

# **One Engineer's Experience In Controlling Residual Stress While Achieving Dimensional Stability In High Strength Aluminum Alloys**

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**March 2011**

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## Forward:

This article represents a thorough history of my 50 years experience in dealing with residual stresses in high strength aluminum alloys. A previous version of this article entitled “Controlling Residual Stress in High Strength Aluminum Alloys - One Engineers History, Approach and Opinions” was developed and distributed to many interested parties. That article was just a detailed chronological presentation of these events, with no graphics or data presented. That previous article can be viewed and or printed in pdf format by clicking on line (2) below; It was suggested by associates that the previous article be updated to include existing data and reference material so that it would provide greater meaning to the reader and could also be published in order to achieve wider distribution. That is the purpose of this current article which is presented in two formats. This website version of the article just contains a summary. The pdf version is a similar presentation, but contains a significant amount of background data and information and many tables and graphs. The entire current article can be viewed and/or printed in pdf format by clicking on the (1) link below.

Also, to those who are interested in the subject, I have prepared a follow up article entitled “Outlining a Systems Approach For Achieving Stress Free Parts in High Strength Aluminum Alloys” that outlines, in detail, the current process that we use to produce stress free parts. This article can be viewed and/or printed in pdf format by clicking on the link (3) below. Other similar reports on this subject and in aluminum heat treating in general can be found on my website at <http://www.Croucher.us>.

(1) Click **HERE** to View and/or Print Entire Current Article With Graphs and Charts in pdf format.

(2) Click **HERE** to View and/or Print the Basic Chronological Article Without the Graphs and Charts in pdf format.

(3) Click **HERE** to View and/or Print Entire “Systems Approach” Article in pdf format.

## Summary

**Residual Stresses that can cause problems with dimensional stability have been a constant problem in the aerospace industry for many years. This problem reached its peak in the 1960's and early 1970's. The results were: (1) premature failure of parts in service, including both stress corrosion cracking and early fatigue failures and (2) unwanted part movement - both in service and during final machining to meet required dimensional tolerances. The stress corrosion cracking problem was the most serious problem throughout the airframe industry. Planes had to be taken out of service with cracked parts, parts would crack while sitting on a shelf overnight and machining suppliers were faced with the constant problem of parts moving all over the place during machining operations. Unfortunately, the problem continues today as (1) the aerospace and aluminum industries push the envelope toward bigger aircraft requiring larger and larger high strength aluminum components and (2) extremely tight dimensional stability and tolerances are required in optical components such as space mirrors and telescope parts. This article summarizes my 50 years experience in combating these problems first as a senior lead metallurgist at a major aerospace prime, then later directing a commercial aluminum heat treating company whose primary mission was the production of distortion free parts, and finally, during an extensive consulting career, in assisting many who were faced with distortion problems in high strength aluminum alloys. Along the way, we developed a systems approach which, when applied correctly, has proven that any high strength aluminum alloy part can be produced with minimum residual stresses while at the same time achieving all the structural properties desired. To achieve these results, it is necessary to have a complete understanding of all the factors that can cause the distortion of an individual part. Then it is necessary to apply the appropriate available tools to assure low stresses in a final part. These include the principles such as cooling rate control using glycol quenching, stress relieving with both mechanical means and cryogenic (mainly uphill quenching) techniques, and proper control regarding the influence that machining can have on stress inducement. When this systems approach is correctly applied, any aluminum part can be produced meeting all the structural requirements but at the same time be dimensionally stable resulting from the absence of residual stress. As I near retirement, it is hoped**

that my experience may help those newcomers who are now starting to face the upcoming problems. The entire article which summarizes that experience and provides a technical synopsis of the problem can be viewed and/or printed in pdf format by clicking on the link below.

(1) Click **HERE** to View and/or Print This Entire Article in pdf format.

## **KEY WORDS**

**aluminum; heat treating; cryogenic; distortion; glycol; quenching; heat treatment; heat treating; liquid nitrogen; polyalkylene glycol; residual stress; solution treating; solution heat treating; stresses; stress relief; stress relieving; machining stresses, uphill quenching; warpage; water quenching; compression; dimensional stability; Ucon Quenchant;**