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**Working Party on the Transport
of Dangerous Goods**

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DOUBLE SHELL ALUMINIUM VESSELS FOR CLASS 2 GASES

Subject: Large Vacuum Insulated Transport Equipment for Cryogenic Liquids
(Class 2, Gases Liquefied by refrigeration) : Minimum equivalent thickness
to ADR 21x 127 (3) and (4) (Impact safety level of tank shells)

Response to submission by German Government proposal document TRANS/WP.15/2000/10
dated 6 March 2000 and item 4 (a) of the sixty-eighth session
of the Inland Transport Committee,
Working Party on the Transport of Dangerous Goods

Transmitted by International Tank Container Association (ITCO)

Foreword

The proposal as currently presented to modify the cubic root formula in margins 21x 127 (3) and (4) of Annexes A and B of the ADR regulations is logical to the laws of mechanics i.e. taking into account properties of strength and elongation. The proposal however is structured in determining the necessary impact damage safety thickness of single skin shells which have high exposure to buckling / puncture during localised impact damage to the vessel wall.

Should the existing cube root formula be replaced by a more conservative determination of material impact strength, then significant appreciation of the unique construction of cryogenic equipment should be included in this revision. It is therefore proposed that the aggregate thickness of the outer vessel and inner vessel be considered in the revised text as recognition of the level of vessel protection and increased mechanical properties at low temperatures.

Justification

Aluminium is used extensively within the Air Gas industry as a material for bulk distribution equipment, with some 400 units operating in Europe alone. Equipment of this construction has been in operation since the 1960's in the United Kingdom, Europe and the United States of America. With a successful in-service history of this type of distribution equipment, it is deemed unnecessary to increase the minimum required material impact thickness beyond the existing requirements.

Mechanical Properties

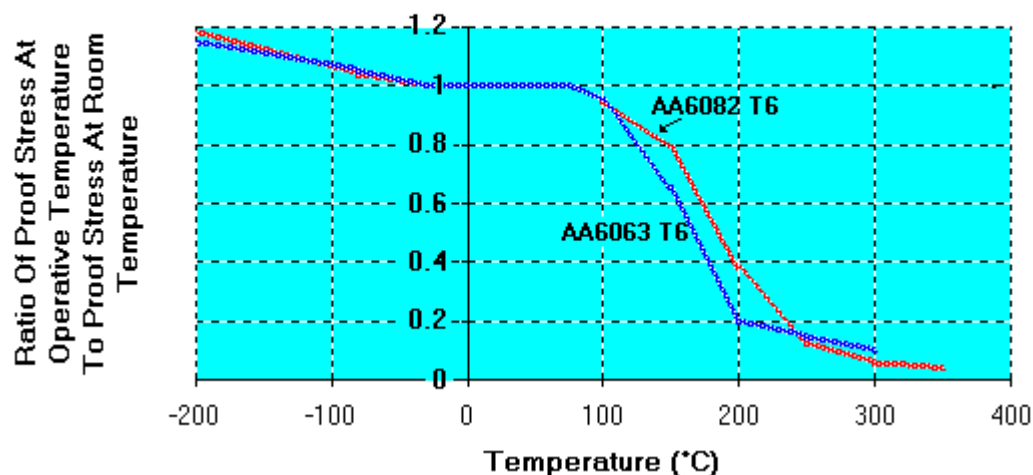
There are various factors evident in aluminium double shell equipment to substantiate the differences between the design approach to those taken to that of a petroleum vessel:-

- (a) In contrast to steel, aluminium alloys do not have low temperature brittleness. Aluminium alloys in fact increase their strength and maintain their ductility and toughness at very low temperatures.

As the temperature falls below 0°C the ultimate strength (R_m) and the yield strength ($R_{p0.2}$) increase slightly for all aluminium alloys ([see figure](#)). The elongation will for the non heat-treatable alloys increase while it will remain at nearly the same level as at room temperature for the heat-treatable alloys.

As can be seen from the diagram, the properties of materials can increase by some 20% under

Change Of Proof Stress With Temperature For Extrusions



operating conditions at low temperatures. The most widely used distribution equipment for refrigerated liquids operate in the regions of -180°C to -196°C which utilises much of these increased mechanical properties. Although these properties should not necessarily be considered in any pressure calculations, this unique improvement in proof stress is of significant contribution to impact loading on the vessel.

Cryogenic liquids and Outer Jacket shell protection

The term cryogenics is applied to all temperatures below -150°C, this being applicable to the majority of liquefied gases transported in IMO7 and IMO8 bulk distribution equipment. To maintain these liquids at such low temperatures it is necessary to insulate these pressure vessels with a degree of high thermal efficiency.

The majority of these vessels are insulated with a secondary outer jacket vessel, which is capable of holding one atmosphere vacuum pressure similar to that of a thermos flask. In the design of such outer jacket vessels it is the norm for these to be thicker in material construction to that of the inner vessel and in most cases providing a higher degree of impact protection than the inner vessel alone.

In the construction of vacuum vessels in aluminium, it should be noted that due to the young's modulus properties in design, a much thicker vessel capable of absorbing one atmosphere vacuum is often achieved to the equivalent thickness in stainless steel. As an example of this a 3.5mm stainless steel outer vessel would equate to 6mm in aluminium construction.

A typical standard design of low pressure vessel for bulk distribution would be of 6mm inner vessel and 6mm outer vessel in aluminium 5083 condition O, equating to an impact aggregate thickness of 12mm. The outer vessel offers the same impact protection to that of the inner vessel, in some cases this is greater with the inclusion of internal vacuum stiffener rings which offer substantial protection in impact conditions to the inner vessel.

It should also be noted that in the United States of America vessels are often constructed with thickness down to 4.5mm. This is for both the inner and outer vessels in aluminium with a good in service safety record. It is therefore proposed that the new amendment to the equivalent thickness formula is not applied to double wall shells for the carriage of deeply refrigerated Class 2 gases.
