NASA TECH BRIEF
Lyndon B. Johnson Space Center

Holographic Nondestructive Testing of Laminates

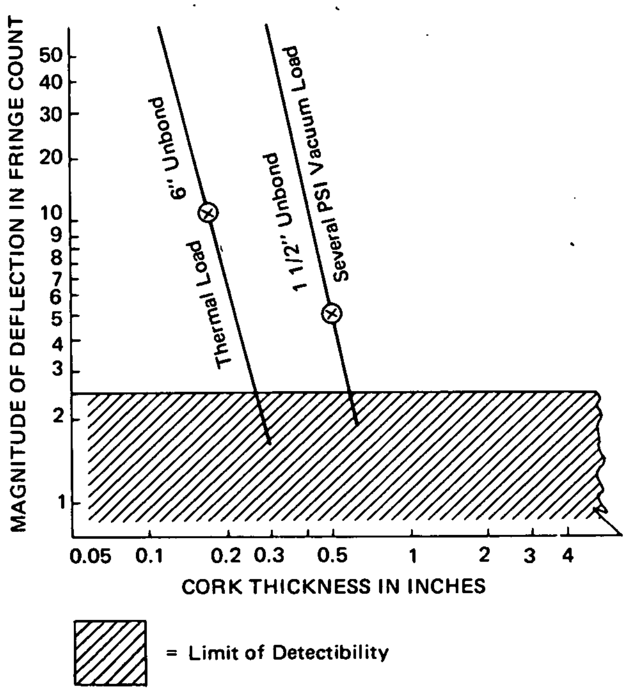

Figure 1. Log-Log Plot of Defect Indication and Cork Thickness for Holographic Nondestructive Testing of Bonded Cork

Holography, a form of laser beam photography, is a relatively new technique that is being increasingly used for quality control testing. For instance, laminated structures in which two pieces of like or unlike materials are bonded together by an adhesive can be checked for bond quality through holography. Even with a common laminate such as plywood it is difficult to discover the existence of unglued portions without tearing the structure apart. With laser beam photography, however, very small differences in the laminate thickness result in interference fringes in the holograph image. These indicate the presence of an unbonded area.

There has in the past been a major drawback to this technique. For each laminate tested, the method had to be "calibrated" by checking a large number of known defective laminates. A new method circumvents much of the needed pretesting by considering the unbonded area to be a sort of membrane. In this way, theoretical knowledge of membrane deflection may be used in conjunction with a much reduced number of pretest experiments to determine the number of optical fringes that should appear for a given laminate. This information can then be directly related to the characteristics of unbonded areas.

The method consists of fitting experimental data to the equation.

$$\log \Delta 1 = 4 \log d - 3 \log t + \log q = K \qquad (1)$$

where Δ is fringe displacement,
d is the diameter of the unbonded area,
t is the facing sheet thickness,
q is the loading factor, and
K is a constant.

It is first necessary to establish a relationship between deflection and laminate thickness for different sizes of unbonded areas and various types of loading. A simplified form of equation (1),

$$\log \Delta = -3 \log t + K' \qquad (2)$$

where K' is the intercept constant,

is used with test points to develop data for the system. Figure 1 was plotted from equation (2) and test points. It shows the observed deflection versus laminate thickness for a bonded cork system. In this experiment the holographic test equipment permitted resolution of the fringe count to 2 1/2 fringes. From the results of Figure 1, a graph as shown in Figure 2 can be used to find the minimal detectable bond-void in terms of laminate thickness. The lines are based on the following relationship.

$$\log \Delta 1 = -3 \log t + 4 \log d + k = \text{a constant} \qquad (3)$$

$$\text{or } \log d = 3/4 \log t + k'$$

where k and k' are intercept constants.

(continued overleaf)

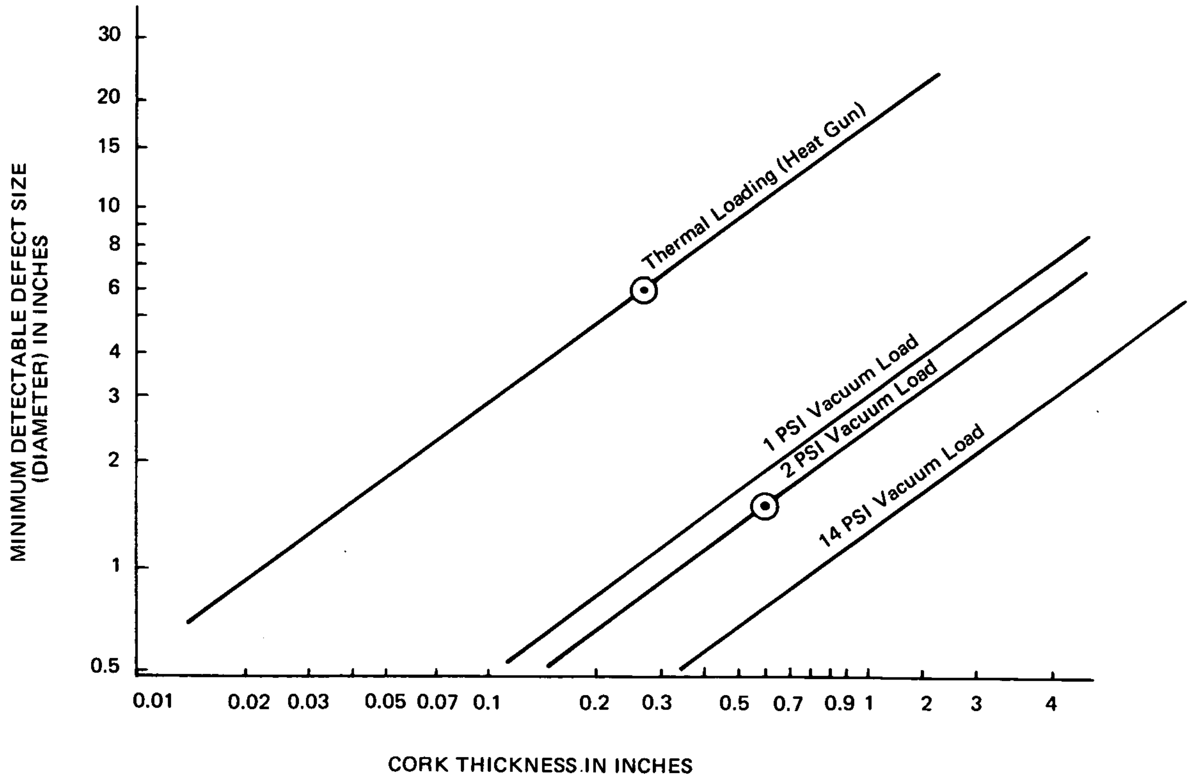

Figure 2. Log-Log Plot of Minimum Detectable Void Size versus Cork Thickness Based on Theory and Experimental Size

To show the effect of increased vacuum loading, another term must be included in equation (2) to give

$$\log d = 3/4 \log t - 1/4 \log q + K''$$

where q is the vacuum loading in psi and

K'' is the intercept value.

In Figure 2, experimental values of d, t, and q were used to find the value of K''. The calculated K' was then used to find the curves for 1 and 14 psi.

Notes:

1. This method can be applied to any adhesive bonded facing that has membrane characteristics over unbonded areas. It allows prediction of the applicability of holographic testing with a minimum of experimental effort.
2. No further information is available. Specific questions, however, may be directed to:

   Technology Utilization Officer
   Lyndon B. Johnson Space Center
   Code JM7
   Houston, Texas 77058
   Reference: TSP73-10108

Patent status:

NASA has decided not to apply for a patent.

Source: F. H. Stuckenberg of Rockwell International Corp. under contract to Johnson Space Center (MSC-19107)