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ASBESTOS IN CIRCUIT BREAKERS AND ALTERNATE ARC CHUTE MATERIALS

By James E. Vachris, M.E.
Fabrication Specialty, Inc.

As man explored and experienced all the wonders of this great planet, asbestos was discovered. Here was a substance that wouldn't burn. It could be added to clays and cements. Like straw added to mud for additional strength, asbestos was found to add body, substance, and additional strength to many materials.

This was an acceptable additive, especially to rigid clays that were used with fire. Asbestos was ideal; a natural. The resulting material would inherently be heat resistant. These properties were evident when electricity was harnessed to become another servant of man.

As electric arcs began to burn away primitive electrical insulations such as wood, paper, shellac, oil soaked paper, casein hard rubber, and vulcanized fibre, asbestos containing materials soon became the most durable and practical insulating and arc resistant material. In addition to its noncombustibility, asbestos does not easily conduct heat or electricity. The above outstanding thermal and arc resistant properties coupled with the relative low cost as well as adequate availability of the material easily prompted asbestos to become widely used in power switch gear. This extensive use of asbestos in electrical apparatus began in the '20s and '30s and continued through the '70s (See Figure 1). All this expansion in the use of asbestos was without the general knowledge of the inherent hazardous circumstances.

Once manufactured in thin sections, this material quickly found acceptance in arc splitters within arc chute assemblies. When the arc plasma contacts this combination of materials, the cement could glaze and the asbestos would not be consumed until confined 1400°F was experienced or exceeded. Although the arc plasma is extremely high in temperature (estimated to be greater than 2200°F), its proximity to these materials through the duration of the arc was acceptable, enabling many cement board asbestos insulated switches to render prolonged acceptable service (See Figure 2).

Electric switch gear, circuit breakers, and other equipment manufacturing progressed rapidly after World War II. In 1964 Dr. Irving Selikoff started research into the effects of asbestos related occupational problems and the asbestos health hazard began surfacing.

Asbestos is a friable material. All three major types of natural mined asbestos: chrysotile, amosite, and crocidolite are friable. The National Emission Standards for Hazardous Air Pollutants (NESHAP) defines friability of an ACM, asbestos containing material, as that quality wherein hand pressure can crumble or pulverize the material. Most other countries regulate asbestos by mineral types, but, in the United States we treat them all the same. Approximately 95% of asbestos products have been produced using chrysotile. Because of friability they are all hazardous. When asbestos fibers are loose and dispersed they can become airborne, inhaled, or ingested and remain in the body, most commonly in the lungs. Asbestos fibers are also dangerous because they are so small and airborne capable. This makes them difficult to detect without instrumentation. Additionally, they break in length and width at the same time multiplying the hazard. The most dangerous fibers are 1 to 5 microns long. A micron is 1/25,000 inch.

Early in his study of 1,760 ship workers, Dr. Selikoff found that 80% had an asbestos related ailment. In addition, 40% of the immediate family members of these workers also had some asbestos related ailment (ARA). Asbestosis, a non cancerous but often fatal scaring of the lungs; mesothelioma, cancer of the lining of the lungs or abdominal cavity; pleural plaques, fluid between the chest cavity and the thickened lining of the lungs; and lung cancer, especially among cigarette smokers were the major problems.

In 1972 the Occupational Safety Health Act (OSHA) limited asbestos exposure without protection at 5 fibers/cubic centimeter. In 1973 the Environmental Protection Agency (EPA) banned asbestos in buildings for thermal and sound proofing insulation. By 1976 OSHA reduced asbestos exposure to 2 fibers/cubic centimeter; but, in 1986 it was further reduced to a Permissible Exposure Limit (PEL) of .2 fibers/cubic centimeter.

The wide spread use of Asbestos Containing Materials (ACMs) in fire-proof curtains, fire boxes of furnaces, floor tiles, ceiling tiles, plaster, brake linings, gaskets, pipe wrapping, as well as cement boards, put ACMs in many applications and locations. An ACM is defined as a material containing greater than 1% asbestos by area. The materials worked well in these uses. Unfortunately the major ARAs mentioned have a minimum dormancy of ten years. Asbestosis has a latency period of 15 to 30 years; Mesothelioma and Pleural Plaques, 20 to 40 years; and lung cancer varies from 10 to 30 years. Smoking while exposed to asbestos increases the risk of lung cancer by 90 times. It was these extended latency periods that delayed wide spread industrial awareness of the ACM hazards until the mid-Sixties.

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In order to protect workers in occupations where they are exposed to airborne concentrations of asbestos fibers, OSHA established regulation 29 CFR 1926.58. This U.S. Department of Labor ruling was published in the Federal Register on June 20, 1986. It set forth definitions, exposure limits, monitoring, compliance, protection, communications, housekeeping, medical surveillance, and record keeping. This regulation spells out an "Excursion Limit" (EL) of 1.0 fibers/cc for short-time exposure of 30 minutes; an "Action Level" (AL) of .1 fibers/cc requiring special medical surveillance along with proper employee training and the "Permissible Exposure Limit" (PEL) of .2 fibers/cc. For both the AL and PEL airborne concentrations of asbestos are measured over an eight hour time-weighted average (TWA) period.

Asbestos fiber airborne concentrations are measured using air samples taken through special filters examined using Transmission Electron Microscopy (TEM) or Phase Contract Microscopy (PCM). Using PCM, fiber count is possible. With TEM the fibers can be identified, one from another; asbestos type determined as well as fiber count down to .002 microns in diameter. Such microscopic analysis is expensive and must be conducted by EPA recognized labs. Hopefully most electrical testing and inspection work will be conducted where experienced airborne asbestos levels are considerably less than the excursion limit (EL) of 1.0 fibers/cc.

Therefore, in the field when checking out breakers a "half mask" respirator with High Efficiency Particulate Air (HEPA) filters should be worn. This should provide adequate protection if any burned out or loosened fibers should be blown towards the inspector while the apparatus is opened. During this time the protected worker can gently break off a small portion of the suspected worn out asbestos insulation and place it in a 6 mil polyethylene bag. A "critical seal" should be established by tape sealing the bag and placing it into another 6 mil poly bag and tape sealing the second bag. Additionally, the area from which the "bulk sample" was broken off should also be sealed with a suitable encapsulant. The encapsulant adhesive matrix creates a membrane over the disturbed broken surface or penetrates the material binding its components together reducing the friability of the ACM. Any repair of previously encapsulated asbestos containing materials may include filling damaged areas with suitable non-asbestos substitutes followed by re-encapsulating. The total time for any such exposure should not exceed 30 minutes. A "half face" air purifying respirator provides the minimal protection factor for the wearer.

The bulk sample in its "critical seal" can subsequently be analyzed in the laboratory using Polarized Light Microscopy (PLM). This will determine the type of asbestos and the percentage by volume, if asbestos is indeed present. If the breaker apparatus is subsequently shipped to your facility for repair, the same precautions are required. Additionally, a high efficiency HEPA-VAC vacuum should be used to remove any loose asbestos dust and fibers before working on the unit. Since there are specific EPA regulations concerning the disposal of what the HEPA-VAC collects and specific OSHA regulations concerning its handling, it is highly recommended that you contact your state Environmental Protection Agency for local guidance. Many states may not permit a "half mask" for certain excursion levels because the protection factor of that respirator is only 10. For gross removal of asbestos containing material a Supplied Air Respirator (SAR) or a Powered Air Purified Respirator (PAPR) may be required. If so , the wearer must be pre-trained after passing medical tests including chest x-ray, pulmonary, and a complete base line occupational physical. After being licensed by your state EPA, medical surveillance continues for that worker's term of employment plus 30 years. Additionally, the work must be performed in a restricted area, under constant negative air pressure with a CPR qualified asbestos licensed supervisor present -- all in accordance with applicable EPA and OSHA regulations.

It was for these reasons that Fabrication Specialty, Inc. (FSI) was established as a subsidiary of Franklin Fibre-Lamitex Corp. FSI has 6 licensed asbestos workers, including this author, with another man in training as this paper was being written. Because of this special facility and appropriately trained and licensed workers, we can properly remove and dispose of the ACMs in an arc chute assembly. Once removed, we can also replace the arc splitters (See Figure 3) and the chute assembly with several non-asbestos insulating materials (See Figure 4).

Mica is the nearest alternative to asbestos. Chemically, Phlogopite Mica $K_2\ Mg_2\ AL_2 \cdot Si_6\ O_{20}\ (OH)_4$ and Amber Mica $H_2\ KMg_3\ AL\ (SiO_4)_3$ contain potassium, aluminum, and magnesiasilica similar to asbestos Mg3 $Si_6\ (OH)_4\ O_8$ Hydrous Magnesium Silicate. Mica has potassium and aluminum added to a very similar chemical structure as asbestos, but unfortunately, does not have the high tensile strength of asbestos. It is readily available, but comes in thin small transparent sheets, the smaller sizes of which are usually ground into powder. A weak mica paper can be made from the mica grindings. Mica's better thermal conductivity and corona resistance is offset by its poorer processability. Thermal rating of mica composites may be limited by the binder systems employed to produce more usable sizes. Research and development is being done to enhance many mica containing materials. Franklin Fibre-Lamitex Corp. is producing Lamitex Grade #136 (See Figure 5) in many round and square tubular shapes from mica/epoxy. As a high pressure laminate, it has strengths close to NEMA G-7 Glass Silicone with arc, corona, and thermal resistance limited by the epoxy binder.

Other mica containing material that is used and considered for certain arc chute replacements is Insularc(TM) L-21 mica cement, for lower voltages and D.C. applications. Insularc(TM) XM glass bonded mica is considered for medium voltage (4.16 to 13.8 KV). Insularc(TM) XC mica bonded sheet is for high voltages. Mica melts at 1800°F to 2000°F and can expand in volume at 1000°F; cement vitrifies at 1500°F and glass bonded mica can expand in volume at 800°F to 900°F. The uses of any of these materials should be tested in actual usage. Machinable ceramics, porcelain type materials, and zirconia have been used in some of these applications. Mineral ceramic alumina talc and clay composites are under development and should withstand approximately 2300°F and higher voltages. Each design and proximity to the arc, as well as voltages, time, AC/DC, and types of contacts used, are variable factors making the specific use of these materials totally not guaranteed without full tests conducted in the appropriate apparatus under actual or closely simulated conditions.

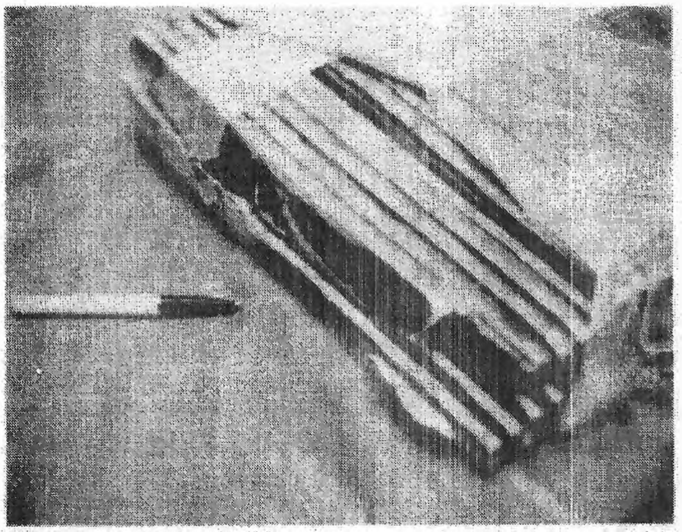

Figure 1

Early asbestos arc chute, many of which are still in use today.

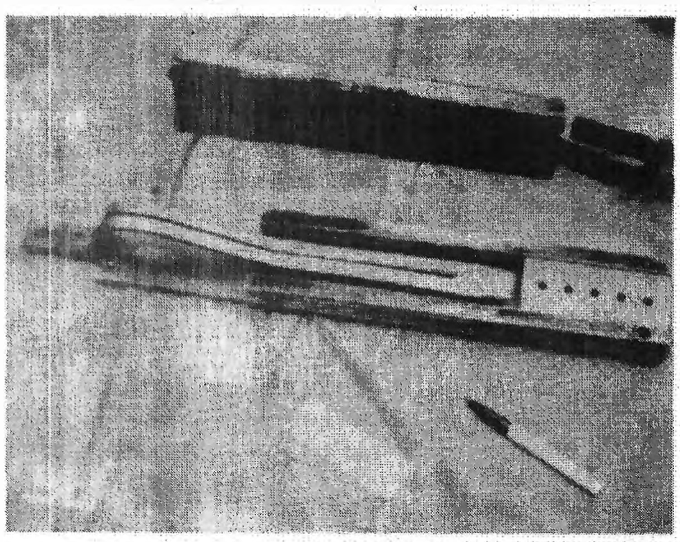

Figure 2

Asbestos cement board and asbestos cloth melamine arc runners.

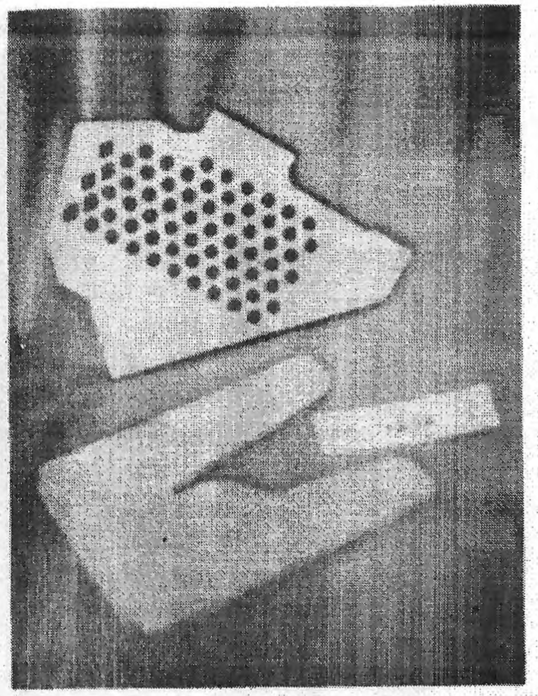

Figure 3

Non-asbestos Insularc(TM) mica cement arc splitters.

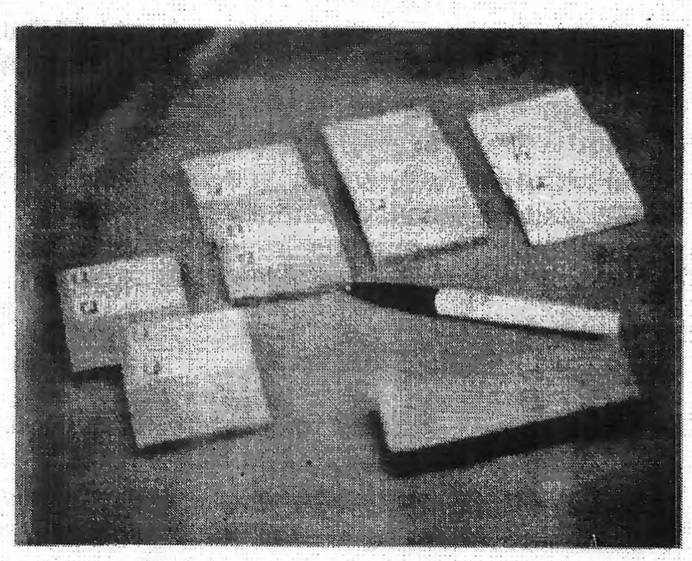

Figure 4

Insularc(TM) mica cement, mica glass, and other mica insulation.

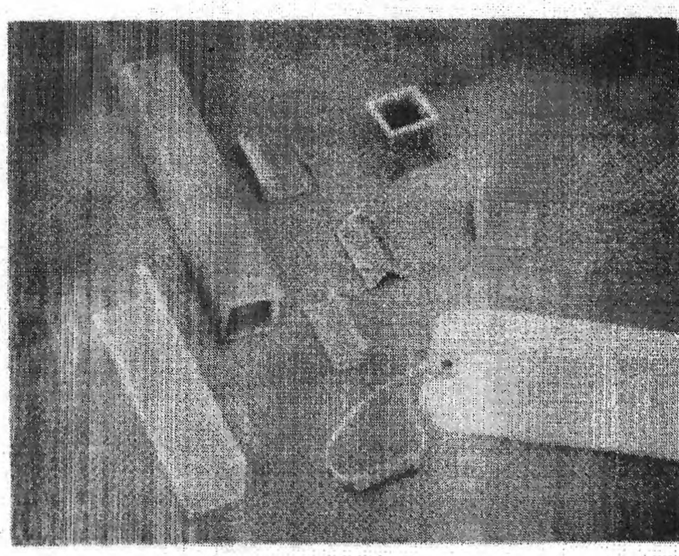

Figure 5

Lamitex(TM) #136 -- mica paper/epoxy high pressure laminated tubes and shapes.