July 12, 1989

MEMO TO: Distribution

FROM: Richard C. Davis RCD

SUBJECT: DEFENSE LOGISTICS AGENCY BERYLLIUM OXIDE HAZMAT PROGRAM

As you may know, the U.S. Defense Logistics Agency (DLA) is evaluating the use of alternative ceramic materials (aluminum nitride and boron nitride) as replacements for beryllium oxide in certain electronic components purchased by the Government. The DLA's evaluation has been prompted by their perception of environmental hazards associated with beryllia ceramics. This concern has been communicated to the marketplace on two separate occasions when DLA disseminated letters on the subject to 2,500 companies and government agencies.

To tell "our side of the story" regarding the safety of beryllia ceramics, Brush is mass-mailing a four-part letter series to the 2,500 recipients of the former DLA letters. Many of these recipients are customers of the Material Systems Division or her sister divisions. Although the focus of the letters is specific to beryllia ceramics, the basic issues discussed are relevant to the alloy and metal product lines as well.

With that thought in mind and also to keep you informed regarding beryllia-related health issues, I am sending you copies of the first two letters mailed by Brush. You may find the letters useful in responding to questions from employees or customers on this subject. If you wish to obtain additional copies please contact Jerry Nice at the Cleveland St. Clair office at 216/486-4200.

The remaining two letters will be sent to you as they are mailed out over the next four weeks. Please feel free to forward the letters to others in your organization.

RCD:lh

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BRUSH WELLMAN
ENGINEERED MATERIALS

Brush Wellman Inc.
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July 5, 1989

Dear Beryllia Ceramic User:

In our continuing effort to set the record straight about beryllium oxide ceramics ("beryllia"), its properties and its safety, we thought you might be interested in learning why beryllia can vastly improve the quality and performance of your electronic components. In that context, it is interesting to compare beryllia with other ceramic materials.

Beryllia's performance is unmatched by any presently available materials. Quite simply, no adequate substitutes exist for beryllia. Recently, you may have been advised to find other materials as substitutes for beryllia. But compared with proposed substitutes, aluminum nitride and boron nitride, beryllia is a vastly superior material.

Finished beryllia products purchased from Brush Wellman are completely safe as normally used in electronics devices. This fact has been proven by years of beryllia's continuing use in laser bores and electronic substrates for Microwave, RF and Power Packaging. On this basis alone, there is no need to seek alternative materials.

Let's take a moment and compare beryllia with aluminum nitride and boron nitride in terms of three factors: (1) thermal characteristics, (2) electrical resistance and (3) mechanical properties.

Thermal Characteristics

In electronics, the trend toward miniaturization has dramatically reduced the size of many devices. The result has been higher levels of heat generated in these devices...heat that must be removed. Beryllia's thermal conductivity is at least two times greater than aluminum nitride and five times greater than boron nitride. The actual amount of thermal conductivity depends upon the temperature at which measurements are taken, as Figure 1 illustrates. Its specific heat is also superior to its competition. The superior thermal conductivity of beryllia makes it the ideal material for use in heat-producing circuits carrying large amounts of current or having dense circuitry.

Electrical Characteristics

In addition to being a good heat sink, beryllia is also an excellent electrical insulator. Measured in terms of electrical properties, the dielectric constant and electrical resistivity of beryllia is superior to aluminum nitride. While boron nitride has a lower dielectric constant, its low thermal expansion coefficient and inability to be metallized make it unsuitable for joining with metal circuitry. Beryllia is an excellent insulator and particularly useful in microwave applications as well as in high-speed memory circuits.

Mechanical Properties

Beryllia is a hard material with very high strength, similar to aluminum nitride in this regard but vastly superior to boron nitride. Beryllia is easily metallized, which is vital for good contacts with components. Metallization of aluminum nitride is still under development.

In Conclusion - Nothing Beats Beryllia!

Beryllia is one of the most effective thermal conducting materials available, with time-tested reliability. So-called substitute materials such as aluminum nitride and boron nitride are not true substitutes at all. Besides their inferior characteristics, aluminum nitride and boron nitride have no long history of reliability, as does beryllia. Many aspects of aluminum nitride, such as commercial availability and metallizability still remain in the developmental stages. Boron nitride is a soft material of low strength that cannot be metallized at all.

Designing components with beryllia eliminates the need for cooling fans and external heat sinks. Circuitry connected to beryllia components can be made very dense and will operate reliably without air flow because of beryllia's superior thermal conductivity.

Designers must consider the thermal coefficient of expansion of materials joined to a heat sink. Incompatibility between metal parts and ceramic heat sinks could lead to mechanical failure. The thermal expansion coefficient of beryllia falls between metals and silicon, making it useful in a wide range of applications where compatible expansion is important.

For the demanding applications of the aerospace industry, modern electronics and defense applications, beryllia is the thermal-conducting and insulating material of choice. The ongoing miniaturization of electronics makes the promise for the material brighter than ever.

At Brush Wellman, our business is beryllium products -- from beryllium ores to the finished metal, alloy and ceramic products. Our scientists are authoritative sources of information on these extraordinary engineered materials. If we can be of any assistance to you in assuring that the full commercial benefits of our products are realized, we urge you to contact us.

Sincerely,

Brian Hill

Brian Hill, Ph.D.
Technical Marketing Manager

BH:lh

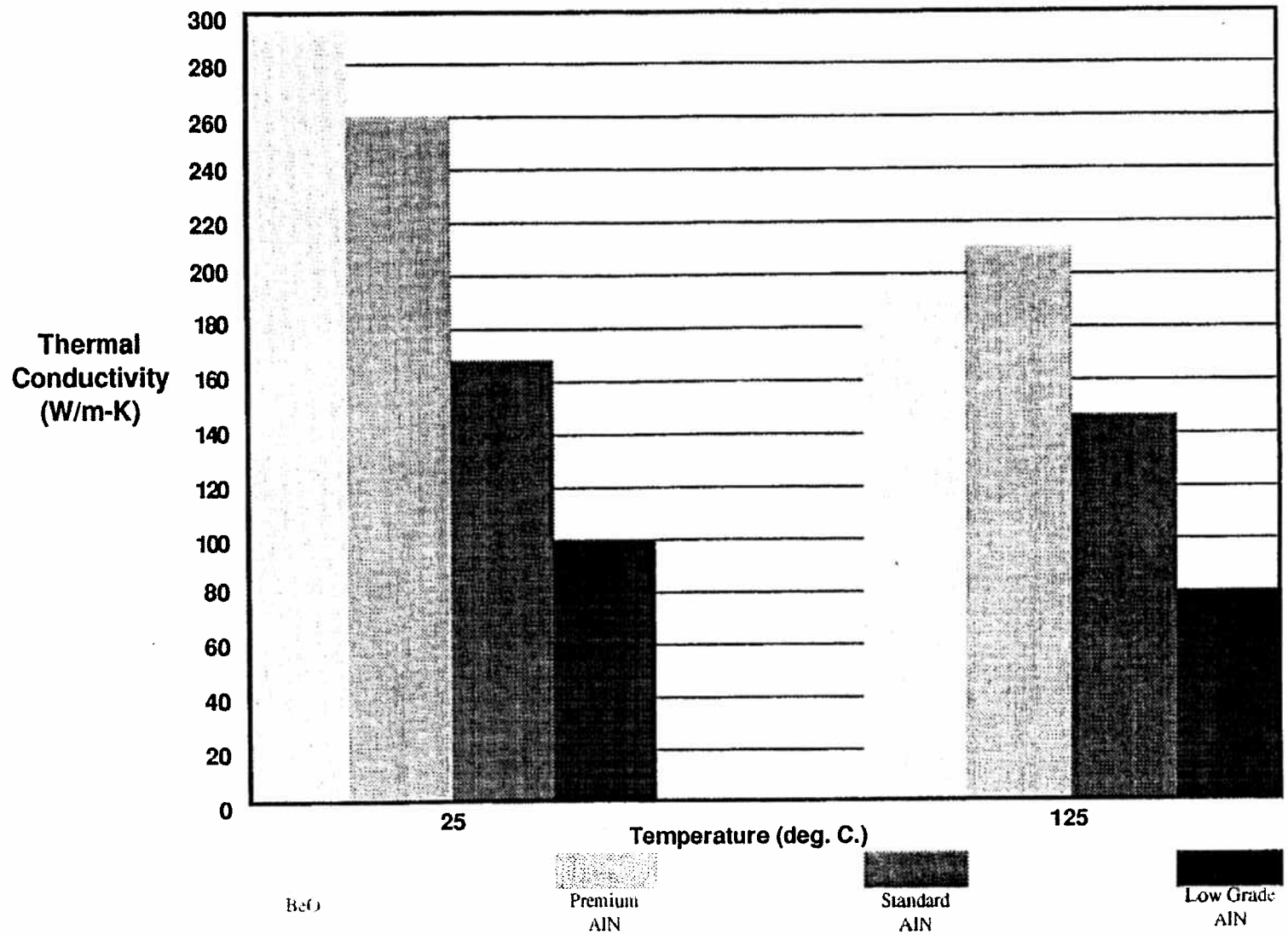
WM 051509

MK010281

FIGURE 1.

Comparative Thermal Conductivities

Beryllia & Aluminum Nitride



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BRUSHWELLMAN
ENGINEERED MATERIALS

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June 21, 1989

Dear Beryllia Ceramic User:

As the President and CEO of Brush Wellman Inc., I want to make sure that you - as a current or prospective manufacturer, user, designer or purchaser of electronic components - have all the pertinent facts about beryllium oxide ("beryllia") ceramics, especially concerning their unmatched performance and safety. Brush Wellman Inc. is a leading manufacturer of high performance engineered materials and the principal producer of beryllia ceramic, a unique material widely used in high-reliability electrical and electronic devices. In spite of our best efforts, there remains a good deal of misinformation on the safe use of beryllia. My purpose in writing this letter is to set the record straight.

FACT: There are No Substitutes for Beryllia Ceramics

Whether used as a heat sink or as part of a materials system package, there are no proven alternative ceramic materials capable of delivering the same high-quality performance as beryllia. In most electronic applications, beryllia ceramic is part of a materials system package consisting of metallizations, brazing materials and specialty alloys. Substitution for the beryllia would disrupt systems whose reliability and peerless performance have been time-tested. The use of beryllia ceramics has <u>not</u> been banned by any government agency and you should not risk degrading the quality and reliability of your products by experimenting with unproven substitutes.

FACT: Beryllia Ceramics Are Safe

Beryllia ceramics may be used with complete safety in any electronics application. A considerable body of scientific knowledge and years of real-world experience bear this out. In those few instances where airborne beryllium oxide dust is emitted during grinding, machining or similar manufacturing operations it is easily controlled by simple and inexpensive procedures. These procedures are of the same type used to control dust produced from other ceramic materials, such as aluminum nitride, silica and boron nitride. However, when the finished ceramic becomes part of an electronic component, no special safeguards are needed.

FACT: Workplace Safety Standards are Proven Effective

The safety standards for beryllia were established 40 years ago and they work. In fact, these standards were just reaffirmed by the U.S. Occupational Safety and Health Administration (OSHA) in January 1989. Among the 400 workplace substances presently regulated by OSHA, few have been as extensively studied or as successfully controlled as beryllia and other beryllium-containing materials.

FACT: Beryllia Ceramics Can Be Safely Disposed of or Recycled

Beryllia is not a hazardous waste under Federal law and may be safely disposed of in accordance with state and local laws. As an inert, insoluble material, beryllia ceramic scrap can be readily managed in an environmentally sound manner. More to the point, beryllia ceramic "wastes" are not wastes at all. In a clean, unmetallized form, they are a valuable, recyclable resource which Brush Wellman accepts for recycling. We at Brush are continuously looking for additional ways to recycle beryllia scrap produced by our customers.

FACT: There is No Valid Evidence That Beryllium Causes Cancer in Humans

There is no valid human evidence and only highly debatable animal evidence that beryllium is a human carcinogen. All existing medical and scientific evidence supports this view. While beryllium compounds have produced tumors in laboratory animal tests, the real questions remains, "What can be learned from over 40 years of human experience?" On this point, the U.S. EPA Carcinogen Assessment Group recently concluded that, "...the epidemiological evidence of beryllium carcinogenicity in beryllium-exposed workers is inadequate." Brush Wellman actively supports ongoing research on the cancer issue.

In future letters, we will provide additional information on each of the above issues. We hope that after reading these letters, you will forward them to others in your organization who are responsible for purchasing, engineering, manufacturing, safety and environmental affairs.

I am proud of Brush Wellman's active participation in the development of beryllia safety standards and of our safety record as a manufacturer and supplier of beryllia ceramics. We invite you to discuss any concerns you may have about the use of our products with your nearest Brush Wellman representative. I promise you will receive a prompt and courteous response.

Sincerely,

Raymond A. Foos

Raymond A. Foos
President and Chief Executive Officer

WM 051512

MK010284

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