonly encountered OEAs, an increased fire hazard is produced by the increased partial pressure of oxygen (e.g., in an atmosphere of compressed air) or by the absence of the diluting effect of an inert gas [e.g., in pure oxygen at a pressure 20.3 kPa (1⁄5 atm)]. An OEA does not, however, by definition produce an increased fire hazard. Certain OEAs can exhibit combustion-supporting properties similar to ambient air, whereas others are incapable of supporting the combustion of normally flammable materials (a decreased fire hazard). The latter case can frequently arise under hyperbaric conditions when the volumetric percentage of oxygen is significantly reduced in a nitrogen or helium mixture, even though the partial pressure of oxygen is equal to or greater than 21.3 kPa (160 torr). For example, a 4 percent oxygen mixture in nitrogen or helium at a total pressure of 1215.9 kPa (12 atm) will not support the combustion of paper even though the partial pressure of oxygen is 48.6 kPa (365 torr). A similar condition (i.e., a reduced fire hazard) can exist at very low hypobaric pressure, even though the volumetric percentage of oxygen is significantly high

C.1.2.2

Figure C.1.2.2(a) and Figure C.1.2.2(b) depict three combustion zones for vertical filter paper strips in hyperbaric mixtures of oxygen-nitrogen and oxygen-helium, respectively. Those combinations of oxygen concentrations and total pressure lying above the 21.3 kPa (0.21 atm) oxygen partial pressure isobar (lower dashed line) are, by definition, OEAs, but they could be located in any of three zones: complete combustion, incomplete combustion, or noncombustion.

C.3.4

The medical profession uses hyperbaric chambers to allow supersaturation of patients with oxygen. The patient, with or without attendants, is placed in a hyperbaric chamber that is sealed and pressurized, sometimes to 405.3 kPa (4 atm) absolute or greater. Generally, pressurization is accomplished with compressed air, and the patient breathes pure oxygen from a mask. However, in some single-occupant (patient only) chambers, the atmosphere is pure oxygen. Although there might be some flammability-inhibiting effect of the increased nitrogen present in compressed air, this effect is more than offset by the increased partial pressure of the oxygen present [up to 506.6 kPa (5 atm)]. *(See Chapter 14 of NFPA 99 for more information on hyperbaric facilities.)*

C.5 Caisson Work and Underwater Tunneling.
When driving a tunnel under or setting a foundation on a river bed, it might be necessary to seal off the work area with an airtight compartment and elevate the air pressure therein to prevent the pressure of the overlying water from inundating the compartment with mud or water. For every 10 m (33 ft) of depth of water outside the compartment, the pressure therein needs to be raised 101.3 kPa (1 atm) to compensate *(see Table C.1.2.1)*. An OEA exists within the compartment while it is pressurized.

C.6.3.1
The space station is designed to operate at 70.3 kPa (absolute pressure of 10.2 psi) with a 30 percent oxygen atmosphere until it is permanently manned. The current schedule is for the space station to be occupied only when a shuttle is docked for the first 5 to 6 years of operations. Once the space station is permanently occupied, it is expected to operate at 101.3 kPa (1 atm) with up to 25 percent oxygen concentration. The space station will have a hyperbaric chamber to treat the bends, if necessary. This chamber will be operated at 405.3 kPa (4 atm) at 21 percent oxygen concentration and used only in an emergency.
D.2.7.9
A commercial aircraft fire occurred during servicing of the passenger oxygen system. Three crew members, four flight attendants, and twelve passengers were onboard the plane when the fire erupted. All passengers and crew were evacuated safely. Shortly after the preboarding of passengers had begun, a sound, described as a muffled bang or boom, came from an area near the forward galley. Within seconds, thick black smoke started to fill the cabin, and flames began to burn through the forward right side of the fuselage. Witnesses stated that they saw a 3 ft to 4 ft (0.9 m to 1.2 m) flame extending sideways from the fuselage on the forward right side of the airplane. A hole several feet in diameter burned through the fuselage, just behind the right side forward galley service door.

D.2.8.5
The Canadian Underwater Mine–countermeasures Apparatus (CUMA) is a self-contained, semi-closed-circuit underwater breathing apparatus used by Canadian Forces for underwater mine search, investigation, and disposal. On November 30, 2001, the Experimental Diving Unit staff at Defense Research and Development Canada – Toronto was preparing for an experimental dive using the CUMA version 2 (V2) in their facility’s hyperbaric chamber. A fire occurred in the CUMA V2 as the team leader (the diver wearing the CUMA V2) opened the oxygen sphere valve. The fire was severe, ejecting fire and molten metal approximately 7 ft (2.1 m) from the diver’s back-mounted unit, and lasting for an extended duration before the diver’s teammates were able to remove the backpack and extinguish the fire. No one was seriously injured in the incident. Key materials were sampled as required and chemical analyses on samples were done to obtain positive material identification. The evidence indicated that the local origin of the fire was within the first-stage regulator close to the nonmetal seat. The evidence also indicated that operationally induced ignition mechanisms developing during valve opening, and incompatible materials, were the causative factors in the ignition and propagation of the fire.

Reference: Forsyth, E. T., Eaton, D. J., and Newton, B. E., “Oxygen Fire Cause and Origin Analysis of the CUMA V2 Underwater Breathing Apparatus,” *Flammability and Sensitivity of*

Materials in Oxygen-Enriched Atmospheres: Tenth Volume, ASTM STP 1454, T. A. Steinberg, H. D. Beeson, and B. E. Newton, Eds., ASTM International, West Conshohocken, PA 2003.

The passenger oxygen system is located in the forward right side of the airplane. The system is composed of two oxygen cylinders, each charged initially to an absolute pressure of 1850 psi (12.8 MPa). The cylinders supply oxygen through steel tubing to the flow control unit, which reduces the pressure of the oxygen and then controls its flow to the passenger masks. During a preflight inspection of the airplane, a mechanic found that the quantity of oxygen in the cylinders was below the acceptable level and, therefore, changed the cylinders. He reported that, as he was about to leave the area, he saw a flash of white light that enveloped the oxygen system's flow control unit.

The inspection team from the National Transportation Safety Board (NTSB) concluded that the fire originated in the passenger oxygen system's flow control unit. (9)

Table E.2.1 Properties of Standard and Oxygen-Enriched Atmosphere Constituents

Constituent	**Molecular Formula**	**Molecular Weight (O = 16.00)**	**Melting Point (°C)**	**Boiling Point (°C)**	**Density (gm/L)**	**Thermal Conductivity X***	**C_p25°C (cal/gm)**	**C_p C_v**
Nitrogen	N_2	28.016	−209.9	−195.8	1.2507	62.40	0.219	1.404
Oxygen	O_2	32.0000	−218.8	−182.96	1.4289	63.64	0.219	1.401
Argon	Ar	39.944	−189.2	−185.9	1.7828	42.57	0.124	1.568
Carbon dioxide	CO_2	44.010	−56.6 5.2 atm	−78.5 Subl.	1.9768	39.67	0.202	1.303
Sodium	Na							
or neon	Ne	20.183	−248.67	−245.9	0.835	115.71	0.246	1.64
Helium	He	4.003	−272.2 26 atm	−268.9	0.1785	360.36	1.24	1.660
Krypton	Kr	83.80	−157.1	−152.9	3.6431	≅23	0.059	1.68
Xenon	Xe	131.30	−112	−107.1	5.897	—	0.038	1.66
Methane	CH_4	16.04	−182.5	−161.5	0.7167	81.83	0.533	1.307
Nitrous oxide	N_2O	44.016	−102.4	−89.49	1.997	41.45	0.2003	1.303
Ozone	O_3	48.0000	−192.5	−111.9	2.144	—	0.1959	—
Hydrogen	H_2	2.0160	−257.14	−252.8	0.0898	446.32	3.41	1.410

For SI customary units, 1 atm = 101.3 kPa.
For U.S. customary units, °F = (1.8 × °C) + 32.

*X = cal/(sec)(cm^2)(°C/cm) × 10^{-6}.

E.4.2.4

Note in Figure E.4.2.4 that, for liquid fuels in equilibrium with their vapors in air (or in oxygen), a minimum temperature exists for each fuel above which sufficient vapor is released to form a flammable vapor-air (or vapor-oxygen) mixture. The experimentally determined value of this minimum temperature is commonly referred to as the flash point. The flash point temperature for a combustible liquid varies directly with environmental pressure. An increase in oxygen concentration also widens the flammability range — the upper limit being affected much more than the lower limit. For example, in an oxygen atmosphere at 21°C (70°F) and 101.3 kPa (1 atm), the upper limit for hydrogen increases to 95 volume percent compared with 74 volume percent in air, whereas the lean limit remains essentially the same. A reduction in oxygen concentration results in a narrowing of the flammability range until, at a certain oxygen concentration, the limits merge and flame propagation is no longer possible. Reduction of the oxygen content below this minimum value is one means of effecting fire control. In practice, carbon dioxide or nitrogen is often utilized for this purpose. Nitrogen pressurization provides effective fire control, and as long as the oxygen partial pressure is about 14.2 kPa (0.14 atm), the environment remains habitable.

E.4.2.5

Total environmental pressure also has an effect on the limits of flammability *(see Figure E.4.2.5)*. For a given atmospheric composition, an increase in pressure generally broadens the flammability range, the rich limit being influenced more than the lean limit. For example, the flammability limits for natural gas-air mixtures at 3445 kPa (34 atm) are 4.45 and 44.20 volume percent compared to 4.50 and 14.20 volume percent at normal atmospheric pressure. A decrease in environmental pressure below 101.3 kPa (1 atm) produces little effect on the limits of flammability until the low-pressure limit is reached, whereupon materials become nonflammable.

Table E.5.3 Oxygen Content, Maximum Fuel Consumption, and Resulting Combustion Temperatures and Pressures in Different Atmospheres in a 10.2 m^3 (360 ft^3) Volume Enclosure

	Cellulose Fuels		**Hydrocarbon Fuels**	
Atmosphere	**In Air at 103.4 kPa (absolute pressure of 15 psi)**	**In 100% O_2 at 103.4 kPa (absolute pressure of 15 psi)**	**In Air at 103.4 kPa (absolute pressure of 15 psi)**	**In 100% O_2 at 103.4 kPa (absolute pressure of 15 psi)**
Oxygen content (kg)	2.9	14.5	2.9	14.5
Maximum burnable fuel[a](kg)	1.2	11	0.36	3.3
Heat of combustion (cal/gm)	~4,000		~11,700	
Maximum heat release(kcal)	~4,924	~43,500	~4,233	~38,200
Maximum theoretical temperature (°C)	1,810	5,670	1,390	5,840
Maximum pressure ratio ($P_{final}/P_{initial}$)[b]	8	36	7	33
Maximum final pressure (kPa)	827 (120 psia)	3,723 (540 psia)	724 (105 psia)	3,413 (495 psia)

For U.S. customary units, °F = (1.8 × °C) + 32.

[a] Assumes all but 10 volume percent of available O_2 can react.
[b] Does not consider dissociation of product gases.

F.2.2.1

The minimum autoignition temperatures (AIT) of most hydrocarbon fuels, solvents, and anesthetic agents fall between 204°C and 538°C (400°F and 1000°F) in air at 101.3 kPa (1 atm) pressure *(see Table F.2.1)*. Generally, the AIT of the paraffinic hydrocarbons decreases with increasing molecular weight. A few hydrocarbon-type combustibles, such as ethyl ether, n-amyl ether, and acetaldehyde, can autoignite below 204°C (400°F) in air. Carbon disulfide can also ignite at a low temperature [90°C (194°F)]. These AIT are primarily applicable to hot surface ignitions in quiescent atmospheres and where the heat source is relatively large. Vessels of Pyrex® or stainless steel usually have the lowest AIT. As a rule, AIT do not vary greatly with fuel concentration except at near-limiting concentrations, where they increase noticeably. Fuel injection pressure can also be important. The AIT of many lubricants decrease as much as 102°C

(200°F) when the injection pressure is increased from 0 to about 6895 kPa (gauge pressure of 1000 psi).

Figure F.2.2.1 shows the noticeable effect that fluid injection pressure can have on the minimum AIT of a diester (MLO-54-581) and several silicate-type (MLO-54-856, MLO-8200, MLO-54-645, MLO-54-540) hydraulic fluids. This figure also illustrates that the AIT of a chlorinated silicone fluid (MLO-53-446) and a mineral oil (MIL-H-5606) are independent of injection pressure to 34,475 kPa (gauge pressure of 5000 psi).

Figure F.2.2.1 Minimum Autoignition Temperatures of Seven Hydraulic Fluids in Air at Atmospheric Pressure and at Various Injection Pressures [200 cm^3 (12.2 in.^{3}) **Pyrex® Vessel]. (13)**

F.2.2.2
Although AIT tend to be lower in oxygen than in air, such differences are not significant for many hydrocarbon combustibles. Similarly, the AIT for many combustibles do not vary greatly when the ambient pressure is increased to a few atmospheres. However, at highly reduced pressures <101.3 kPa (<1 atm) or reduced-oxygen concentrations (<21 percent), AIT tend to be noticeably higher than in air at 101.3 kPa (1 atm). Thus, the autoignition hazard is less severe in such atmospheres. The use of an inert diluent of higher thermal conductivity than nitrogen (e.g., helium) also reduces the autoignition hazard in some instances. Because AIT are normally dependent on oxygen partial pressure, the data obtained at various oxygen percentages can be used to estimate AIT at various total pressures.

In the case of lubricants and hydraulic fluids, the effect of oxygen concentration on AIT tends to be greater than observed for the neat hydrocarbon combustibles in Table F.2.1. Figure F.2.2.2(a) shows that the AIT for five of the hydraulic fluids decrease between 93°C and 149°C (200°F and 300°F) when the oxygen content is increased from 21 percent to 100 percent. The AIT of the chlorinated silicone fluid (MLO-53-446) and the mineral oil (MIL-H-5606) are unaffected by such changes in oxygen concentration, similar to when these fluids are subjected to varying injection pressure.

A correlation of AIT with oxygen partial pressure is shown in Figure F.2.2.2(b) for several such combustible fluids at various initial pressures and oxygen concentrations. According to these data, the aromatic ether and chlorinated silicone fluids would be favored over the other fluids for protection against autoignition.

Figure F.2.2.2(a) Minimum Autoignition Temperatures of Seven Hydraulic Fluids at Atmospheric Pressure in Various Oxygen-Nitrogen Atmospheres [200 cm^3 (12.2 in.^{3}) **Pyrex® Vessel]. (13)**

F.2.2.3
In comparison with autoignition, the spark ignition of a flammable mixture requires much higher temperatures and is governed primarily by the rate of energy input rather than by the heat source temperature. The importance of minimum spark ignition energies is evidenced by the fact that most flammable mixtures of combustibles can be ignited in air or oxygen by the energy dissipated from common electrostatic discharges. The range of ignition energy values provided in Table F.2.1 is from about 0.1 mJ to 3 mJ (9.5 × 10^{-8} Btu to 2.8 × 10^{-6} Btu) for most of the

hydrocarbon fuels, anesthetics, and solvents with air as the oxidant. Ammonia and some of the halogenated hydrocarbons (halons) require ignition energies of much higher magnitude [>1000 mJ (>9.5 × 10^{-4} Btu)]. In comparison, such combustibles as acetylene, hydrogen, and carbon disulfide can be ignited with spark energies of only about 0.015 mJ (1.4 x 10^{-8} Btu).

F.2.2.4

Minimum ignition energy values refer to the most ignitible composition of the given fuel vapor-air mixture and are noticeably higher for mixtures that are highly fuel-lean or fuel-rich. In addition, energy values can be expected to be higher at reduced pressures but much lower in oxygen than in air. Many ignition energy data vary inversely with the approximate square of the total pressure. For some liquids and gases, ignition values are as much as about 100 times lower in oxygen. Figure F.2.2.4 shows the variation of the minimum spark ignition energies of propane-oxygen-nitrogen mixtures with fuel concentration and oxygen concentration at 50.7 and 101.3 kPa (0.5 and 1 atm) pressure. The substitution of helium for nitrogen results in higher ignition energies but does not eliminate the risk of spark ignitions.

F.2.3.1 Nonmetallics.

The extent of combustion or flame propagation depends on a number of factors, including the pressure, the temperature, and the composition of the fuel and oxidant. With near-stoichiometric mixtures of hydrocarbon vapors in air, the flames propagate at rates of at least a few feet per second at 101.3 kPa (1 atm) pressure and through apertures as small as about 2.5 mm (0.1 in.) diameter. The rates of flame propagation (flame speeds) normally increase with an increase in chamber diameter.

The maximum pressure rises that are produced by the ignition of such mixtures in a large confined space are generally about 689 kPa (gauge pressure of 100 psi). The explosions are even more severe in oxygen where detonations might occur and the pressure rises and propagation rates are much higher than in air. The transit of a deflagration (subsonic) to a detonation (supersonic) can also occur in air with many fuels if the ratio of the length to the diameter of the reaction chamber is sufficiently great.

F.2.4.2

The lower limits of most hydrocarbon fuels, anesthetics, and solvents are equal to or less than about 5 volume percent in air or oxygen at 101.3 kPa (1 atm). Table F.2.1 provides data obtained at ordinary temperatures [≤593°C (≤1100°F)], except where otherwise noted. Vapors and gases, such as ammonia, carbon monoxide, and certain halogenated hydrocarbons, have much higher lower limits.

In comparison, the values for most lubricants are less than 1 volume percent because of the high molecular weights of such fluid. At the same time, lubricants need much higher temperatures, for example, 93°C to 371°C (200°F to 700°F), to form lower limit mixtures than do the paraffins and many other hydrocarbons. (13)

F.3.2.1

Organic solid materials in the form of finely dispersed dust clouds are extremely susceptible to combustion when heated to temperatures of generally less than 538°C (1000°F) and where spark ignition energies are less than 0.1 J (9.5×10^{-5} Btu). The degree of this type of fire hazard has been expressed conveniently in the literature as an explosibility index with a range of 0 to 10+. According to this scale, vinyls and fluorocarbons are outstanding, with an index of less than 0.10, which agrees with other flammability data (17) on these materials.

The index of explosibility is the product of the ignition sensitivity and the explosion severity. The indices are dimensionless quantities and have a numerical value of 1 for a dust equivalent to the standard Pittsburgh Coal Dust. An explosibility index greater than 1 indicates a hazard greater than that for coal dust. The ignition sensitivity is the product of the ignition temperature multiplied by minimum energy, multiplied by minimum concentration of Pittsburgh Coal Dust, divided by the product of ignition temperature, multiplied by minimum energy, multiplied by minimum concentration of the sample dust under consideration. The explosion severity is the product of maximum explosion pressure multiplied by maximum rate of pressure rise of the sample dust under consideration, divided by the product of maximum explosion pressure, multiplied by maximum rate of pressure rise of Pittsburgh Coal Dust. (17)

F.3.2.2

Single fibers of organic material, such as those of lint, cotton tufts, and fluffy fabrics, are especially vulnerable to a localized heat source such as an electrical discharge. Single cotton fibers can be ignited by a 0.02 J (1.9×10^{-5} Btu) static spark in 100 percent oxygen but not in 64 percent oxygen in air. Fibers contaminated with greasy substances can be ignited by much weaker sparks. (18)

F.3.2.3

Textile fabrics, such as those used in clothing, can be ignited and burned by high-energy repetitive electrical sparks. For example, both cotton and wool have been ignited with a spark energy as low as 2.3 J (2.2×10^{-3} Btu) in 100 percent oxygen at atmospheric pressure, whereas, in normal air, a spark energy as high as 193 J (0.2 Btu) was required. Silk and polyester fabrics are more difficult to ignite than cotton or wool. Oily fabrics are highly flammable and can be ignited with a spark energy as small as 1/10,000 of that for a clean sample. (19)

F.3.2.4

Frictional sparks in 100 percent oxygen can be much more incendive than in air. For example, a grinding wheel in contact with metal that produces low-energy sparks incapable of igniting fuel vapors normally requiring only 0.0003 J (2.8 × 10-7 Btu) spark energy in air will ignite textile fabrics in 100 percent oxygen due to increased reactivity of the abrasive particles in oxygen. Cotton and wool fabrics can also be ignited by a spark from the impact of a hardened steel tool against a rusty steel plate.

F.3.2.5

Combustible materials, when heated, can self-ignite at relatively low temperatures that approach the SIT or AIT obtained under ideal test conditions. Limited data and theory indicate that the SIT for typical materials, such as polyethylene and polyvinyl chloride, decrease linearly with an increase in partial pressure of the oxygen. A decrease of about 93°C (200°F) in SIT is indicated for these materials with an increase in oxygen partial pressure from 155 mm [21 kPa (absolute pressure of 3.0 psi)] to 760 mm [101 kPa (absolute pressure of 14.7 psi) (1 atm)]. Temperatures much higher than those for SIT are indicated to cause hot surfaces to ignite materials by direct contact. For example, polyvinyl chloride will not ignite when exposed to a surface temperature of 649°C (1200°F) in air. However, in 100 percent oxygen at 101.3 kPa (1 atm), this material will ignite at about 393°C (740°F). (20)

Other test results show that, for cotton sheeting, the minimum hot plate temperature for ignition decreases from 465°C (869°F) in normal air to 360°C (680°F) in 100 percent oxygen at 101.3 kPa (1 atm). For this same material, decrease in the temperature with increase in the air pressure from 101.3 kPa to 608 kPa (1 atm to 6 atm) is about equal to that specified for 100 percent oxygen. No ignition for Nomex® was obtained under similar test conditions in normal air. However, ignition does occur at 520°C (968°F) in 100 percent oxygen at 101325 Pa (1 atm) and at 560°C (1040°F) in air at 608 kPa (6 atm). (21)

Table F.3.2.6.1 Friction Ignition Test Data for Similar Pairs of Test Specimens (23, 26–28)

	P_v Product at Ignition	
Test Materials	**W/m^2 × 10^{-8}**	**lbf/in.^{2} × ft/min × 10^{-6}**
Inconel MA 754	3.96-4.12*	11.30-11.75[27]
Inconel MA 758	2.64-3.42	7.53-9.76
Nickel 200	2.29-3.39	6.50-9.66[26]
Inconel 600	2.00-2.91	5.70-8.30[26]
Inconel 625	1.63-1.73	4.65-4.94
Monel® 400	1.44-1.56	4.12-4.46[26]
Monel® K-500	1.37-1.64	3.91-4.68[26]
Inconel 718	1.10-1.19	3.13-3.37[27]
17-4 PH (H 900)	1.00-1.21	2.87-3.45[28]
304 Stainless steel	0.85-1.20	2.33-3.41[27]
Brass CDA 360	0.70-1.19	1.98-3.41[26]
17-4 PH (Cond. A)	0.61-1.05	1.75-2.99[28]
316 Stainless steel	0.53-0.86	1.50-2.50[26]
Aluminum 6061-T6	0.061	0.18[26]

Test Materials	P_v Product at Ignition	
	W/m² × 10^{-8}	lbf/in.² × ft/min × 10^{-6}
Ti-6Al-4V	0.0035	0.01[26]

For SI customary units, 1 lbf/in.² = 6.894 kPa, 1 ft/min = 0.3 m/min.

Note: The source of all unannotated data is previously unpublished frictional heating tests performed at NASA White Sands Test Facility.

*This material did not ignite at these P_v products.

Table F.3.2.8 Minimum Hot Plate Ignition Temperatures of Six Combustible Materials in Oxygen-Nitrogen Mixtures at Various Total Pressures

Material	Oxidant	Ignition Temperature (°C)			
		Total Pressure (atm)			
		1	2	3	4
Cotton sheeting	Air	465	440 (425)[a]	385	365
	42% O_2, 58% N_2	390	370	355	340
	100% O_2	360	345	340	325
Cotton sheeting, treated[b]	Air	575	520 (510)[a]	485 (350)[a]	370 (325)[a]
	42% O_2, 58% N_2	390 (350)[a]	335	315	295
	100% O_2	310	—	300	285
Conductive rubber sheeting	Air	480	395	370	375
	42% O_2, 58% N_2	430	365	350	350
	100% O_2	360	—	345	345
Paper drapes	Air	470	455	425	405
	42% O_2, 58% N_2	430	—	400	370
	100% O_2	410	—	365	340
Nomex® fabric	Air	>600	>600	>600	560
	42% O_2, 58% N_2	550	540	510	495
	100% O_2	520	505	490	470
Polyvinyl chloride sheet	Air	>600	—	495	490
	42% O_2, 58% N_2	575	—	370	350
	100% O_2	390	—	350	325

For SI customary units, 1 atm = 101.3 kPa.

For U.S. customary units, °F = (1.8 × °C) + 32.

[a] Values in parentheses indicate the temperature at which material glowed.

[b] Cotton sheeting treated with DuPont® X-12 fire retardant; amount of retardant equal to 12 percent of cotton specimen weight.

F.3.3.1

There is general agreement that nonmetallic materials are made more flammable by increasing the partial pressure of the oxygen in an air mixture rather than by increasing the total pressure of air. Thus, a mixture of 42 percent O_2 and 58 percent N_2 at 101.3 kPa (1 atm) pressure is more hazardous than a 21 percent oxygen normal air mixture compressed to 202.7 kPa (2 atm), although the same amount by weight of oxygen is present in both mixtures. It is also recognized that materials in 100 percent oxygen at 258 mm Hg (absolute pressure of 5 psi) are more flammable than those in normal air at 101.3 kPa (1 atm). Small increases in oxygen concentration at atmospheric pressure have a similar effect on the flammability of many materials, (35) as is shown in Table F.3.3.1. Only glass fiber materials, Teflon, and other fully fluorinated materials, of those tested, appear to be safe for use in OEAs. However, caution is necessary. Glass fabrics (and asbestos fabrics) frequently contain an organic sizing material that burns vigorously in OEAs. Thin films of Teflon, Kel-F®, and other fluorocarbons will also sustain combustion in OEAs, but thicker sections burn only if strongly heated from an external source.

Table F.3.3.1 Flame Resistance of Materials Held Vertically at One Atmosphere Pressure in O_2/N_2 Mixtures

NRL Sample Number	**Material**	**Combustion in O_2/N_2 Mixtures**		
		21% O_2	**31% O_2**	**41% O_2**
FM-1	Rosin-impregnated paper	Burned		
FM-3	Cotton terry cloth	Burned		
FM-28	Cotton cloth, white duck	Burned		
FM-4	Cotton terry cloth, roxel-treated	No	No	Burned
FM-5	Fleece-backed cotton cloth, roxel-treated	Surface only	Burned	Burned
FM-14	Cotton O.D. Sateen, roxel-treated	No	Burned	—
FM-15	Cotton green whipcord, roxel-treated	No	Burned	—
FM-16	Cotton white duck, roxel-treated	No	Burned	—
FM-17	Cotton King Kord, roxel-treated	No	Burned	—
FM-29	Cotton white duck, treated with 30% boric acid, 70% borax	No	Burned	Burned
FM-30	Cotton terry cloth, treated with 30% boric acid, 70% borax	No	Burned	Burned
FM-6	Fire-resistant cotton ticking	No	Burned	—
FM-7	Fire-resistant foam rubber	No	No	Burned
FM-9	Nomex temperature-resistant nylon	No	Burned	—
FM-10	Teflon fabric	No	No	No
FM-11	Teflon fabric	No	No	No
FM-12	Teflon fabric	No	No	No
FM-13	Teflon fabric	No	No	No
FM-19	Verel fabric	No	Burned	Burned
FM-22	Vinyl-backed fabric	No	Burned	Burned
FM-23	Omnicoated DuPont® high-temperature fabric	No	Burned[a]	Burned
FM-24	Omnicoated glass fabric	No	No	Burned[a]
FM-20	Glass fabric, fine weave	No	No	No
FM-21	Glass fabric, knit weave	No	No	No
FM-25	Glass fabric, coarse weave	No	No	No
FM-26	Glass fabric, coarse weave	No	No	No

NRL Sample Number	Material	Combustion in O_2/N_2 Mixtures		
		21% O_2	31% O_2	41% O_2
FM-27	Aluminized asbestos fabric	No	No	Burned
FM-32	Rubber from aviator oxygen mask	Burned	Burned	Burned
FM-33	Fluorolube grade 362	No	No	No[b]
FM-34	Belco no-flame grease	No	No	No[b]

[a] Burned only over igniter.
[b] White smoke only.

Table F.3.3.4 Effect of Oxygen on Flame Spread Rates over Various Materials (Edges Not Inhibited)

Material	Flame Spread Rate (mm/sec)	
	In Air	In 258 mm Hg Oxygen
Aluminized Mylar® tape	—	49.53
Aluminized vinyl tape	NI	78.74 ± 10.16
Asbestos insulating tape	NI	2.03
Butyl rubber	0.152	0.40 ± 0.04
Canvas duck	NP	6.35
Cellulose acetate	0.305	7.1
Chapstick	NI	46.23
Cotton shirt fabric	NP	38.1 ± 1.27
Electrical insulating resin	NI	6.86
Electrical terminal board	NI	1.524 ± 0.254
Fiberglass insulating tape	NI	106.68± 15.24
Foam cushion material	4.83	314.96
Foamed insulation	0.051	55.88 ± 5.08
Food packet, aluminized paper	NI	7.112 ± 1.27
Food packet, brown aluminum	NI	17.78 ± 7.62
Food packet, plastic	8.38	13.97

Material	Flame Spread Rate (mm/sec)	
	In Air	In 258 mm Hg Oxygen
Glass wool	NI	NI
Kel-F	NI	NI
Masking tape	4.32	46.228
Natural rubber	0.254	15.49
Neoprene rubber	NI	(8.13 ± 1.0)
Nylon 101	NI	(4.83 ± 1.27)
Paint, Capon, ivory	NI	9.652 ± 1.016
Paint, Pratt & Lambert, grey	NI	15.24 ± 5.08
Plexiglas®	0.127	(8.89 ± 0.25)
Polyethylene	0.356	(6.35 ± 1.27)
Polypropylene	0.254	(8.89 ± 0.25)
Polystyrene	0.813	(20.32± 5.08)
Polyvinyl chloride	NI	(2.54 ± 0.25)
Pump oil	NI	122.606
Refrigeration oil	NI	20.828± 1.778
Rubber tubing	0.76	6.096
Silicone grease	NI	23.368
Solder, rosin core	NI	4.572
Sponge, washing	1.78	205.74± 2.54
Teflon pipe-sealing tape	NI	NI
Teflon tubing	NI	NI
Tygon tubing	4.57	12.7 ± 1.27
Viton A®	NI	(0.076± 0.051)
Wire, Mil W76B, blue	NI	—

	Flame Spread Rate (mm/sec)	
Material	**In Air**	**In 258 mm Hg Oxygen**
Wire, Mil W76B, orange	NI	14.478± 1.27
Wire, Mil W76B, yellow	NI	—
Wire, Mil W16878, black	NI	NI
Wire, Mil W16878, green	NI	NI
Wire, Mil W16878, yellow	NI	NI
Wire, Mil 16878, white	NI	NI
Wire, misc., black, 3⁄16	NI	—
Wire, misc., brown, 7⁄32	NI	12.954± 1.27
Wire, misc., white, 3⁄32	NI	8.382
Wire, misc., yellow 7⁄64	NI	22.606
Wire, misc., yellow, 5⁄32	NI	10.414

For SI customary units 1 in./sec = 25.4 mm/sec, 1 atm = 760 mm Hg = 101.3 kPa.
NP: No sustained propagation of flame. NI: No ignition of material.

Table F.3.3.5 Typical Measured Burning Rates for Strips of Filter Paper at 45 Degree Angle (41)

			Burn Rate, cm/sec					
		atm abs	0.21 atm	0.53 atm	1.00 atm	4.03 atm	7.06 atm	10.09 atm
Total Pressure		ft of seawater	—	—	0 ft	100 ft	200 ft	300 ft
Gas Composition (dry basis)								
% O_2	% N_2[a]	% He						
99.6	0.4	0.0	2.32	3.13	4.19	[d]	[d]	[d]
50.3	49.7	0.0	1.13	1.44	2.36	3.72	5.10	6.34
			1.17			3.77	4.06	
20.95[b]	79.05	0.0	[c]	0.80	1.17	1.82	2.80	3.13
					1.17	1.78	2.28	3.25
					1.10			
49.5	0.0	50.5	1.24	1.87	2.96	4.06	4.90	[d]
				1.90	2.89		4.82	
					2.89			
20.3	0.0	79.7	[c]	[c]	[c]	2.23	2.61	2.49
47.0	24.6	28.4	[d]	[d]	2.74	3.66	4.41	5.53
					2.68		4.64	6.78

			Burn Rate, cm/sec					
Total Pressure		atm abs	0.21 atm	0.53 atm	1.00 atm	4.03 atm	7.06 atm	10.09 atm
		ft of seawater	—	—	0 ft	100 ft	200 ft	300 ft
Gas Composition (dry basis)								
% O_2	% N_2[a]	% He						
20.9	39.6	39.5	[d]	[d]	1.38	2.28	2.71	3.72
					1.38	2.28	2.83	3.13
					1.35	1.97	2.74	3.56
					1.27	2.28		3.33
						1.81		3.00
						1.72		

For SI customary units, 1 atm = 101.3 kPa, 1 ft = 0.3 m.

[a] Includes any argon that was present.
[b] Compressed air.
[c] Sample would not burn, even with brightly glowing igniter grid.
[d] No run was made under these conditions.

Table F.3.3.8 Oxygen Compatibility Data for Selected Materials (33, 46, 64–74)

Trade Name or Generic Material	Description	AIT (°C)	H of C (cal/grm)	OI (%)
	Plastics			
ACLAR 22 and 23	Chlorotrifluoroethylene (PCTFE)	349–390	See PCTFE	95–100
ABS	Acrylonitrile-butadiene-styrene	243	8500	18–39
Delrin, Acetal	Poly(acetyl)	178–195	4029	14.2–16.1
Halar®	Copolymer of ethylene and chlorotrifluoroethylene	171	3254–3900	52
Hypalon Sheet 0.60 in.	Chlorosulfonated polyethylene		6800	25.1
Kel-F 81	PCTFE plastic	388	2300	DNP
Kynar	Polyvinylidene fluoride (PVDF)	268	3277	39–43.7
Lexan	Polycarbonate	286	7407	27
Mylar	Polyethylene terephthalate	181	2300	22.7
Neoflon, M400H-amorphous	PCTFE plastic (Daikin Japan)	382	1220	DNP
Neoflon, M400H-crystalline	PCTFE plastic (Daikin Japan)	377	1230	DNP
Noryl	Polyphenylene oxide blended with polystyrene	348	6615	33.3
Nylon	Nylon 66, polyamide	178–259	7400–7900	23.5–30.5

Trade Name or Generic Material	Description	AIT (°C)	H of C (cal/grm)	OI (%)
PEEK	Polyetheretherketone	305–325	7775	35
Plexiglas	Poly(methyl methacrylate)	230	6000	17–18.5
Polycarbonate, generic	Polycarbonate, generic	300–340	7400–9400	22.5–27.4
Polyester	Polyester resin		4300	41.5
Polyethylene (PE)	Polyethylene plastic	176	11100	17.5
PPS	Polyphenylene sulfide	285	6853	43
PP	Polypropylene (PP)	174	11000	17–18
PS	Polystyrene, hard plastic	250	9900	17–23
PVC	Polyvinyl chloride	239	4300	42–65
PVDC	Polyvinylidene chloride		5000	60
Rulon A, E, J, LD	Filled TFE fluorocarbon	360–427	1400–2100	DNP
Teflon FEP	Fluorinated ethylene-propylene	378	2500	77
Teflon PFA	Perfluoroalkoxy tetrafluoroethylene	424	1250	100
Teflon TFE	Polytetrafluoroethylene	427+	1700	95–100
Tefzel	ETFE, copolymer of tetrafluoroethylene and ethylene	243	3538	30
Ultem	Polyetherimide	385	7026	47
Vespel SP21	Polyimide with 15% graphite	328–347	6002–6318	53–65
Zytel	Zytel, polyamide	259	7708	36
	Lubricants and Sealants			
PTFE pipe tape (clean)	TFE-fluorocarbon tape thread sealant	427+	See TFE	83–100
Bel-Ray FC1245	PCTFE oil/graphite		3709	DNP
Bel-Ray FC1260	PCTFE oil/graphite		1117	57
Braycote 667	Perfluoroalkyl polyether grease	427+		
Christo-Lube MCG111	Perfluoroalkyl polyether grease	470	1049	DNI
CYL-Seal	Thread sealant		3294	38
Everlube 6711	Colloidal graphite powder	363		
Everlube 811 (cured)	MoS_2 in sodium silicate	427+		
Fluorolube GR362	PCTFE/filler		4994	67
Fluorolube LG160	PCTFE	382	2516	
Fluorosilicone grease #822	FS grease			30
Fomblin RT15	Perfluoroalkyl polyether grease	427+	995	DNP
Fomblin Y25 oil	Perfluoroalkyl polyether oil	427+	706	DNI
Gore-Tex joint sealant	0.25- in. thick white			91

Trade Name or Generic Material	Description	AIT (°C)	H of C (cal/grm)	OI (%)
Halocarbon PCTFE oil	PCTFE oil (various grades)	385–410	1047–1994	75-DNP
Halocarbon PCTFE grease	PCTFE grease (various grades)	427+	1600–2366	67-DNP
Kel-F-1, 3, 10	PCTFE oil	374–385		
Key Abso-Lute	Thread sealant		5155	67
Krytox 240 AB	Perfluoroalkyl polyether grease	427+		
Krytox 240 AC	Perfluoroalkyl polyether grease	427+	900–1000	DNP
Krytox GPL 105	Perfluoroalkyl polyether grease			DNP
Krytox GPL 205	Perfluoroalkyl polyether grease			DNI
Krytox GPL 225	Perfluoroalkyl polyether grease			DNP
Loctite pipe sealant	Anaerobic sealant (cured)	170–260	4204–7600	17–20
Molykote 321	MoS_2 fluorocarbon spray	427+	2702	
Molykote Z powder	Pure MoS_2	260	1709	45
Nujol oil	Mineral HC		10930	
Poly(methyl phenylsiloxane)	Silicone grease, cup test			26 ± 1
Tribolube 13C	PFPE grease, cup test F			DNP
	Gaskets			
Blue Gard 3000	Garlock Co., Aramid /Buna N Gasket		3047	30.5 ± 0.5
Blue Gard® 3200, 3400, 3700	Garlock Co., Aramid/Buna N Gasket			31–53
Durabla gasket	Asbestos in GRS binder		1600	28.0 ± .5
Garlock 900 gasket	Asbestos/GRS		1676–1869	23
Gore-Tex	Expanded PTFE		1431	100
Grafoil GHE, GHR	Flexible graphite with SS tang metal interlayer	400+		
Gylon Fawn	Filled PTFE		1069	
Klingersil C4400	Nonasbestos gasket		1376	
	Elastomers			
Aflas	Copolymer of TFE and FKM	254–285	3600–4000	
Buna-N (nitrile rubber)	Butadiene-acrylonitrile	173–200	5400–9911	18
Butyl rubber	Copolymer of isobutylene and small quantities of isoprene	208	10789	17.1

Trade Name or Generic Material	Description	AIT (°C)	H of C (cal/grm)	OI (%)
Disogren (urethane rubber)	Polyurethane rubber	265–271		
EPR rubber (EPR/EPDM)	Ethylene-propylene rubber	153–206	8833–11287	21.9–25.5
Fluorel	FKM, copolymer of vinylidene fluoride and hexafluoropropylene	297–302	3400–3992	73.9–93.5
Hycar	Nitrile rubber copolymer	180–310	8500	
Hycar 1053	Nitrile rubber copolymer	310		
Hypalon rubber	Chlorosulfonated polyethylene	25–27	6800	
Kalrez	FPM elastomer, generic	355	1565–2089	DNP
Kalrez 1045	FPM elastomer		1565	DNP
Kalrez 4079	FPM elastomer		2090	DNP
Neoprene GRT	Polychloroprene	166		
Neoprene	Polychloroprene	258	6532	26.3
Neoprene	Diaphragm, nylon reinforced			29.5
Nitrile rubber, generic	Butadiene and acrylonitrile	173	9911	
Nordel (EPDM)	Ethylene propylene rubber		9220	25.5
Silicone rubber (RT 60)	Poly(methyl phenylsiloxane)		3289	28.5
Silicone rubber (RTV 102)	Poly(methyl phenylsiloxane)		4956	23
Silicone rubber, generic	Poly(methyl phenylsiloxane)	262	4156	27.9–39.2
Poly(methyl methacrylate)	Epichlorohydrin (ECO) rubber			18.5
Viton 77-545®	FKM, Fluorocarbon rubber			78
Viton A	FKM, Fluorocarbon rubber	268–322	3603	57–58
Viton B®, #V494-70	FKM, Fluorocarbon rubber		3089	DNP
Viton E-60C	FKM, Fluorocarbon rubber		3084	60.5
Viton® part #5103-32	FKM, Fluorocarbon rubber			68
	Composites			
Epoxy/aramid composite	Composite	217	6223	
Epoxy/fiberglass composite	Composite	258	2495	
Epoxy/graphite composite	Composite	258	7077	
	Other Materials			
Asbestos paper				DNI
Cerawool paper				DNI
Cotton	Cotton		4000	

Trade Name or Generic Material	Description	AIT (°C)	H of C (cal/grm)	OI (%)
Epoxy cement	Epibond 104	232		41
Fiberglass/cement board				DNI
Grafoil ribbon packing	Graphite	450+	7580	
Kaowool insulation	Alumina/silica fireclay		25	DNI
Nomex nylon	Cloth			27–30
Sindanyo CS51	Asbestos cement board			DNI
Transite	Asbestos cement board			DNI
Turnalite TI 150	Asbestos cement board			DNI

For SI customary units, 1 in. = 25.4 mm, 1 cal/grm = 453.6 cal/lb.

For U.S. customary units, ^{o}F = (1.8 × ^{O}C) + 32.

Note: Data for all tests are not available on some materials.

DNI: Did not ignite. DNP: Did not propagate.

F.4.2.2

Flammability limits can be determined under quiescent conditions by the partial pressure method or under flow conditions. The reaction vessel diameter should be at least 51 mm (2 in.) for determinations at 101.3 kPa (1 atm). Where wall effects are great (e.g., at reduced pressures), quenching distance data should be relied on to determine the suitable vessel size. Also, the ignition source should be of sufficient strength to ignite the test mixture.

F.4.4.7

The method applicable to building lining materials and considered to be standard in North America is ASTM E84, colloquially known as the Tunnel Test. The specimen under test is 7.62 m (25 ft) long and is ignited under controlled draft conditions by a gas flame enveloping the first 1.5 m to 1.8 m (5 ft to 6 ft) of the specimen. It would most likely be possible to supply a suitably constructed apparatus with a specified oxygen atmosphere at pressures of up to, for example, 304 kPa (3 atm). Specification of the igniting flame would still constitute a problem, however, because both flame dimensions and rate of gas supply could not be maintained invariant regardless of atmospheric constituency and pressure. No laboratory has yet attempted to investigate flame spread in nonstandard atmospheres using a modified ASTM E84 technique.

First Revision No. 1-NFPA 53-2019 [Chapter 2]

Chapter 2 Referenced Publications

2.1 General.

The documents or portions thereof listed in this chapter are referenced within this recommended practice and should be considered part of the recommendations of this document.

2.2 NFPA Publications.

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 51, *Standard for the Design and Installation of Oxygen–Fuel Gas Systems for Welding, Cutting, and Allied Processes,* ~~2013~~ 2018 edition.

NFPA 55, *Compressed Gases and Cryogenic Fluids Code,* ~~2013~~ 2020 edition.

NFPA 70®, National Electrical Code®, ~~2014~~ 2020 edition.

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems,* ~~2015~~ 2021 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and ~~Noncombustible~~ Particulate Solids,* ~~2015~~ 2020 edition.

NFPA 99, *Health Care Facilities Code,* ~~2015~~ 2021 edition.

NFPA 99B, *Standard for Hypobaric Facilities,* ~~2015~~ 2021 edition.

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment,* ~~2013~~ 2021 edition.

2.3 Other Publications.

2.3.1 API Publications.

American Petroleum Institute, 1220 L Street, NW, Washington, DC 20005-4070.

API STD. 620, *Design and Construction of Large, Welded, Low-Pressure Storage Tanks*, 2013, Addendum 2, 2018 .

2.3.2 ASME Publications.

American Society of Mechanical Engineers, ~~Three~~ Two Park Avenue, New York, NY 10016-5990.

ASME B31.3, *Process Piping,*~~2012~~ 2016 .

ASME B31.5, *Refrigeration Piping and Heat Transfer Components,*~~2013~~ 2016 .

ASME B31.8, *Gas Transmission and Distribution Piping Systems,*~~2012~~ 2016 .

ASME Boiler and Pressure Vessel Code,~~2013~~ 2017 .

2.3.3 CGA Publications.

Compressed Gas Association, 14501 George Carter Way, Suite 103, Chantilly, VA 20151~~-2923~~ .

CGA G-4, *Oxygen*, ~~2008~~ 2015 .

CGA P-1, *Safe Handling of Compressed Gases in Containers*, ~~2008~~ 2015 .

CGA S-1.1, *Pressure Relief Device Standards — Part 1 — Cylinders for Compressed Gases*, 2011.

CGA S-1.2, *Pressure Relief Device Standards — Part 2 — Cargo and Portable Tanks for Compressed Gases*, 2009.

CGA S-1.3, *Pressure Relief Device Standards — Part 3 — Stationary Storage Containers for Compressed Gases*, 2008.

2.3.4 U.S. Government Publications.

U.S. Government ~~Printing~~ Publishing Office, 732 North Capitol Street, NW, Washington, DC ~~20402~~ 20401-0001 .

Title 49, Code of Federal Regulations, Part 173.301, “General Requirements for Shipment of Compressed Gases in Cylinders and Spherical Pressure Vessels,” ~~2013~~ 2019 .

Title 49, Code of Federal Regulations, Part 173.302, “Charging of Cylinders with Non-Liquefied Compressed Gases,” ~~2013~~ 2019 .

Title 49, Code of Federal Regulations, Part 173.337, “Nitric Oxide,” ~~2013~~ 2019 .

Title 49, Code of Federal Regulations, Part 178.37, “Specification 3AA and 3AAX Seamless Steel Cylinders,” ~~2013~~ 2019 .

Title 49, Code of Federal Regulations, Part 178.45, “Specification 3T Seamless Steel Cylinders,” ~~2013~~ 2019 .

2.3.5 Other Publications.

Merriam-Webster’s Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

Phillips, B.R., “Resonance Tube Ignition of Metals,” Ph.D. Thesis, University of Toledo, Toledo, OH, 1975.

Pressure-Relieving Systems for Marine Cargo Bulk Liquid Containers, National Academy of Sciences, Washington, DC, 1973.

Schmidt, H. W.; and Forney, D. F. “ASRDI Oxygen Technology Survey, Volume IX: Oxygen Systems Engineering Review.” NASA SP 3090, NASA, Washington, DC, 1975.

2.4 References for Extracts in Recommendations Sections.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting,* ~~2013~~ 2018 edition.

NFPA 99, *Health Care Facilities Code,* 2018 edition.

NFPA 921, *Guide for Fire and Explosion Investigations,* ~~2014~~ 2017 edition.

Submitter Information Verification

Committee: OXY-AAA

Submittal Date: Wed Jan 30 10:46:17 EST 2019

Committee Statement

Committee Statement: Chapter 2 Referenced Publications were updated to the current technical references that are available.

Response Message: FR-1-NFPA 53-2019

Public Input No. 5-NFPA 53-2018 [Section No. 2.3]

First Revision No. 4-NFPA 53-2019 [Section No. 3.3.25]

3.3.25 Oxygen-Enriched Atmosphere (OEA).

~~An~~ For the purposes of this [recommended practice], an atmosphere in which the concentration of oxygen exceeds ~~21 percent~~ 23.5 percent by volume ~~or its partial pressure exceeds 21.3 kPa (160 torr)~~ . [**99,** 2018]

Submitter Information Verification

Committee: OXY-AAA

Submittal Date: Thu Feb 21 13:56:32 EST 2019

Committee Statement

Committee Statement: NFPA 99, section 3.3.129 definition of OEA does not match the definition in NFPA 53; this change would bring both standards to the same definition.

The committee is planning to develop Annex material at the second draft stage to clarify this definition.

Response Message: FR-4-NFPA 53-2019

Public Input No. 7-NFPA 53-2018 [Section No. 3.3.25]

Public Input No. 3-NFPA 53-2018 [Section No. 3.3.25]

First Revision No. 3-NFPA 53-2019 [Chapter G]

Annex G Informational References

G.1 Referenced Publications.

The documents or portions thereof listed in this annex are referenced within the informational sections of this recommended practice and are not part of the recommendations of this document unless also listed in Chapter 2 for other reasons.

G.1.1 NFPA Publications.

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 51, *Standard for the Design and Installation of Oxygen–Fuel Gas Systems for Welding, Cutting, and Allied Processes*, ~~2013~~ 2018 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, ~~2014~~ 2019 edition.

NFPA 55, *Compressed Gases and Cryogenic Fluids Code*, ~~2013~~ 2020 edition.

NFPA 99, *Standard for Health Care Facilities*, 2005 edition.

NFPA 99, *Standard for Health Care Facilities*, ~~2015~~ 2021 edition.

NFPA 410, *Standard on Aircraft Maintenance*, ~~2015~~ 2020 edition.

G.1.2 Other Publications.

G.1.2.1 ASTM Publications.

ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM D56, *Standard Test Method for Flash Point by Tag Closed Cup Tester*, ~~2010~~ 2016a .

ASTM D92, *Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester*, ~~2012~~ 2018 .

ASTM D568, *Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Flexible Plastics in a Vertical Position*, ~~1985~~ Withdrawn .

ASTM D1230, *Standard Test Method for Flammability of Apparel Textiles*, ~~2010~~ 2017 .

ASTM D1929, *Standard Test Method for Determining Ignition Temperature of Plastics*, ~~2010~~ 2016 .

ASTM D2863, *Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)*, ~~2013~~ 2017a .

ASTM D4809, *Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)*, ~~2013~~ 2018 .

ASTM D7194, *Standard Specification for Aerospace Parts Machined from Polychlorotrifluoroethylene (PCTFE)*, 2012.

ASTM D7211, *Standard Specification for Parts Machined from Polychlorotrifluoroethylene (PCTFE) and Intended for General Use*, 2013.

ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, ~~2013~~ 2018b .

ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, ~~2012~~ 2016a .

ASTM E162, *Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source*, ~~2013~~ 2016 .

ASTM E659, *Standard Test Method for Autoignition Temperature of Liquid Chemicals*, ~~2014~~ 2015 .

ASTM G63, *Standard Guide for Evaluating Nonmetallic Material for Oxygen Service*, ~~2007~~ 2015 .

ASTM G72/G72M , *Standard Test Method for Autogenous Ignition Temperature of Liquids and Solids in a High-Pressure Oxygen-Enriched Environment*, ~~2009~~ 2015 .

ASTM G88, *Standard Guide for Designing Systems for Oxygen Service*, 2013.

ASTM G93, *Standard Practice for Cleaning Methods and Cleanliness Levels for Material and Equipment Used in Oxygen-Enriched Environments*, 2003 (reapproved 2011) .

ASTM G94, *Standard Guide for Evaluating Metals for Oxygen Service*, 2005 (reapproved 2014) .

ASTM G125, *Standard Test Method for Measuring Liquid and Solid Material Fire Limits in Gaseous Oxidants*, ~~2008~~ 2015 .

ASTM G128/G128M , *Standard Guide for the Control of Hazards and Risks in Oxygen-Enriched Atmospheres*, ~~2008~~ 2015 .

Fire Hazards in Oxygen Systems.

G.1.2.2 CGA Publications.

Compressed Gas Association, 14501 George Carter Way, Chantilly, VA 20151-~~2923~~ .

CGA E-2, *Hose Line Check Valve Standards for Welding and Cutting*, 2004.

CGA G-4, *Oxygen*, ~~2009~~ 2015 .

CGA G-4.1, *Cleaning Equipment for Oxygen Service*, ~~2009~~ 2018 .

CGA G-4.4, *Industrial Practices for Gaseous Oxygen Transmission and Distribution Piping Systems*, 2012.

CGA P-14, *Accident Prevention in Oxygen-Rich and Oxygen-Deficient Atmospheres*, 1992.

CGA Video AV-8, "Characteristics and Safe Handling of Cryogenic Liquid Gaseous Oxygen."

G.1.2.3 EIGA Publications.

European Industrial Gases Association, Avenue des Arts 3-5, B-1210 Brussels, Belgium.

EIGA 33/~~06/E~~ 18 , *Cleaning of Equipment for Oxygen Service*.

EIGA 5/75/E, *Code of Practice for Supply Equipment and Pipeline Distributing Non-Flammable Gases and Vacuum Services for Medical Purposes*.

EIGA 6/77, *Oxygen Fuel Gas Cutting Machine Safety*.

EIGA 8/76/E, *Prevention of Accidents Arising from Enrichment or Deficiency of Oxygen in the Atmosphere*.

EIGA 12/80/E, *Pipelines Distributing Gases and Vacuum Services to Medical Laboratories*.

EIGA 10/~~09/E~~ 17 , *Reciprocating Compressors for Oxygen Service*.

EIGA 27/82/E, *Turbo Compressors for Oxygen Service, Code of Practice*.

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(Reserved)

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