AEROSPACE INFORMATION REPORT

AIR1133	REV. B

Issued 1969-10
Revised 1991-04
Reaffirmed 2012-10
Stabilized 2014-10

Superseding AIR1133A

Chemical Oxygen Supplies

RATIONALE

This document has been determined to contain basic and stable technology which is not dynamic in nature.

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FOREWORD

Generation of breathing oxygen from chemicals has been practiced since the 1930's. Two primary sources are used. The first is thermal decomposition of alkali metal chlorate slugs, called "chlorate candles" because they are solid grains that generate oxygen at a hot reaction zone that travels the length of the "candle". The second is alkali metal superoxides or peroxides that produce oxygen by reaction with moisture and remove carbon dioxide by reaction with the hydroxide produced in the first step.

Chlorate candles are compounded and shaped for desired oxygen production characteristics, and do not remove carbon dioxide. They are used primarily in submarine service and in aircraft, or as the oxygen supply in personal breathing equipment. When used in a closed cycle system, a method of carbon dioxide removal is required. Potassium superoxide is used in rebreathers, taking advantage of the control of oxygen generation by moisture from the breath to adjust to work rate of the wearer: carbon dioxide is absorbed after the moisture reaction step. The material is packaged for specific applications, taking into account chemical performance changes as the reactions progress with use time. Applications of superoxide include damage control, rescue operations, and closed habitat atmosphere control.

Chemical oxygen supplies are of interest because of storability and oxygen density of the chemicals. As emergency oxygen supplies, they require no storage inspection, do not lose oxygen on storage, and have long shelf life. Given sealed container storage, shelf life is basically unlimited; packaged units have been activated after 25 years and performed as designed. Potassium superoxide contains 34% by weight available oxygen: a cubic foot of chlorate candle will deliver 85% as much oxygen as a cubic foot of liquid oxygen. This document treats general information on both materials, but with emphasis on chlorate candles since they are used for emergency passenger oxygen supply in aircraft. Specific design information is not given; each application requires appropriate sizing, heat management, gas purification, compounding, etc.

1. SCOPE:

Solid chemical oxygen supplies of interest to aircraft operations are "chlorate candles" and potassium superoxide (KO_2). Chlorate candles are used in passenger oxygen supply units and other emergency oxygen systems, such as submarines and escape devices. Potassium superoxide is not used in aircraft operations but is used in closed-cycle breathing apparatus. Characteristics and applications of both are discussed, with emphasis on chlorate candles.

2. REFERENCES:

Air Revitalization Using Superoxides, Ames Research Center, NASA Technical Briefs, January 1988.

Kyriazi, N. and Shubilla, J. P., Performance Comparison of Oxygen Self Rescuers, RI 8876, Bureau of Mines Report of Investigation/1984, U.S. Department of Interior.

Mausteller, J. W., Oxygen Generation Systems, Kirk-Othmer Encyclopedia of Chemical Technology, V16, 3rd Ed., pg 673, John Wiley and Sons, 1982.

Mausteller, J. W., Review of Potassium Superoxide Characteristics and Applications. Presented at ASME Meeting, November 15, 1982.

Volnov, I. I., Peroxides, Superoxides and Ozonides of Alkali and Alkaline Earth Metals. Monographs in Inorganic Chemistry, Ed. by E. G. Rochow, Plenum Press, 1966.

3. CHLORATE CANDLES:

Candles are composed of sodium chlorate, a fuel, perhaps a material to remove contaminants and a binder as necessary. Iron is the fuel most commonly used, although cobalt and sodium monoxide have also been used. Once started, reaction is self-sustaining, the fuel being oxidized by oxygen from thermal decomposition of the chlorate, the heat from the oxidation then promoting more thermal decomposition. The overall reaction is generically shown in Equation 1:

$$NaClO_3 + Fe = NaCl + Fe_xO_y + O_2 + heat \quad \text{(Eq. 1)}$$

Iron concentration is 4-11% by weight. Sodium chlorate is 85% and up. Barium peroxide is sometimes used to remove chlorine or chlorine compounds, and is 1-3% of the total. Binders are most frequently glass fibers or fibrous iron, running 2-5%.

Reaction is initiated by a preformed "cone" or starting button, generally of the same ingredients as the body of the candle. The iron content is increased to perhaps 30% and is of high purity to assure ignition. Ignition is accomplished thermally, using a cartridge firing onto the cone, electric squib, fuse wire, or similar means.