DEPARTMENT OF TRANSPORTATION
UNUTED STATES COAST GUARD

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NAVIGATION AND VESSEL INSPECTION CIRCULAR NO. 2-79

Subj: Aluminum Bus Bars

1. PURPOSE. The purpose of this Circular is to distribute a "Guide for the Use of Aluminum Bus Bars in a Shipboard Installation," which provides guidance for the design and assembly of switch-boards, panelboards, and motor controllers utilizing aluminum bus bars. This Circular applies to vessels subject to salt atmospheres as well as vessels operating only in fresh water (Great Lakes, Western Rivers, etc). For vessels operating in fresh water only the corrosion aspect should have minimal effect, however, other problems discussed in the guide are relevant.

2. BACKGROUND. There has been an increase in the usage of aluminum as a bus bar material due to the relative economics of copper and aluminum. Both marine and shore industrial experience has shown that careful attention must be paid to materials, joint design, and quality control, if unsatisfactory and unsafe installations are to be avoided.

3. DISCUSSION. Enclosure (1) is a guide which will help to obtain a satisfactory installation if aluminum bus bars are utilized. The problems of corrosion, creep, and oxide buildup, as well as thermal properties differences between steel, copper, and aluminum are discussed. Design and assembly details are recommended which, if followed, should eliminate these problems.

4. ACTION. Recipients are urged to distribute the enclosed information and encourage the use of the recommended design and assembly details. It is anticipated that this guide will require modification as feedback is received as a result of its application. Comments and suggestions are welcome and additional guidance will be issued as necessary.

HENRY H. BELL
Chief, Office of Merchant Marine Safety

End: (1) Guide for the Use of Aluminum Bus Bars in a Shipboard Installation

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Guide for the Use of Aluminum Bus Bars in a Shipboard Installation

A. INTRODUCTION

1. The purpose of this guide is to amplify the regulations and standards for the design and installation of aluminum bus bars used in a shipboard installation. It is not intended to modify or in any way change the applicable regulations, but rather to supplement and clarify them.

2. Acceptability of bus bar materials is not specifically addressed in 46 CFR Parts 110-113, The Electrical Engineering Regulations. The switchboard requirements, 46 CIR 111.30-5, which refers to IEE Standard No. 45 for bus bar installations, indicates aluminum may be used in switchboards. The panelboard requirements contained in 46 CFR 111.40-1(d) indicate that all unspecified panelboard construction details shall conform with UL 67, Standard for Panel boards, which states that bus bars should be of a "metal suitable for the application." The marine supplement to this standard published by UL prohibits aluminum current carrying parts. The marine supplement to UL 508, Standard for Industrial Control Equipment, referenced by 46 111.70-20 requires aluminum current - carrying parts to be "suitably plated or coated to resist marine atmosphere containing salt." The UL marine supplements probably will be modified to permit aluminum bus bars provided the equipment, after being subjected to a salt spray, passes temperature rise test similar to section 14 of UL 67.

3. There is no consensus in the marine industry regarding the suitability of aluminum current carrying parts. Some operators have satisfactory experience while others have had severe problems requiring equipment replacement after a few months of operation. As noted below, three of the four problems discussed are applicable to fresh water ships.

B. PROBLEMS AND PROPERTIES ASSOCIATED WITH ALUMINUM BUS BARS

1. Corrosion - Aluminum in contact with certain other metals, such as steel, form a galvanic couple which causes severe corrosion in a marine atmosphere. Aluminum alloys containing copper are particularly subject to corrosion in a damp salt atmosphere even when not in contact with other metals.

2. Oxide coat - Most aluminum alloys form a hard inert oxide coat when a fresh surface is exposed to air. This layer of aluminum oxide, which is a high electrical resistance can create a hot spot at connection points.

3. Creep - Aluminum exhibits a phenomenon known as creep which is a plastic deformation that occurs at stresses below its yield strength. Periodic tightening of many types of aluminum connections is required to prevent connections becoming loose. If connections do become loose, the surface contact area is reduced permitting the oxide coat to form which in turn causes hot spots.

4. Thermal Properties

(a) The coefficient of linear expansion of aluminum alloys is considerably larger than that for steel or copper. Provisions must be made in the design to account for these different expansion rates.

(b) The thermal conductivity of aluminum while alloy dependent, is approximately half that of copper. Thus heat is not conducted away from a hot spot in aluminum as quickly as with copper.

C. GENERAL RECOMENDATIONS

1. It is recommended that aluminum bus bars not be used in panelboards and motor controllers.

2. The use of aluminum bus bars in switchboards, large switchboard type panelboards, and motor control centers is generally acceptable. The design and practices recommended in Part D of this guide should be considered.

3. Other applications will be acceptable if sufficient details and/or test results are submitted to clearly indicate that the problems noted above have been adequately resolved and that a level of safety equivalent to that attained through the use of other acceptable materials is achieved.

D. SPECIFIC RECOMENDATIONS

1. If aluminum bus bars are used, they and all current carrying parts should be made of alloy 6101 or other alloy with a maximum of 0.1 percent copper. The bus bars, including any copper bars should be silver, nickel or tin plated after all drilling has been completed. The bus bars should be plated at the manufacturer's facility and not in the field.

2. The connection of the copper cable or wire to the aluminum bus should be accomplished with a plated compression type terminal connector.

3. If an aluminum - bodied connector is used it should be packed with oxide-inhibitor paste. The fitting should be UL approved. A shrinkable sleeve should be utilized to seal the wire terminal connector interface.

4. A generous amount of joint compound should be applied to all joint surfaces before assembly to seal Out air and improve corrosion resistance. A bead of compound should appear all around the edges of the joint when the connection is tightened. Excess sealant squeezed out of the joint may be left as is or removed. A joint compound containing coarse grit should not be used on flat-bar connections.

5. A plated copper bar or plated copper terminal fitting may be connected to a plated aluminum bar. The connection should be made with a plated steel bolt in conjunction with plated Belleville spring washers and wide series plated steel washers. The Belleville washer should be assembled with the crown toward the nut or bolt head with the concave side bearing on the flat washer. The nut should be tightened until the Belleville washer is just flat.

6. An aluminum to aluminum connection may be made with either plated aluminum bolts or plated steel bolts. If steel bolts are used, the recommendations of paragraph 5 should be followed. If aluminum bolts are used, they should be made of a high strength aluminum alloy. The aluminum bolt, nut, and any washers should be made of an alloy containing 0.1 percent copper or less.

7. A plug-in type circuit breaker should not be directly connected to an aluminum bus. Circuit breakers or fused switches may be attached to the aluminum bus if a bolt or lug arrangement is used with joint preparation in accordance with paragraph 5. The plug-in type circuit breaker may be used for a copper bus feeder.

8. A plated bus bar surface should not be wire brushed prior to assembly.