

## **SECTION 5 MANUFACTURE AND DISTRIBUTION**

### **I. PERCHLORATE PRODUCTION**

The outstanding oxidizing ability of perchlorate led to its early use as a propellant and an explosive (Mendiratta et al. 1996). France, Germany, Switzerland, and the United States began production in the 1890s. Before the 1940s, annual global production of perchlorate was estimated to be 1,800 tons. In the middle 1940s, annual perchlorate production increased dramatically to 18,000 tons because of demand by Introduction the military and aerospace industry. Current production values are difficult to estimate because ammonium perchlorate is classified as a strategic compound.

A number of processes has been patented for the production of perchlorate. Commercial quantities of sodium perchlorate are usually prepared by electrolysis of aqueous solutions of sodium chloride, in which the chloride ion is successively oxidized through hypochlorite ( $\text{ClO}^-$ ), chlorite ( $\text{ClO}_2^-$ ), chlorate ( $\text{ClO}_3^-$ ), and finally to perchlorate ( $\text{ClO}_4^-$ ). Potassium perchlorate and ammonium perchlorate are produced in a second step by reacting sodium chlorate as a water solution with other chemicals to create concentrated solutions of either potassium perchlorate or ammonium perchlorate, depending on the added chemical(s). Perchlorate crystals are precipitated from the solution and are then dried to produce a homogeneous dry granular product.

In the United States, about 90 percent of the perchlorate production is ammonium perchlorate for use in solid rocket motors and to a very limited extent in pyrotechnic and explosive compositions. Sodium perchlorate is used as a precursor to potassium and ammonium perchlorate and is used in explosives. Potassium perchlorate is used extensively in flares, pyrotechnic compositions and in black-powder-substitute gun propellants. It is used in some spotting charges that enable range control personnel to assess the accuracy of inert (nonexplosive) rounds. Magnesium perchlorate is used for military batteries and as a drying agent.

### **II. PERCHLORATE MANUFACTURERS**

#### **Production History of Perchlorate**

On May 4, 1998, a fire and explosion destroyed the Pacific Engineering and Production Company (PEPCON) ammonium perchlorate manufacturing plant. Before this mishap, PEPCON and Kerr-McGee provided approximately 90 percent of the free world supply of ammonium perchlorate. Both plants were built in Henderson, Nevada, and had the combined capacity of producing 76 million

pound of ammonium perchlorate annually (40 million by PEPCON and 36 million by Kerr McGee).

Companies that produced perchlorate in large quantities, but are no longer in business include:

Western Electrochemical Company (WECCO) started perchlorate production in 1941 in Los Angeles. WECCO closed its Los Angeles plant in 1948. All its operations were transferred to Las Vegas, Nevada, in 1952.

Kerr-McGee Chemical Corporation was located in Henderson, Nevada. This plant began production of perchlorates for the United States Navy in May 1945 under operation of WECCO. In 1955, WECCO merged with American Potash and Chemical Company (AP & CC). Kerr-McGee acquired the AP & CC plant in 1967 and in 1997 announced the sale of its ammonium perchlorate business to American Pacific Corporation (AMPAC). The Henderson plant produced sodium perchlorate, potassium perchlorate, ammonium perchlorate and magnesium perchlorate.

PEPCON began sodium and ammonium perchlorate production in 1958 at its Henderson, Nevada, facility. PEPCON merged with AMPAC in 1982. The 1988 explosion closed the plant.

Hooker Chemical (now Oxychem) located in Niagara Falls, New York, began full scale production of military grade ammonium perchlorate in 1940 and continued until 1975. Since 1968, Hooker Chemical (known as Occidental Chemical Corporation) has been a subsidiary of Occidental Petroleum of Los Angeles, California. Other products produced were sodium perchlorate, potassium perchlorate, magnesium perchlorate, and perchloric acid.

Oldbury Electro-Chemical, Niagara Falls, New York, the processor of Hooker Chemical is believed to be the earliest producer of perchlorate in the United States began operations in 1910 until 1940.

HEF, Incorporated was operated as a joint venture plant in Columbus, Mississippi, by Hooker Chemical and Foote Mineral. HEF manufactured ammonium perchlorate and a very small amount of lithium perchlorate from 1959-1965. Eka Chemicals is an operating unit of Akzo Nobel and operates as Eka Nobel.

Pennsalt Chemicals (Pennwalt) located in Portland, Oregon, produced perchlorate from 1958 until 1965. Pennsalt has since merged with Elf Atochem North America in 1989.

### **Current Perchlorate Production**

The sole producer of perchlorate chemicals in North America is AMPAC in Cedar City, Utah. This facility which opened in 1989 produces ammonium perchlorate, sodium perchlorate, anhydrous sodium perchlorate, and potassium perchlorate. AMPAC also produces sodium azide, an airbag deployment chemical; and Halotron, an ozone-friendly fire suppressant; ChlorMaster system for use at sewage treatment plants.

Grade I ammonium perchlorate is supplied principally to NASA and to DOD. Alliant Techsystems (Alliant acquired Thiokol in 2001) accounts for nearly half of AMPAC's sales. Alliant Techsystems produces rocket motors for the Space Shuttle Program, Minuteman, Delta, Pegasus, and Titan. Aerojet General Corporation supplies motors for the Atlas family of commercial rockets. Ammonium perchlorate is also supplied for the production of the Patriot, Atlas, Navy Standard Missile, and Multiple Launch Rocket Systems programs. Since 1998, AMPAC acquired Kerr McGee and sales of ammonium perchlorate have ranged between 12.6 and 20.2 million pounds for the years 1998 to 2003. Suspension of the Shuttle program after the 2003 Columbia disaster reduced sales to 11.3 million pounds and sales are expected to range between 10.0 and 13.0 million pounds.

In addition to Grade I ammonium perchlorate, this facility also produces other grades of ammonium perchlorate and different types and grades of sodium and potassium perchlorates. The approximate percentages sold for specific end uses are 92% as an oxidizer, 7% as an explosive, and 1% for other uses.

Perchlorate chemicals are manufactured by electrochemical processes. The raw materials used in the manufacture of ammonium perchlorate are salt, sodium chlorate, graphite, ammonium, and hydrochloric acid. This facility has a capacity to produce 30 million pounds annually. France, Japan, China and Taiwan also produce Ammonium perchlorate but are not approved suppliers of Grade I ammonium perchlorate for NASA and DOD programs. (AMPAC 2004 10K Financial Report)

Most of the other perchlorate salts are manufactured outside the U.S. and are imported from China, Russia, and India.

### **III. PERCHLORATE-CONTAINING PRODUCT MANUFACTURERS**

G.F. Smith (GFS) Chemicals in Columbus, Ohio is the original manufacturer of perchlorates, starting production in 1928. GFS is a manufacturer of high purity/specialty chemicals for research, development and analysis. GFS provides analytical reagent grade quaternary ammonium salts and solutions and has been the primary supplier of anhydrous lithium perchlorate to the battery industry for decades. (gfschemicals.com)

The largest manufacturer of safety flares in the U.S. is Orion Safety Products/ Standard Fusee Corp. formerly Olin Safety Corp. Orion manufactures automotive and railway flares at plants in Easton, Maryland, and South Beloit, Illinois. Marine and wilderness survival products are manufactured at plants in Peru, Indiana, and Bristol, Pennsylvania.

Pyrotechnics and specialty fireworks are manufactured in California. The majority of consumer fireworks are imported from China and other countries.

Aerojet and Alliant manufacture solid rocket motors. Testing of rocket motors and missiles are done now mostly at military bases such as Edwards AFB, and China Lake.

### **Manufacturing of Explosives Containing Perchlorate Compounds**

Currently, most commercial explosives manufacturers making perchlorate-containing products purchase perchlorate from third party chemical manufacturers. Perchlorate containing compounds are sold as either a dry or a liquid product. During the manufacture of dry products, perchlorate crystals are precipitated from the solution and then dried and screened to produce a homogeneous granular product that is shipped in sacks and drums. In addition, sodium perchlorate, ammonium perchlorate and potassium perchlorate can be manufactured in liquid form as a concentrated water-based solution. These products generally are delivered via tanker truck. (IME 2005, White Paper)

Liquid perchlorate solution commonly is delivered in tankers and is stored in aboveground tanks equipped with secondary containment. Perchlorate in solid form may be delivered in "super-sacks" or bags and typically is stored on pallets within buildings constructed with concrete floors. Perchlorate may also be supplied in drums. Perchlorate containing materials, like all oxidizers, are stored separately from potential fuels such as wood, oil, grease, etc in structures that also provide isolation from the environment. Perchlorate salts and solutions are very corrosive to steel, and degrade fiberglass and concrete. Measures should be taken ensure that storage vessels, piping, and secondary containment are protected against corrosion. In addition, measures should be taken to minimize the generation of dust during pouring/transfer operations of perchlorate in the solid form; any accumulation of perchlorate dust should be promptly cleaned up.

### **Manufacturers of Sodium Chlorate**

During the electrochemical manufacture of chlorine products, such as chlorate, from chloride brine feedstocks, perchlorate may be formed as an impurity at concentrations of 50 to 500 mg/kg. The estimated North American annual chlorate manufacturing capacity is 2.4 million tons, whereas the total annual consumption of sodium chlorate in the U.S. is approximately 1.2 million tons. Many of the sodium chlorate producers in the United States include the same manufacturers that at one time produced perchlorate. See table below.

**U.S. Sodium Chlorate Producers**

ATOFINA, Portland , Ore. (idle)

Eka Chemicals, Columbus , Miss.

Eka Chemicals, Moses Lake , Wash.

FINNCHEM USA , Augusta , Ga.

FINNCHEM USA , Eastover , S.C.

Georgia Gulf , Plaquemine , La. (idle)

Kerr-McGee, Hamilton , Miss.

Nexen Chemicals, Taft , La. (idle)

Erco Worldwide, Valdosta , Ga.

Western Electrochemical, Cedar City , Utah

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