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DEVELOPMENT OF ASSEMBLY TECHNIQUES FOR FIRE RESISTANT AIRCRAFT INTERIOR PANELS

FINAL REPORT - MAY 1978

PREPARED FOR
AMES RESEARCH CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

UNDER CONTRACT **NAS 2-9153**

HITCO
DEFENSE PRODUCTS DIVISION
GARDENA, CALIFORNIA 90249

NASA CR-152119

DEVELOPMENT OF ASSEMBLY TECHNIQUES FOR FIRE RESISTANT AIRCRAFT INTERIOR PANELS

Samuel C. S. Lee

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16. Abstract

Ten NASA Type A fire resistant aircraft interior panels were fabricated and tested to develop assembly techniques. These techniques were used in the construction of a full scale lavatory test structure for flame propagation testing. The Type A panel is of sandwich construction consisting of Nomex honeycomb filled with quinone dioxime foam, and bismaleimide/glass face sheets bonded to the core with polyimide film adhesive. The materials selected and the assembly techniques developed for the lavatory test structure were designed for obtaining maximum fire containment with minimum smoke and toxic emission.

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DEVELOPMENT OF ASSEMBLY TECHNIQUES FOR FIRE RESISTANT AIRCRAFT INTERIOR PANELS

Samuel C. S. Lee

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1.0 INTRODUCTION

This report finalizes the results of NASA Contract NAS 2-9153 for development of assembly techniques for NASA Type A fire resistant aircraft interior panels. The Type A panel is a sandwich construction consisting of a core of Nomex honeycomb filled with quinone dioxime foam, and bismaleimide/glass face sheets bonded to the core with a polyimide film adhesive. Initially a study phase of the program was conducted to establish fabrication procedures and to develop adhesives and potting compounds formulated especially for low flammability, low smoke generation and low toxic emission. In the second phase of the program, a series of ten panels using the materials and processes developed in the first phase were fabricated to investigate methods of assembly, including attach methods, installation and selection of inserts, bonding techniques, panel edge close-outs and corner joint designs, for maximum fire containment capability with minimum smoke and toxic characteristics. In the final phase of the program, a full size lavatory test structure utilizing the materials and techniques developed was constructed to a NASA/Ames design for flame propagation testing.

2.0 PROGRAM DEFINITION

The program was conducted in three phases. Following is a description of these phases, with the objective of each outlined.

2.1 Phase I. Material and Process Studies

Material and process studies were undertaken to tie down the variables in the processing of the components of the basic sandwich paneling, and to select or formulate materials to be used in the assembly of the paneling into structures. The basic paneling used on the program was a NASA/Ames defined composite sandwich designated as Type A, consisting of QDO (quinone dioxime) foam filled Nomex (polyaramid) honeycomb type HRH 10-1/8-1.8 with a single ply 1581 glass/Kerimid 601 bismaleimide precured face sheet bonded to each side of the core with .15 kg/m^2 (.03 lb/ft^2) FM 34 polyimide film adhesive. The target composite density of the basic sandwich was 2.4 kg/m^2 (.5 lb/ft^2) for 19 mm (.75 in) thick paneling. The sandwich construction is depicted graphically in Figure 1. The study phases of the program utilized the 19 mm (.75 in) thick sandwich. This thickness was later changed to 25.4 mm (1.00 in) for the full scale lavatory test structure.

2.1.1 Foamed Core Study

The procedure for foaming the honeycomb was specified by NASA/Ames. This portion of the material and process study was primarily conducted to adapt the foaming procedure to standard production equipment. The NASA specified procedure was originally carried out in a small press. Since the foaming was conducted at a low temperature with a reasonably slow rate of intumescence, and the press was utilized merely for restraint, the whole process was redesigned to be carried out in an oven where control of the exhaust gases was more convenient. Oven processing was considered preferable to press because of the relative availability of large ovens in most production facilities as compared to large presses.

A Hitco developed foam system was investigated as an alternative to the QDO system. This system consisted of a mechanically pressed-in-place foam as opposed to the QDO, which was chemically foamed-in-place, and offered potential cost and processing advantages.

2.1.2 Sandwich Bonding Study

This portion of the material and process study was undertaken to determine the adequacy of the selected configuration, i.e., precured face sheets secondarily bonded to the core with film adhesive. There was some concern that the use of a thin film adhesive, made necessary by the weight restrictions for the total sandwich, would not give a uniform bond due to the inherent unevenness of the foamed core, especially in very large panels. In addition, the selected process was an expensive one in terms of materials and labor. Great savings could be realized by using single stage layup and curing, where the face sheet material served as the adhesive as well. A number of alternate sandwich constructions were investigated, utilizing in addition to the Kerimid 601 bismaleimide resin, Skybond 703 polyimide and Narmco 9251 phenolic.

2.1.3 Potting Compound Study

The search for potting compounds suitable for use on this program was conducted by means of a survey of commercially available products as well as the formulation of special compounds at Hitco. These compounds were intended for two uses: the potting of metal inserts into the core, and as pack-in-place foam for edge close-out and corner joint reinforcement. They had to be low in density, cure at reasonably low temperatures, and exhibit low shrinkage during cure, low flammability as cured, low smoke generation and low toxic fume emission. As an insert potting compound, the material had to be of a consistency, or thinnable to a consistency to be used with standard Semco type guns.

2.2 Phase II. Panel Fabrication and Testing

This phase of the program involved fabrication of all the test panels required by the Statement of Work for NASA Contract NAS 2-9153 and testing as specified, with the objective of selecting the type of inserts, the type of potting compound, the method and material for edge close-outs and corner joint design, and establishment of preliminary design allowables for Type A panels.

2.2.1 Insert Study Panel Fabrication and Testing per Statement of Work Tasks 1, 2 and 5.

In this portion of Phase II, Panels 1, 2, 3 and 10 were fabricated, cut into test specimens, prepared for testing, and mechanically tested. Two types of inserts and three potting compounds were evaluated. Trim tag ends of each panel were used to determine mechanical properties of the basic Type A sandwich panel.

2.2.2 Edge Close-out and Corner Joint Development per Statement of Work Tasks 3, 4 and 5

In this portion of Phase II, basic sandwich paneling was prepared for Panels 14, 17, 18, 21, 22 and 25 and used to develop and demonstrate methods for edge close-out and corner joining. Mechanical testing was performed as required for evaluation.

2.3 Phase III. Fabrication of Lavatory Test Structure

In Phase III a full scale lavatory test structure per a NASA/Ames design was constructed utilizing the techniques and materials developed in Phases I and II of this program to meet the requirements of Statement of Work Tasks 6, 7, and 8. A preliminary process specification was prepared detailing the exact materials and procedures used, to satisfy the requirements of Statement of Work Task 9.

3.0 RESULTS AND DISCUSSION

3.1 Phase I. Material and Process Studies

3.1.1 Foamed Core Study

3.1.1.1 The study of foamed core was undertaken to optimize the process for foaming Nomex honeycomb with QDO, and to adapt the process to standard production equipment. To accomplish this goal, a series of 13 samples were produced, of which the last five were subsequently used as the core for program panels No. 1, 2, 3 and 10 of Statement of Work Task 2, and panels No. 14, 17, 18, 21, 22 and 25 of Statement of Work Task 4. The balance of the samples were used for bond studies, or scrapped if not of acceptable quality. Table I outlines the fabrication of the 13 samples.

3.1.1.2 As a result of the foamed core study, the process for producing the QDO foam filled Nomex core was finalized and used throughout the balance of the program. This process is shown in paragraph 3.4.2 of Hitco Process Document P-195044 which is attached to this report as Appendix I. It is essentially identical to that called out in the NASA/Ames specification, with the exception that the process is carried out in an oven rather than in a press.

3.1.1.3 Following are some observations on the foaming process:

a. QDO foam was of a soft spongy consistency and clung to the webs of the honeycomb. This necessitated a considerable amount of hand working to clean the core down to expose the edges of the webs in order to get good filleting of the adhesive during bonding.

b. The foaming process appeared to do little or no damage to the honeycomb, although there was some evidence that heat cycling of the sandwich structure at temperatures in excess of 455^{o}K (360^{o}F) did damage the core properties.

c. There were considerable variations in foam densities in samples prepared with the identical process. Note that in Table I, the range varied from 19 to 37 kg/m^3 (1.2 to 2.3 lb/ft^3), excluding samples No. F2, which had slightly different processing.

d. The foaming process developed a peak exotherm of 466^{o}K (379^{o}F) maximum.

3. The foam appeared to be hygroscopic. Weight gains of up to 12% of the foam weight were noted 24 hours after foaming.

3.1.1.4 "Toasted" ICU (isocyanurate) foam, a Hitco developed material, was investigated as a possible alternative to QDO. This foam offered the advantages of low cost, ease of processing, and less chance of damage to the honeycomb during heat cycling of the bonded composite sandwich. The precurser material was Upjohn's CPR 9545 foam, a trimerized isocyanurate foam with an average density of 35 kg/m^3 (2.2 lb/ft^3). CPR 9545 was a standard insulation material used in the construction industry and was readily available as rigid boardstock at nominal cost. Processing simply consisted of baking at 650°K (711°F) under restraint. The resultant char was a very friable foam with a density of approximately 22 kg/m^3 (1.4 lb/ft^3), which could easily be pressed onto the Nomex honeycomb. Because it did not cling to the walls of the honeycomb cells, preparation for bonding was greatly simplified. The foam appeared to be inert at the postcure temperatures of the composite sandwich. There were some drawbacks to the ICU system. Since the foam was extremely friable, a problem with an excess of airborn particles during handling and processing was encountered. In addition, when very large slabs of ICU foam were heat processed, a problem with cracking due to shrinkage was noted.

3.1.1.5 The heat resistance of both the QDO and ICU systems was checked and compared to that of bare Nomex honeycomb using Hitco's Insulated Hot Plate (similar to the ASTM Guarded Hot Plate) Test Method. Four panels were fabricated and tested. The tests showed that the QDO was a slightly better insulator than the ICU, though this was probably due to its higher density. As expected, all foam filled core panels showed greatly improved insulative properties over the bare core panel. The fabrication particulars and thermal conductivity results are shown in Table II. The temperature versus time data is plotted as Figure 2.

3.1.2 Sandwich Bonding Study

3.1.2.1 Sandwich bonding studies were conducted primarily to tie down the variables in processing Type A sandwich panels, which consisted of precured face sheets bonded to QDO filled Nomex honeycomb with FM 34 film adhesive. Among the variables evaluated were press versus oven curing, the use of a paste adhesive rolled onto the core to improve the bond, and the effects of postcure on the bond. A series of six panels were produced and tested to evaluate these variables. Flatwise tension was used as the screening property. The fabrication particulars and test results are shown in Table III. An analysis of the results show:

a. It was difficult to achieve a good bond with FM 34 film adhesive on the foamed core. Note that the majority of the failures were bond, rather than core failures.

b. Oven curing seemed to give equally good results as press curing.

c. BR 34 paste adhesive seemed to give better results than FM 34 film adhesive, however it should be noted that the BR 34 was very difficult to apply due to its heavy, sticky consistency.

d. Postcuring of the bare core sandwich panel (H3) seemed to have little effect on the bond, whereas postcuring of foam filled core sandwich panels seemed to deteriorate the bond.

e. More work should have been done in evaluating the Type A construction. The test results showed a great amount of inconsistency in the bond.

3.1.2.2 Single stage processing for Type A panels was evaluated as an alternative to the specified multi-stage construction. There were a number of reasons for investigating this alternative. Firstly, the Type A was a very expensive and labor intensive construction because it used precured face sheets. This added three steps to the manufacturing process; curing of the face sheets, postcuring of the face sheets, and preparation of the face sheets for bonding. In addition, the FM 34 film adhesive was extremely expensive, accounting for over 50% of the material costs for a Type A panel. Lastly, there were potential weight savings because with single stage processing, the resin in the prepreg face sheet material would also serve as the adhesive. This portion of the study was therefore designed to find a prepreg material with acceptable adhesive qualities that could be wet laminated to the foamed core, and that would not require postcure to develop its fire resistant qualities.

A series of nine panels were produced for this portion of the sandwich bonding study. The earlier panels utilized the Kerimid 601 bismaleimide resin prepreg either co-cured with FM 34 or with K601 resin rolled onto the core. Later, Skybond 703 (a Monsanto polyimide resin) prepreg and Narmco's 9251 phenolic prepreg were evaluated. As in the earlier study, flatwise tension was used as the screening property, but peel was added later because it seemed to be a more critical property. A summary of the fabrication and test results is presented as Table IV. Analysis of the table showed:

a. K601 prepreg, either co-cured with FM 34 or with K601 resin rolled onto the core, gave acceptable bonds, however, these panels were flammable as cured. Postcure after bonding at 472°K (390°F) deteriorated the bond approximately 30%, at 522°K (480°F) approximately 60%. Even so, these panels were the equal of the Type A construction evaluated earlier. The better bond of this series of panels was attributed to better filleting of the adhesive; use of a wet system resulted in greater resin flow during cure.

b. Skybond 703 polyimide prepregs were completely compatible with FM 34 adhesive and could be co-cured with it in a single stage process. This system was not flammable as cured.

c. Skybond 703 prepreg, together with 703 resin rolled onto the core, also produced good bonds although the resin by itself was somewhat brittle. While flatwise tensile strengths were satisfactory, the peel strengths were on the order of 40% lower that that of the 703/FM 34 combination. The same result would be expected for K601 resin.

d. Narmco's 9251 phenolic prepreg produced good results, giving satisfactory strengths in both flatwise tension and peel. The material was non-flammable as cured. The manufacturer also claimed low smoke generation and low toxic emission. The prepreg was priced at approximately 40% above epoxy prepregs currently in use for aircraft interiors, and approximately 50% below K601 or 703 prepregs.

3.1.2.3 A study of the use of vinyl acetates to modify Skybond 703 was undertaken in an attempt to improve the adhesive properties of that resin. Skybond 703 was selected for the study over K601 because it did not require postcure to attain its non-flammability as cured. The overall aim of the study was to produce a vinyl acetate modified 703 prepreg suitable for use as an adhesive type face sheet material for single stage processing of Type A panels. To achieve this goal, a series of seven panels were fabricated and tested. Two vinyl acetates were evaluated; Monsanto's Butvar B-72 polyvinyl butyral, and Formvar 15/95E polyvinyl formal, at proportions of 5, 10 and 15% by weight. In addition Cab-O-Sil Grade M-5, a fumed silica, was incorporated into the mixes to promote thixotropy. The results of the study are shown in Table V. A survey of the results showed:

a. The vinyl acetates were compatible with Skybond 703 resin and acted to increase the adhesive properties of that resin. Peel strengths on the order of 2.5 N·m/7.5 cm (22 lb-in/3 in) were readily obtainable. This represented an approximately 75% increase over the peel strengths observed in typical Type A panels utilizing FM 34 adhesive.

b. Polyvinyl butyral and polyvinyl formal appeared to improve the bond strength of the 703 polyimide resin to a comparable degree. The polyvinyl formal would therefore be preferred over the polyvinyl butyral because of its greater heat resistance.

c. Resins solids contents of greater than 60% in the prepregs were required to achieve consistent bonds.

d. Use of the A-1100 silane finished glass fabrics did not produce better results over the Volan A chrome finished glass fabrics, however, a difference may have shown up if testing had been done at high temperature.

e. A minimum cure of 8 hours at 450°K (351°F) was required to develop the full strength of the vinyl acetate modified polyimide resin.

f. The addition of vinyl acetates to the 703 polyimide resin in quantities greater than 10% seemed to render the resultant laminate slight flammable.

g. The flatwise tensile strengths of two of the panels (H22 and H23) were lower than expected, however, since all the failures were in the core, this may have been the result of a bad lot of honeycomb.

h. The effect of long term postcuring on the bond strength of the vinyl acetate modified polyimide has not been investigated.

i. All panels in the study utilized bare Nomex core because of the unavailability of QDO foamed honeycomb for this purpose at the time of the study. It is not believed that the QDO foam would inhibit the cure of the modified polyimide, nor would it lower its properties, but this remains to be verified.

3.1.3 Potting Compound Study

The study of potting compounds was conducted by means of a survey of commercially available products, as well as Hitco formulations. Two classes of compounds were sought; one for bonding metal inserts in honeycomb sandwich panels, and the other for pack-in-place foam for edge close-out and corner joint reinforcement of sandwich panels.

3.1.3.1 The survey of commercially available products was unfruitful. A number of manufacturers were contacted, among them Dalco, Furane, Hysol, Coast Pro-Seal, Crest and Emerson and Cumings. These manufacturers generally supplied a product to one of the aircraft company's specifications. Any flame retardent products they offered were epoxy syntactics with additives to impart the flame retardency, usually antimony trioxide, halogen/antimony oxide combinations or hydrated alumina. One specialty adhesive manufacturer, Aremco, offered a heat resistant modified novolac, Aremco-Cast 554, that was of some interest in that it had a heat distortion temperature of 573°K (572°F), a tensile strength of about 70,000 kPa (10,200 psi) and could be cured at low temperature with minimal shrinkage. The drawbacks of the material were its high density, approximately 1900 kg/m3 (118 lb/ft3), and its high cost, approximately $18/kg ($8/lb). American Cyanamid's BR 34 paste type polyimide adhesive was also considered, but it had the same objections to it as the Aremco material, namely high density and high cost. It also required a higher temperature cure.

3.1.3.2 In addition to contacting potting compound manufacturers, Rhodia, Monsanto and Dupont, the leading manufacturers of low temperature curing heat resistant resins were contacted with negative results.

3.1.3.3 During the Hitco formulated portion of the Potting Compound Study, nine mixes were tried; the first four were low temperature curing novolac syntactics, all of which proved to be extremely flammable after cure. Of the remaining five, two were Kerimid 601 syntactics, and three Skybond 703 syntactics. The nine formulations are shown in Table VI. Both the 601 and 703 resins were difficult to handle, requiring high temperature cures in the 450°K (351°F) range, and both had high solvent (NMP) contents. The 703 resin tended to skin upon cure and required the addition of a low boiling point solvent to minimize this tendency. With this additional solvent, a greater amount of filler had to be added to obtain a good working consistency. The 601 syntactic was flammable as cured and required a long postcure. Formulations 8 and 9 looked good from a handling standpoint and were screened for tensile pull-out strength. Fifteen 7.5 cm x 7.5 cm (3 in x 3 in) specimens were prepared from a typical Type A Panel (No. H17), and a NAS 1832-3-4 blind insert was potted in the center of each specimen; 5 specimens with a standard epoxy compound, Epocast 8675, 5 with formulation No. 8, and 5 with formulation No. 9. The results are presented in Table VII. As can be seen, the two Hitco formulations gave somewhat better results than the epoxy on average, however, they had a larger scatter in the individual values. Based on these results, formulations 8 and 9 were selected for use on the Phase II Insert Study Program.

3.2 Phase II. Panel Fabrication and Testing

3.2.1 Insert Study Panels

Four insert study panels were fabricated to meet the requirements of Statement of Work Tasks 1 and 2. The panels were identified as No. 1, 2, 3 and 10. Each panel was 48 cm (19 in) x 70 cm (28 in) in size. Panel 1 was for use in evaluating a standard epoxy insert potting compound to serve as the control, Panel 2 and 3 for evaluating the two selected Hitco formulated potting compounds (Formulations No. 8 and 9), while Panel 10 was a spare to be sent to NASA/Ames for their evaluation.

3.2.1.1 The insert study panels were fabricated as follows:

a. The precured face sheets were laminated per paragraph 3.4.1 of Hitco Process Document P-195044, which is attached to this report as Appendix I.

b. Core manufactured in the Phase I work was used for these panels; Sample F9 for Panel 1, F10 for Panel 2, F11 for Panel 3, and F12 for Panel 10.

c. The panels were bonded per paragraph 3.4.4 of HPD P-195044.

3.2.1.2 Panels No. 1, 2 and 3 were cut into test specimens per Figure 3. For Panel No. 10, only the peel and flatwise tensile specimens, and approximately 2 cm (.8 in) from each of the opposite edges, were cut. The remaining 35 cm x 60 cm (14 in x 24 in) panel was shipped to NASA/Ames.

3.2.1.3 The specimens cut from Panels 1, 2, 3 and 10 were prepared for test as follows:

a. Tensile Tear-Out Test Specimens

The tensile tear-out test specimens were 7.5 cm (3 in) square with a single insert installed in the center. Five specimens were prepared with NAS 1832-3-4 blind inserts, and five with NAS 1833-3-750 thru threaded inserts from each of Panels No. 1, 2, and 3 using Epocast 8675, a room temperature curing epoxy syntactic, for Panel 1, Formulation 8 (bismaleimide syntactic) for Panel 2, and Formulation 9 (polyimide syntactic) for Panel 3. The installation of the inserts using the two Hitco compounds was per paragraph 3.4.5.d of HPD P-195044.

b. Shear Tear-Out Test Specimens

The shear tear-out test specimens were 7.5 cm x 15 cm (3 in x 6 in) in size, with 2 inserts installed on centerline 7.5 cm (3 in) apart. Five specimens were prepared with NAS 1832-3-4 blind inserts, and five with NAS 1834-3-750 thru clear inserts from each of Panels 1, 2 and 3 using the potting compounds as specified in "a" above.

c. **Torque-Out Test Specimens**

The torque-out test specimens were identical in size, number, insert type and potting compounds as the tensile tear-out specimens.

d. Flatwise Tensile Test Specimens

The flatwise tensile test specimens were 5 cm x 5 cm (2 in x 2 in) in size and were prepared for testing per Mil-Std-401B.

e. Peel Test Specimens

The peel test specimens were 7.5 cm x 30.5 cm (3 in x 12 in) in size and were prepared for testing per Mil-Std-401B.

3.2.2 Testing of Insert Study Panels Test Specimens

The specimens prepared from the insert study test panels were mechanically tested to meet the requirements of Statement of Work Task 5.

3.2.2.1 Test Methods

The test methods used for the insert tests were basically those developed by the Shur-Lok Corporation, a leading manufacturer of aircraft type sandwich panel inserts, with the exception that the specimen sizes were reduced by approximately 25% to obtain a greater number of specimens from the limited amount of paneling available for testing.

a. Tensile Tear-Out Test Method

The specimen was supported on the top platform of a Tinius Olsen test machine with a 5 cm (2 in) outside diameter x 6 mm (.25 in) wall aluminum ring. A threaded pulling bar attached to the cross head of the test machine was screwed into the insert, which was centered with respect to the ring. Deflection was measured with a dial indicator. The specimen was loaded to failure with deflection readings taken every 110 N (25 lb) of load. Figure 4 is a photograph of a similar tensile tear-out test in progress. In that illustration, an alternative method of taking deflections is shown, i.e., the use of a deflectometer.

b. Shear Tear-Out Test Method

Two straps 7.5 cm (3 in) x 15 cm (6 in) x 3 mm (.12 in) thick were bolted to the test specimens with NAS 1303 bolts for the blind, and NAS 1203 bolts for the thru clear inserts. The straps were necked down to 2.5 cm (1 in) wide at the free ends. The assembly was mounted in a Tinius Olsen test machine using tensile jaws to engage the neck of the straps. A dial indicator was mounted by means of a clip to the lower bolt to monitor the relative movement between the two bolts. The specimen was loaded to failure, with deflection readings taken every 220 N (50 lb) of load. Figure 5 is a photograph of a similar shear tear-out test in progress. Deflections were not taken in the test illustrated.

c. Torque-out Test Method

The specimen was mounted in a vise and a NAS 1303 or NAS 6103 bolt was screwed into the insert. The bolt was then loaded to failure with an indicator type torque wrench. Two different types of bolts were used because more bolt failures than anticipated were experienced, and the NAS 1303 bolts were used up. Both bolts were shear types with 1.1 MPa (160,000 psi) heat treats, although the NAS 1303 bolt was alloy steel, while the NAS 6103 was titanium.

d. Flatwise Tensile Test Method

The test method used for flatwise tensile testing was that called out in Mil-Std-401B for sandwich structures. Figure 7 is a photograph of a flatwise tensile test in progress.

e. Peel Test Method

The test method used for peel testing was the climbing drum method called out in Mil-Std-401B. Figure 8 is a photograph of a peel test in progress.

3.2.2.2 Test Results

The individual results of the insert tests are presented in Tables VIII, IX, and X, while a summary of the results is presented in Table XI. Table XI is set up with Panel 1 as the control, and the Panel 2 and 3 results expressed both as individual average values and as a percent of control for ease of comparison. As expected the Panel 2 (bismaleimide syntactic) results compared very favorably with the epoxy control, however, the Panel 3 (polyimide syntactic) results were unexpectedly low, especially the shear tear-out "moduli" and the torque-out strengths, which were in the neighborhood of 17-35% of control. The only comparable property was the tensile tear-out strength for blind inserts, a property which unfortunately had been used as the screening criterium in evaluating potting compound formulations. It is believed that the low results experienced with the polyimide syntactic were directly related to its low density. This low density was not intentional; it was the result of the amount of solvent and glass bubbles necessary to render the resin cureable as a foam binder with a good working consistency.

Figure 9 is a photograph of the failed test specimens from Panels 1 and 2 arranged in the order they were cut. The failed test specimens from Panel 3 were shipped to NASA/Ames per contract requirements.

The results of the tag end testing for Panels 1, 2 and 3 are presented in Table XII. As can be seen in the table, while the flatwise tensile values were not generally out of line on average, the standard deviations were very large for Panels 1 and 2. It is believed that this amount of scatter was due to taking the specimens too close to the edge of the panels.

3.2.3 Edge Close-Out and Corner Joint Development

A single basic Type A composite sandwich panel was fabricated for the edge close-out and corner joint development work. This panel was prepared in identical fashion to Panels 1, 2, 3 and 10 of the insert study. Foam Sample F13 was used as the core, with a portion of that sample reserved for the wet laminated chamfered edge close-out designs.

3.2.3.1 Chamfered Edge Close-Out Panels No. 14 and 17

The design of the chamfered edge close-out, as incorporated into Panel 17, is shown in Figure 10. Because of the panel configuration, it was not practical to use the typical Type A construction with precured skins, therefore the panel was designed for a single stage layup with Kerimid 601 bismaleimide skins, doublers and filler plies co-cured with FM 34 adhesive and the QDO foam-filled core. The laminated panel was postcured for 48 hours at 472°K (390°F) in a circulating air oven. This postcure cycle was considered equivalent to the typical 16 hours at 522°K (480°F) by the resin manufacturer. Panel 14 was the trial panel, used to develop the laminating technique. Panel 17 was shipped to NASA/Ames to satisfy contract requirements.

3.2.3.2 Full Thickness Edge Close-Out Panels No. 18 and 21

Panels 18 and 21, cut from the basic sandwich panel described in 3.2.3 above, were used to investigate full thickness edge close-outs. Panel 18 was cut up into smaller samples to evaluate various ways of undercutting the core and for development of a suitable pack-in-place potting compound. The results of the studies were incorporated into a procedure as follows:

a. The core was routed away to a depth of 2 mm (.08 in) from the edge of the sandwich.

b. The following potting mix was prepared:

30 pbw Skybond 703 polyimide resin (70% solids)
20 pbw Acetone
18 pbw #731-1/32 milled glass fibers
17 pbw Type B40D glass bubbles

The 703 resin and acetone were thoroughly blended prior to addition of the fillers.

c. The foam was hand packed into the recess.

d. The panel was cured in a circulating air oven to the following cycle:

60 minutes at 320°K (117°F)
60 minutes at 340°K (153°F)
120 minutes at 360°K (189°F)
120 minutes at 450°K (351°F)

e. The as cured foam was slightly ballooned. It was ground flush to the face sheet edges.

The density of the edge potting foam prepared per the procedure was approximately 500 kg/m³ (31 lb/ft³). Panel 21 was prepared per the above procedure and shipped to NASA/Ames per the contract requirements.

3.2.3.3 Corner Joint Design Panels No. 22 and 25

Panels 22 and 25, which were cut from the basic Type A sandwich panel described in 3.2.3 above, were used to evaluate corner joint designs. From past work with L1011 interiors, it had been determined that the potted mitered corner was the most efficient corner design when no metal structural elements were used. Therefore this configuration was initially screened for use on this program. Five small joint samples were fabricated using the potted mitered corner joint with various inside supports; precured doublers, wet laminated doublers, and potting compound fillet. Three of the samples incorporated a joint between a piece of Panel 22 and a piece of Panel 25, while the remaining two were joints between pieces of a sandwich panel constructed identical to Panels 22 and 25 except that the core was not foamed. The potting compound used was mixed per the following formulation:

30 pbw Skybond 703 resin
20 pbw Acetone
20 pbw Type B35A glass bubbles
6 pbw #731-1/32 milled glass fibers

For samples incorporating Panels 22 and 25, the QDO foam was carefully dug out of the core prior to potting. The doublers, where used, were 2 plies of 1581/Skybond 703 prepreg, either precured or wet laminated. Precured doublers used Skybond 703 resin as the adhesive. All samples were cured for two hours at 455°K (360°F) under restraint. The cured samples were cut into specimens and tested. The specimen configurations and a summary of the test results are presented as Figure 11, while Figure 12 is a photograph of a test in progress.

A survey of the test results showed a considerable amount of scatter. The use of precured doublers seemed to have produced the best results, but those were still only on the order of 60% of typical L1011 epoxy state of the art panels. The results of the bare core joint specimens were unexpectedly lower than those for Panels 22/25, however, all of the failures in those specimens were core shear failures, thereby indicating possibly a bad batch of honeycomb. In view of these results, and the probable need for special tooling to produce the potted mitered corner joint in very large panels, it was decided to used an aluminum extrusion bolted joint for the lavatory test structure. This type of joint, while heavier than the potted mitered type, is inherently more reliable. It is used on a number of L1011 interior structures. Accordingly a sample from the balance of Panels 22 and 25 was prepared per Figure 13 and shipped to NASA/Ames to satisfy contract requirements. This specimen contained the typical inserts, potting and fasteners that would be used on the lavatory test structure.

3.3 Phase III. Fabrication of the Lavatory Test Structure

The lavatory test structure per Tasks 6, 7 and 8 of the Statement of Work was fabricated to an engineering sketch supplied by NASA/Ames, with concepts and materials developed in Phases I and II of the program adapted to the design. A preliminary process specification, Hitco Process Document P-195044 entitled "Fabrication of Lavatory Test Structure Utilizing NASA/Ames Type A Fire Resistant Aircraft Interior Paneling"was prepared per Task 9 of the Statement of Work, and is attached to this report as Appendix I. The process document outlines the exact materials and procedures actually used to fabricate the lavatory test structure.

3.3.1 During the fabrication of the lavatory test structure, a problem with the quality of the bond between the core and the precured face sheets was encountered. In several cases the bond was so poor that the face sheets delaminated completely upon further processing and/or handling after bonding. It was believed that this poor bond was due primarily to the unevenness of the foamed core. Because of the size of the paneling used in the lavatory test structure, irregularities in the surface of the core were more pronounced, and the use of such a thin adhesive film (.15 kg/m^2) (.03 lb/ft^2), made necessary to keep the total sandwich density within the drawing requirements, did not give enough body to take up the differences. This problem was accentuated by our use of a caul plate during sandwich bonding. The caul plate was thought to be desirable to keep the inner (bag side) face sheet smooth and flat, but in retrospect, it probably served to keep the face sheet and adhesive from making intimate contact with the core webs in areas where the core surface was uneven. To help alleviate this problem, a thicker adhesive film could have been used, or possibly the core could have been rolled with BR 34 paste adhesive prior to bonding. The latter procedure would have been difficult because of the loose nature of the foam. The rollering of such a heavy, sticky material as BR 34 would have caused bits of foam to deposit on top of the honeycomb webs, causing a very difficult cleanup problem. The use of a thicker film of FM 34 would have put the basic sandwich weight over that required by the engineering drawing.

3.3.2 The Nomex honeycomb used to fabricated the large paneling for the lavatory test structure was not available in a size large enough to produce splice free cores. Each of the sidewall panels and the ceiling panel had one splice in the core. Following are the measured densities for the panel elements:

Panel	Core Fab	Surface Density - kg/m^2 (lb/ft^2) Bare Core	Foamed Core	Est. Sandwich*
Side Wall 1	Piece 1	.815(.167)	1.66(.340)	3.17(.65)
	Piece 2	.835(.171)	1.66(.341)	
Side Wall 2	Piece 1	.879(.180)	1.73(.355)	3.22(.66)
	Piece 2	.879(.180)	1.72(.353)	
Ceiling	Piece 1	.718(.147)	1.53(.314)	3.08(.63)
	Piece 2	.708(.145)	1.54(.315)	
Ceiling Extension	Piece 1	.737(.151)	1.63(.333)	3.12(.64)

*Note: In estimating the sandwich density, the following were used:

1.32 kg/m^2 (.27 lb/ft^2) for the face sheets
.15 kg/m^2 (.03 lb/ft^2) for the adhesive film
.05 kg/m^2 (.01 lb/ft^2) for the joint adhesive

It was not possible to directly measure the basic sandwich surface density because single stage layup and cure together with the precured edging was used.

3.3.3 A standard extruded aluminum corner trim piece sized to fit the lavatory test structure paneling could not be found, therefore, a design was made based on extrusions for thinner paneling, and a custom extrusion ordered. Figure 14 is a copy of the supplier's drawing for this extrusion.

3.3.4 The completed lavatory test structure was shipped to NASA/Ames on November 22, 1977. Figure 15 is a photograph of the completed structure.

4.0 CONCLUSIONS AND RECOMMENDATIONS

This program has demonstrated the feasibility of fabricating large aircraft interior structures utilizing NASA/Ames Type A sandwich paneling for maximum fire containment capability with minimum smoke generation and toxic fume emission. While many problems exist for adapting the processes to production, the basic concepts were shown to be sound. Probably the greatest stumbling block to adoption of this type of construction by the aircraft industry is the cost factor. In 1977 the materials alone for producing Type A paneling were on the order of 20 times the cost for materials used on standard aircraft interior paneling, while factoring in labor costs would at least double that figure. It is recommended that the Type A configuration be altered somewhat to allow the use of a single stage process using either a modified phenolic or polyimide face sheet material which would serve also as the adhesive material, much like the epoxies in current use. This single change could halve the material costs, with an attendant savings in labor due to the single stage processing, which eliminates 3 production steps. Even with the severe cost penalties, the Type A construction should be considered for critical locations in passenger aircraft cabins for humanitarian reasons.

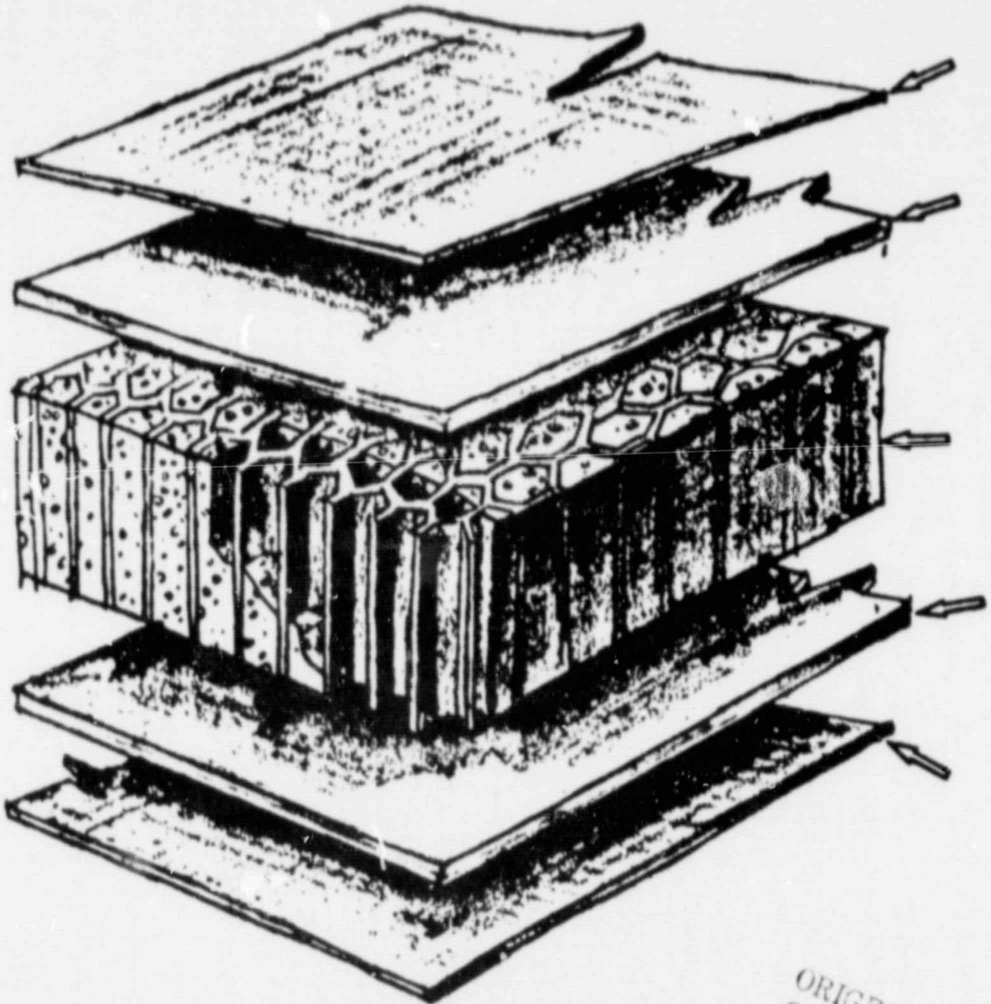

FIGURE 1

NASA TYPE A FIRE RESISTANT AIRCRAFT INTERIOR PANEL CONSTRUCTION

FIGURE 2 SIMULATED HEAT RESISTANCE TEST RESULTS - COMPOSITE SANDWICHES USING 19 MM (.75 INCH) NOMEX HONEYCOMB CORE WITH QDO FOAM, ICU FOAM, AND NO FOAM

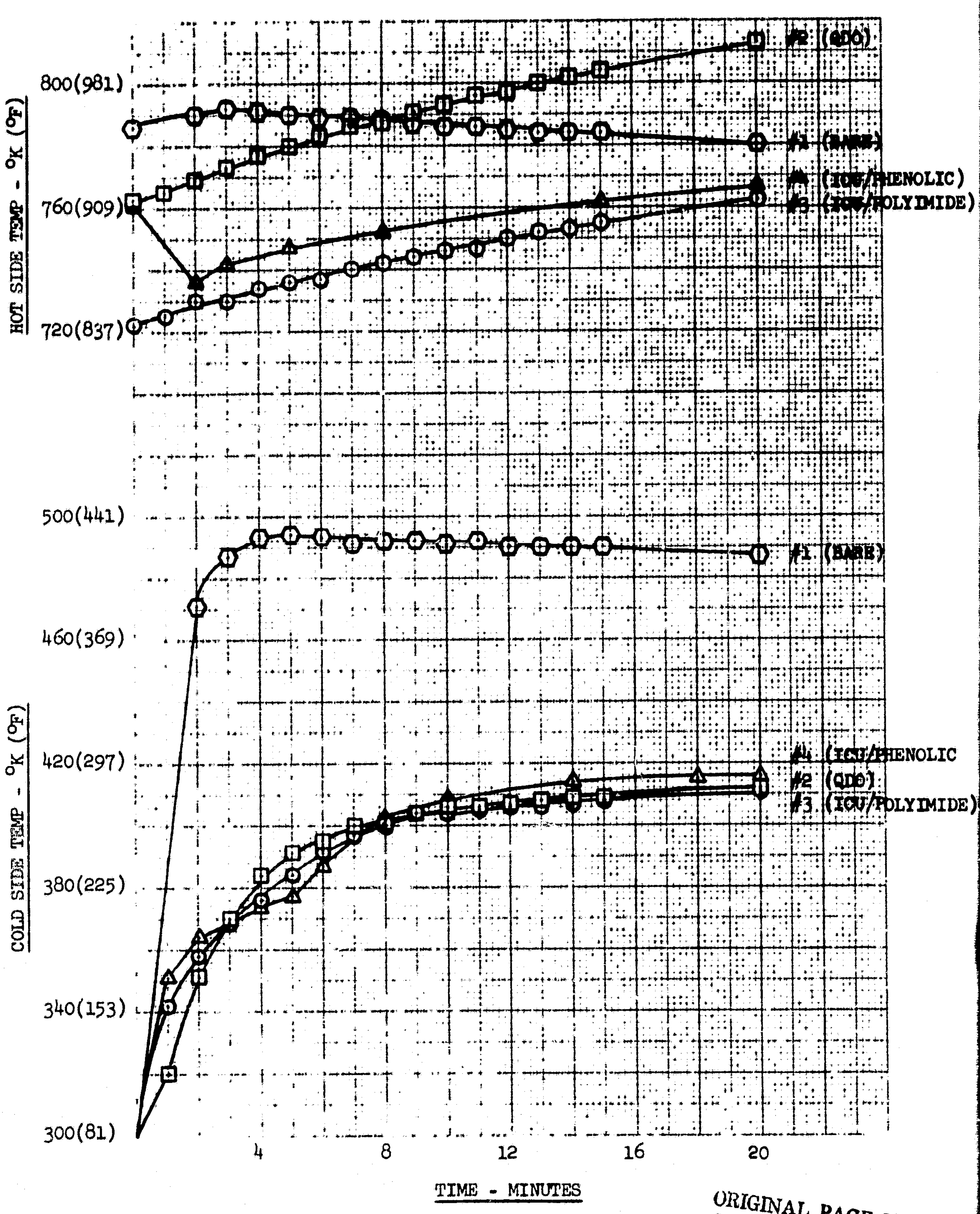

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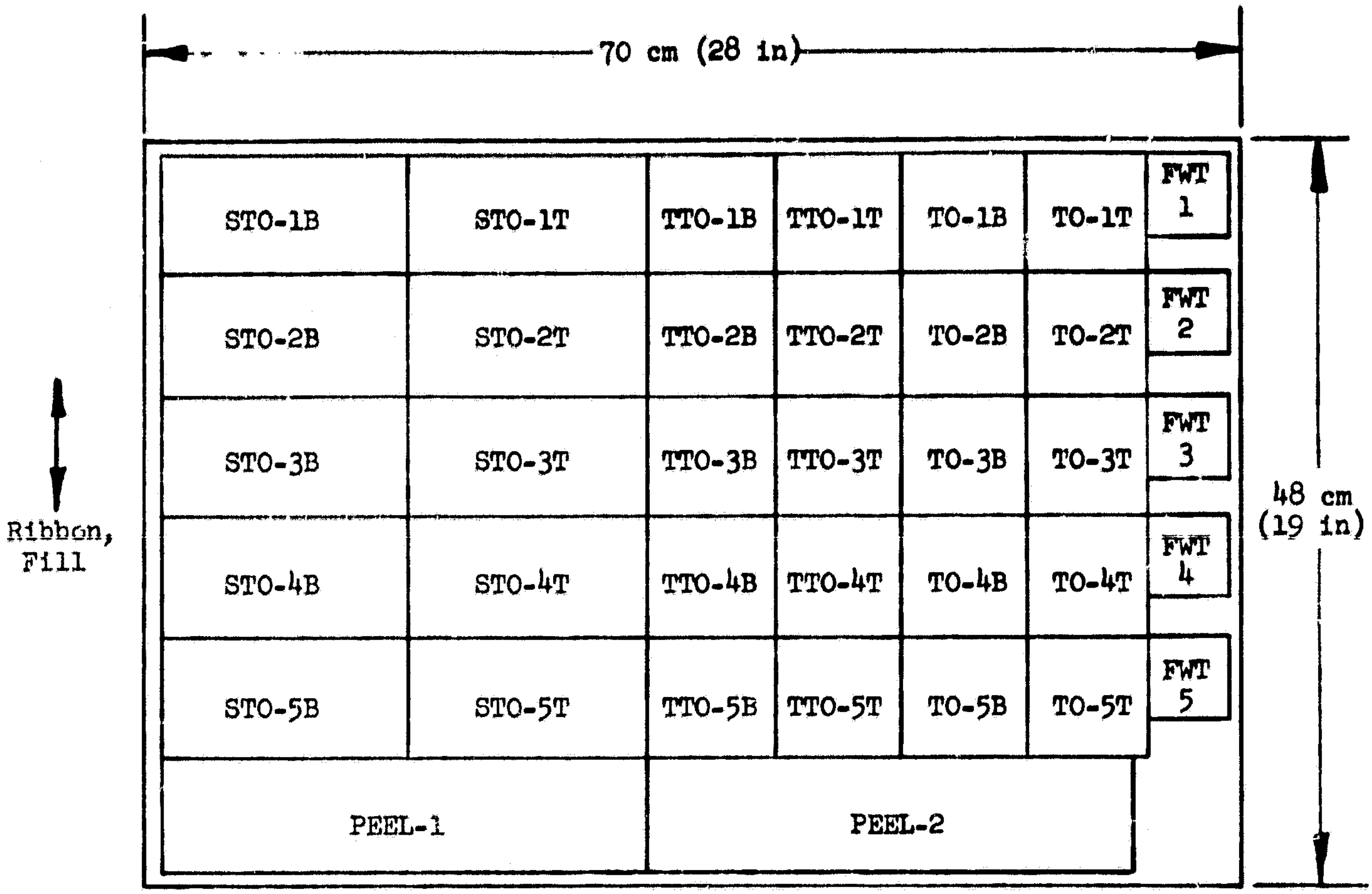
Figure 3

Cutting Plan for Insert Study Panels



Symbol	Description	Specimen Size (where applicable)
STO	Shear Tear-Out	7.5 cm x 15 cm (3 in x 6 in)
TTO	Tensile Tear-Out	7.5 cm x 7.5 cm (3 in x 3 in)
TO	Torque-Out	7.5 cm x 7.5 cm (3 in x 3 in)
FWT	Flatwise Tension	5 cm x 5 cm (2 in x 2 in)
PEEL	Peel	7.5 cm x 30.5 cm (3 in x 12 in)
-B	For blind insert	
-T	For thru insert	

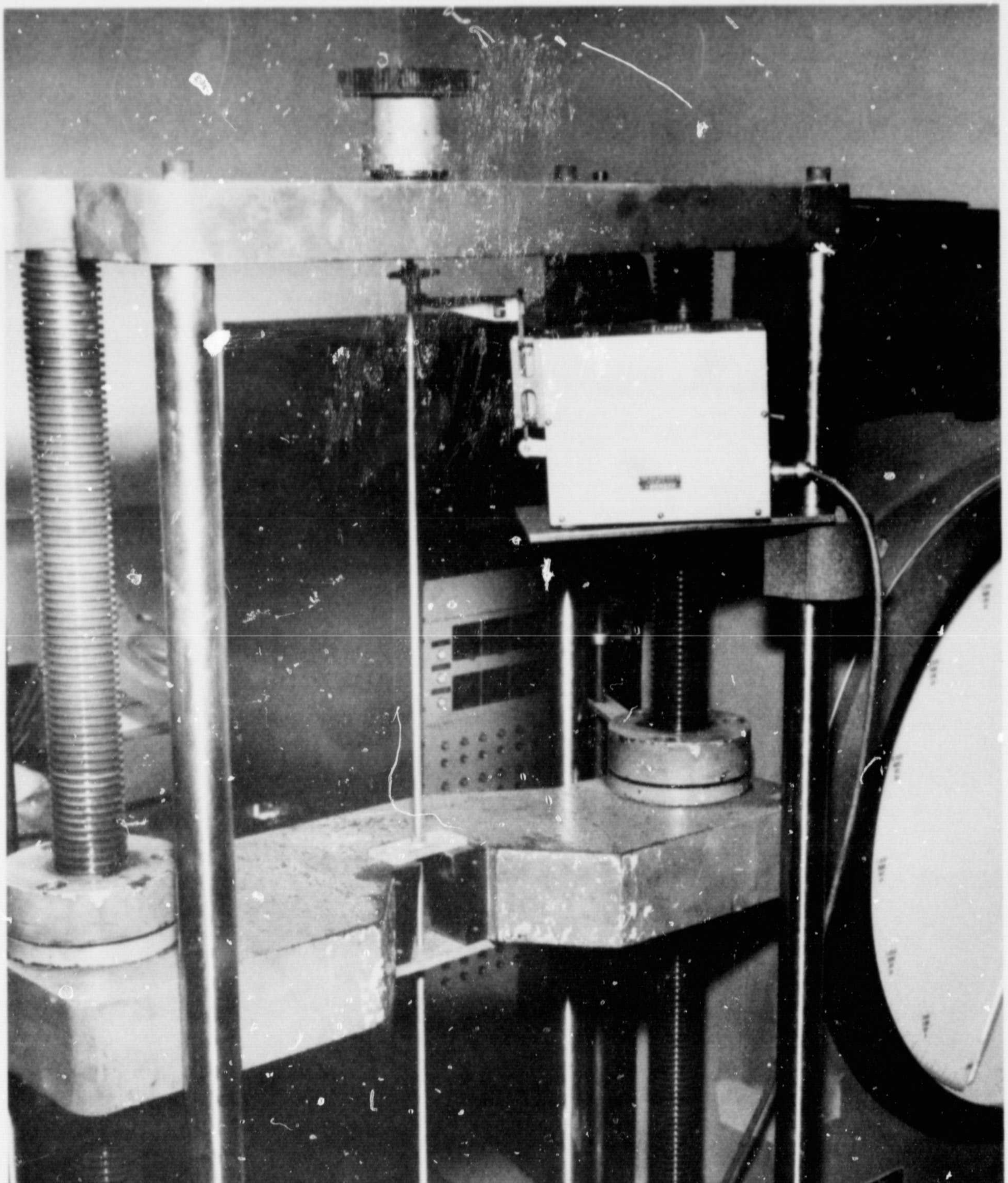


Figure 4 Insert Tensile Tear-Out Test in Progress

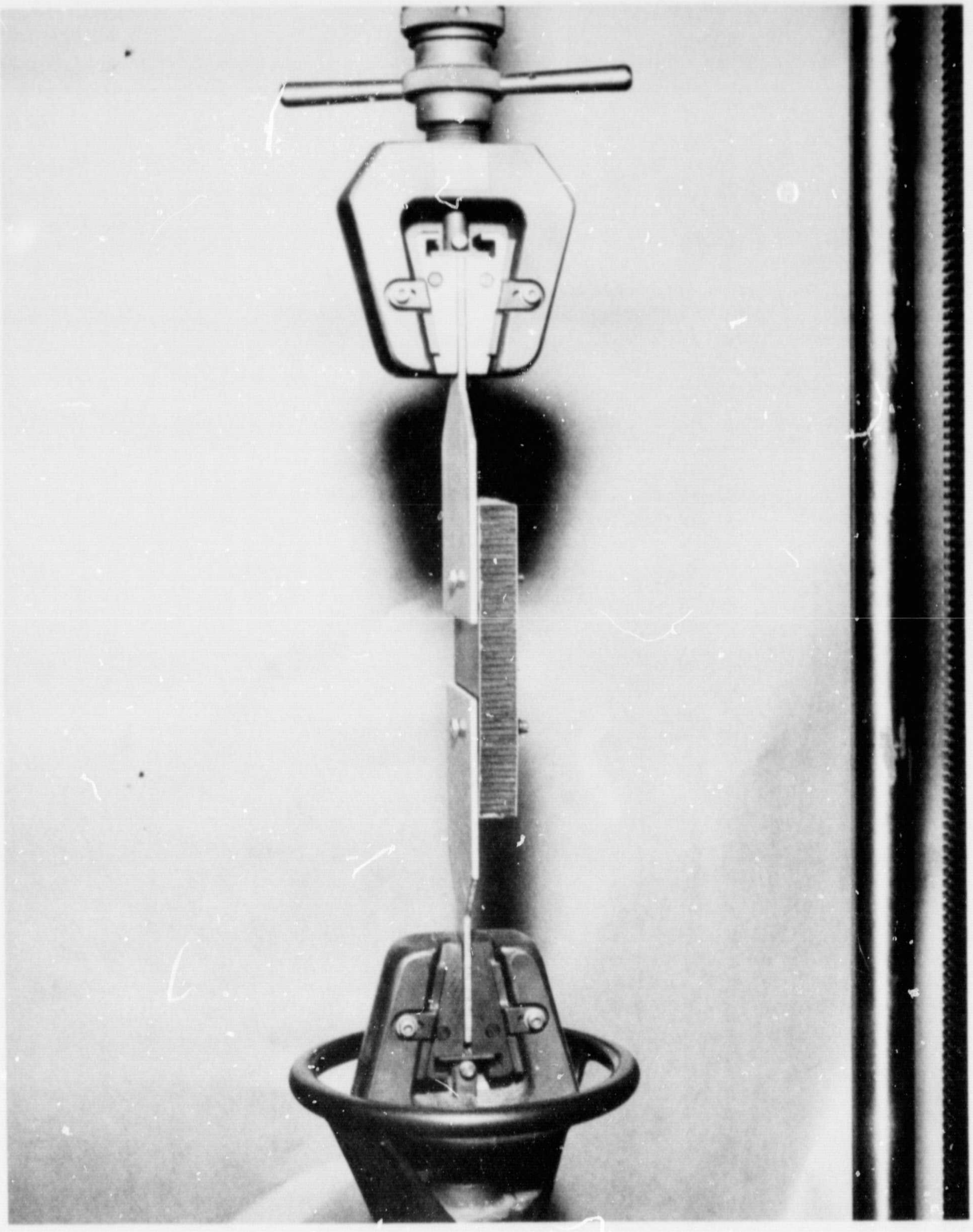


Figure 5 Insert Shear Tear-Out Test in Progress

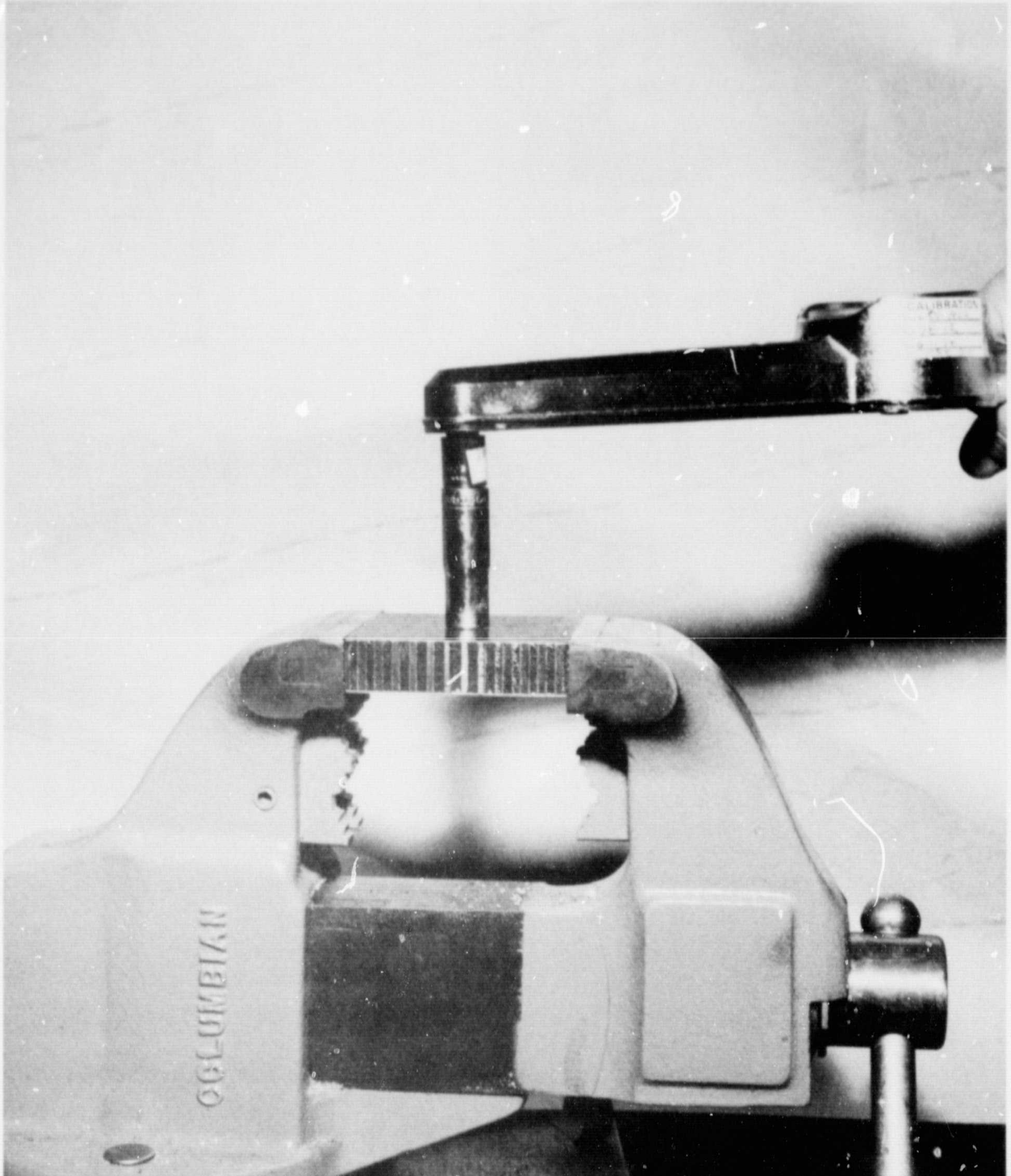


Figure 6 Insert Torque-Out Test in Progress

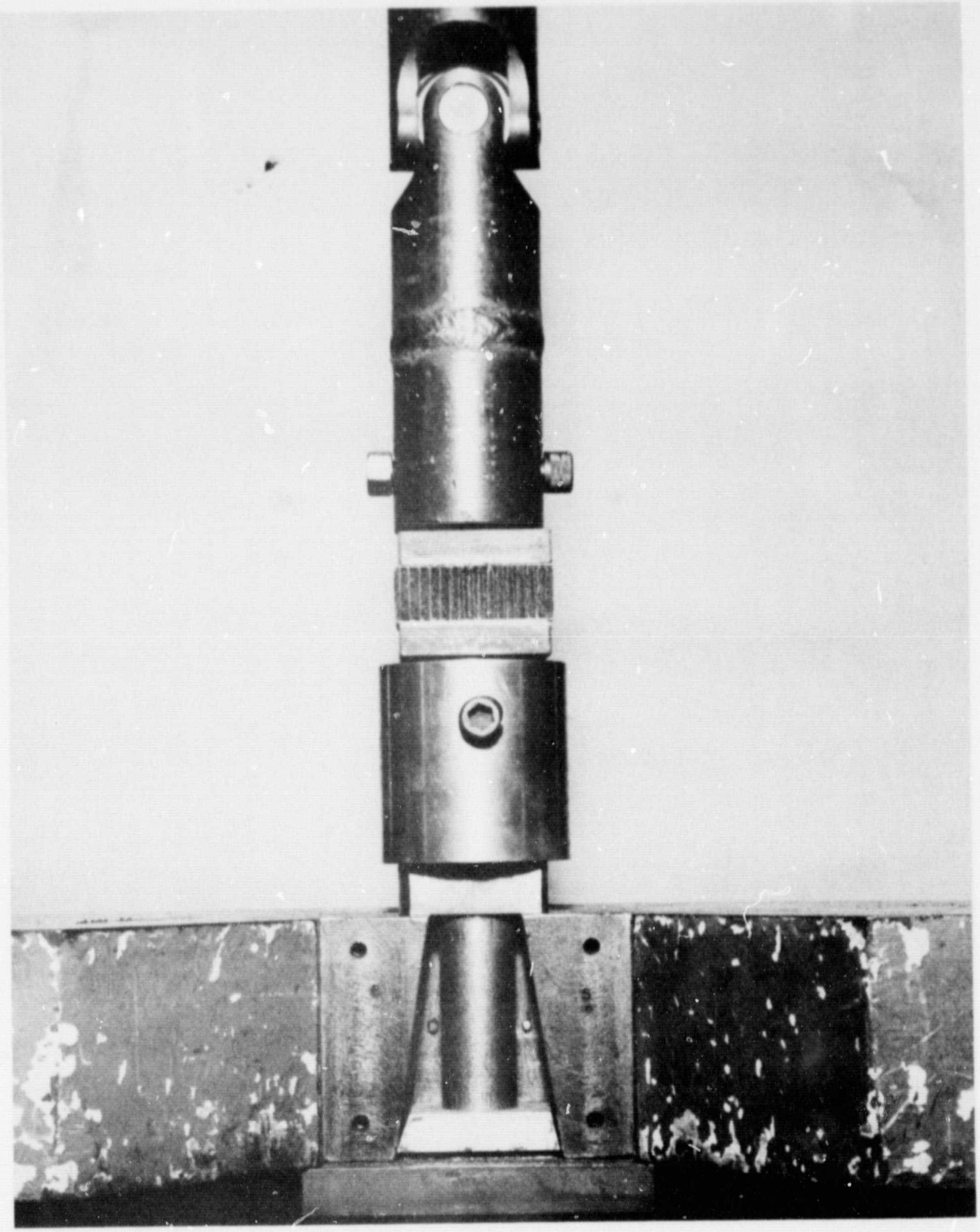


Figure 7 Sandwich Flatwise Tensile Test in Progress

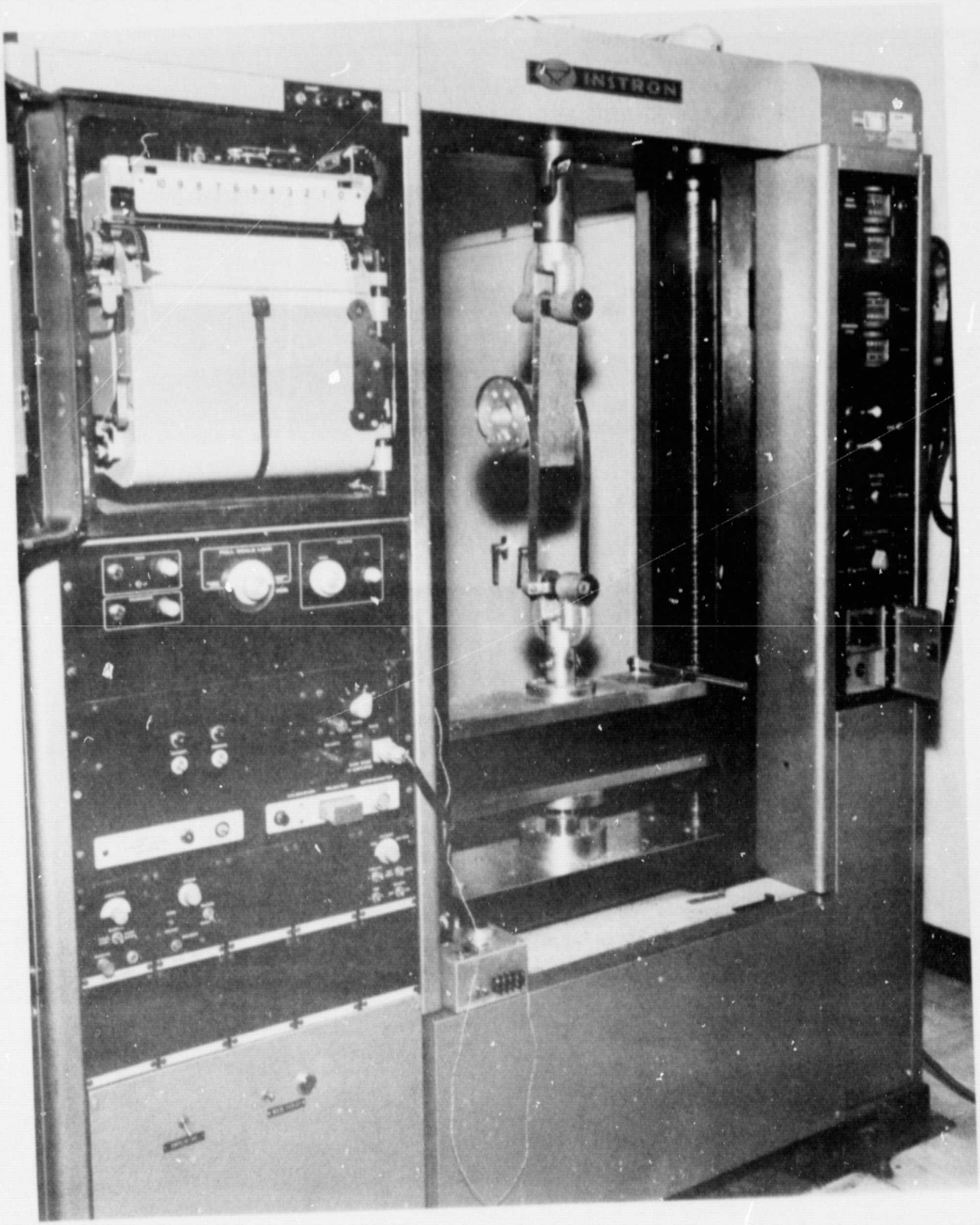


Figure 8 Sandwich Peel Test in Progress

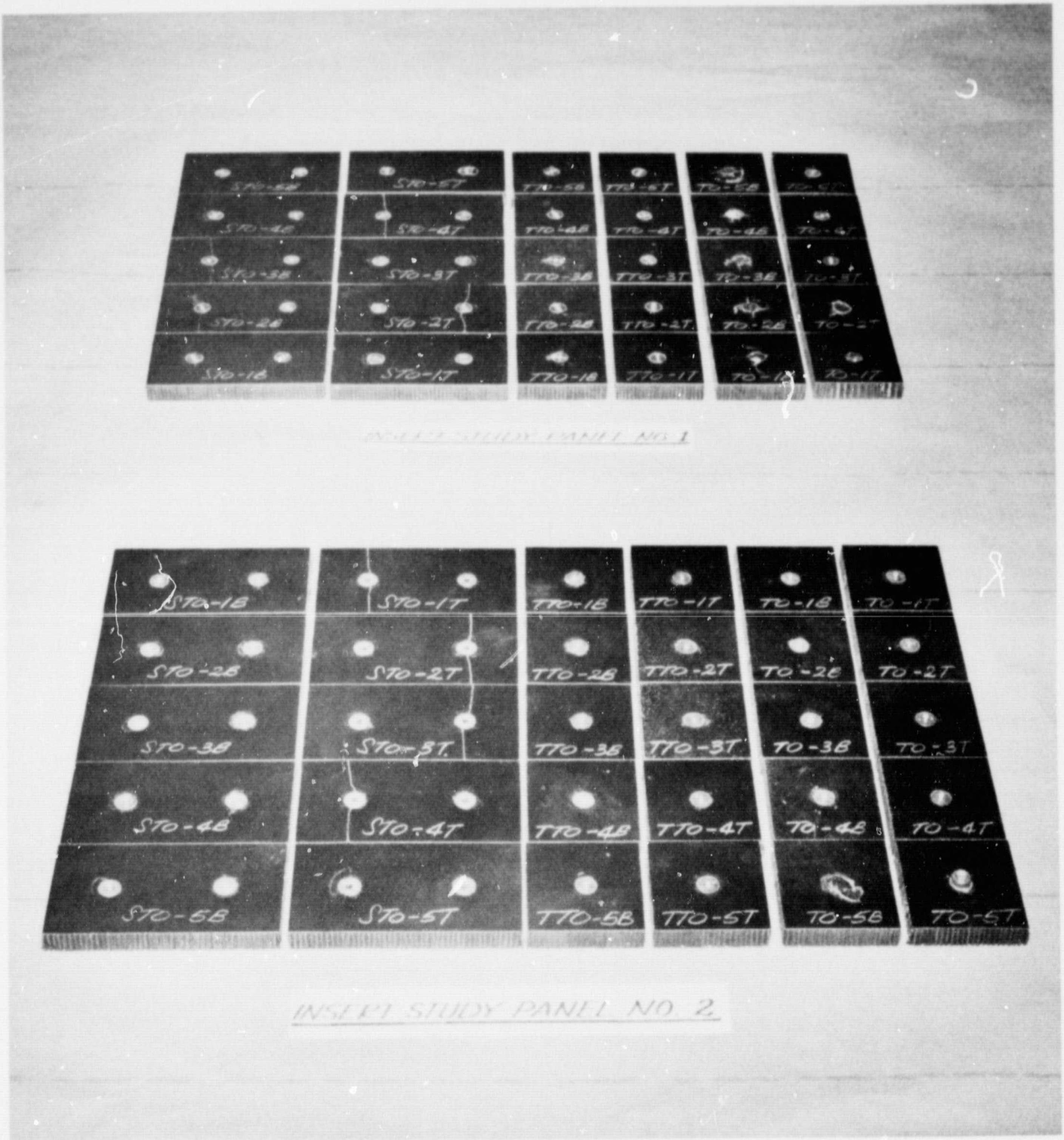


Figure 9 Failed Test Specimens - Insert Study Panels No. 1 and 2

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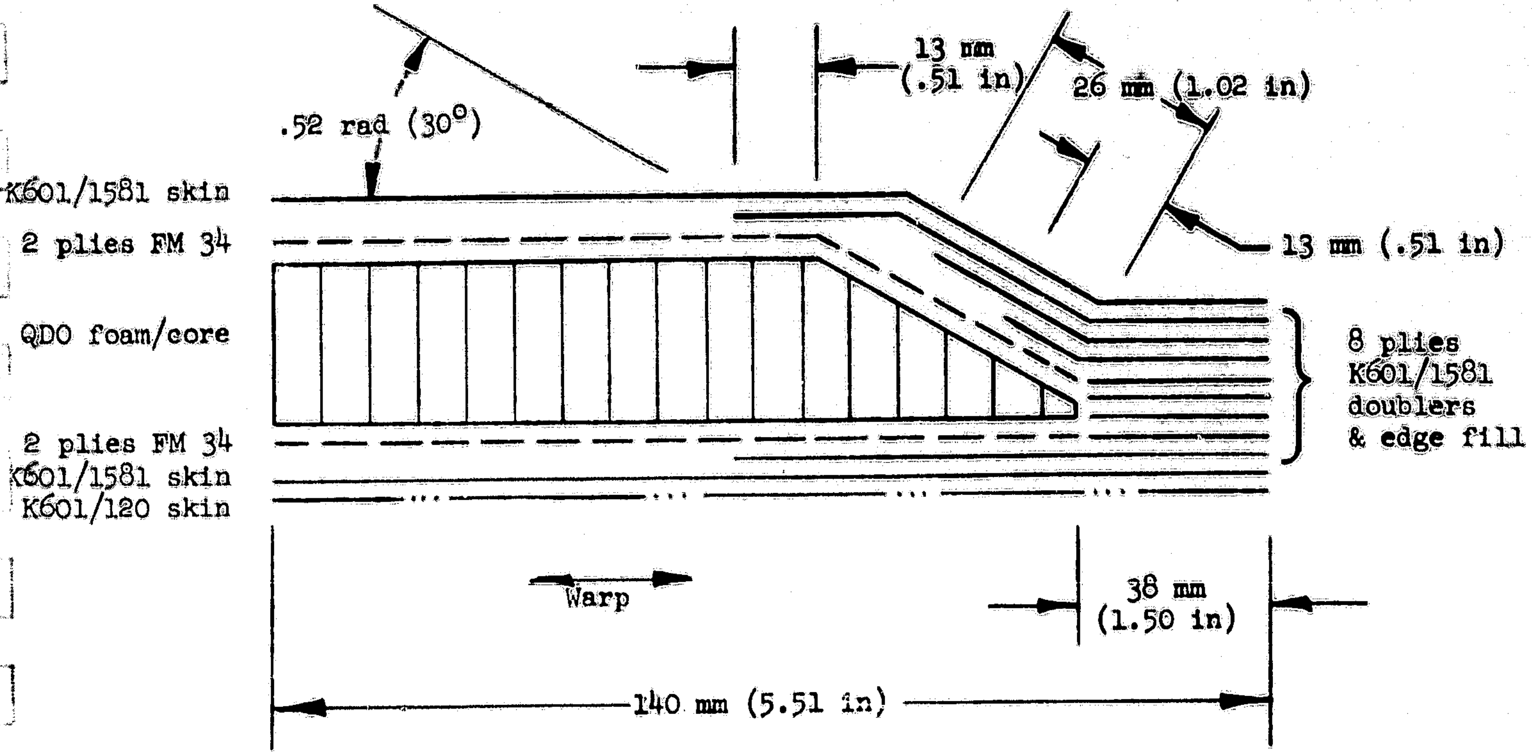
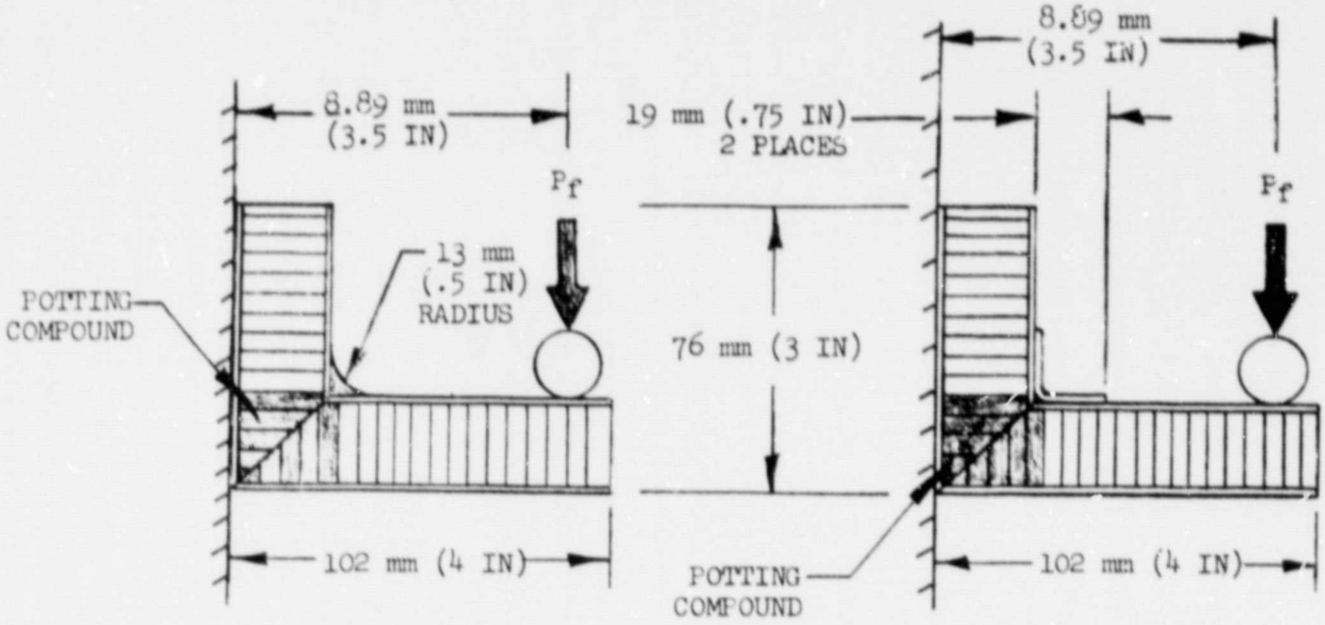


Length of panel = 450 mm (17.72 in)
Core ribbon in the length direction.

Figure 10. Construction of Chamfered Edge Close-Out Panel No. 17

FIGURE 11 - CORNER JOINT CONFIGURATIONS AND TEST RESULTS



PANELS JOINED	TYPE INSIDE CORNER SUPPORT	SPEC. NO.	MAXIMUM MOMENT N·m (LB-IN)	TYPE FAILURE
#22 & #25	PRECURED DOUBLER	1	7.72 (68.3)	SKIN TO CORE BOND
		2	8.70 (77.0)	" " " "
BARE CORE	PRECURED DOUBLER	1	7.49 (66.3)	CORE SHEAR
		2	6.98 (61.8)	" "
		3	6.24 (55.2)	" "
#22 & #25	WET LAM DOUBLER	1	3.56 (31.5)	SKIN TO CORE BOND
		2	3.96 (35.0)	" " " "
BARE CORE	WET LAM DOUBLER	1	6.25 (55.3)	SKIN TO CORE BOND
		2	6.98 (61.8)	" " " "
		3	5.88 (52.0)	" " " "
#22 & #25	FILLET	1	3.56 (31.5)	FILLET TO SKIN BOND
		2	5.93 (52.5)	" " " "
TYP L1011	FILLET	AVG	12.32 (109.0)	CORE SHEAR

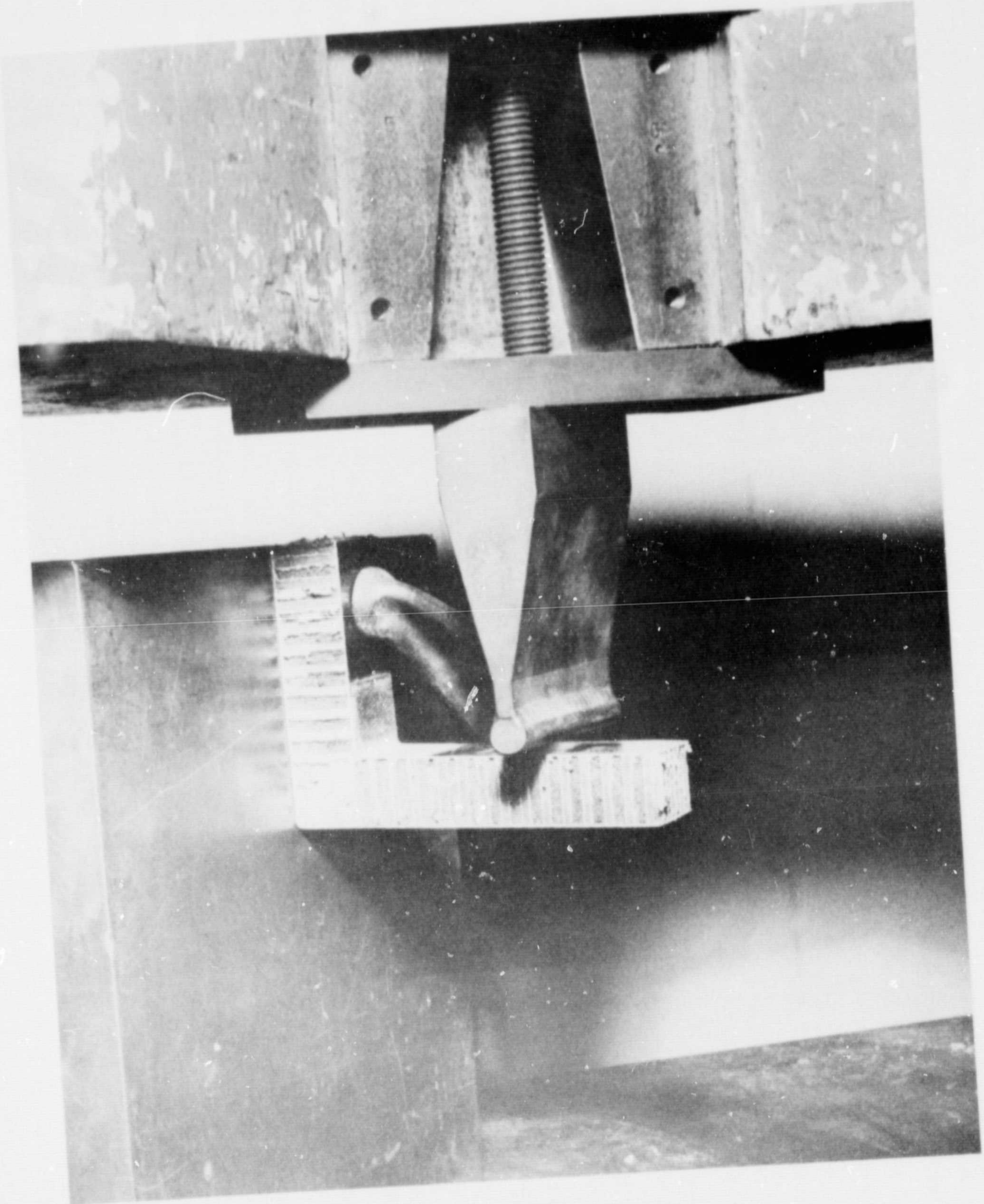


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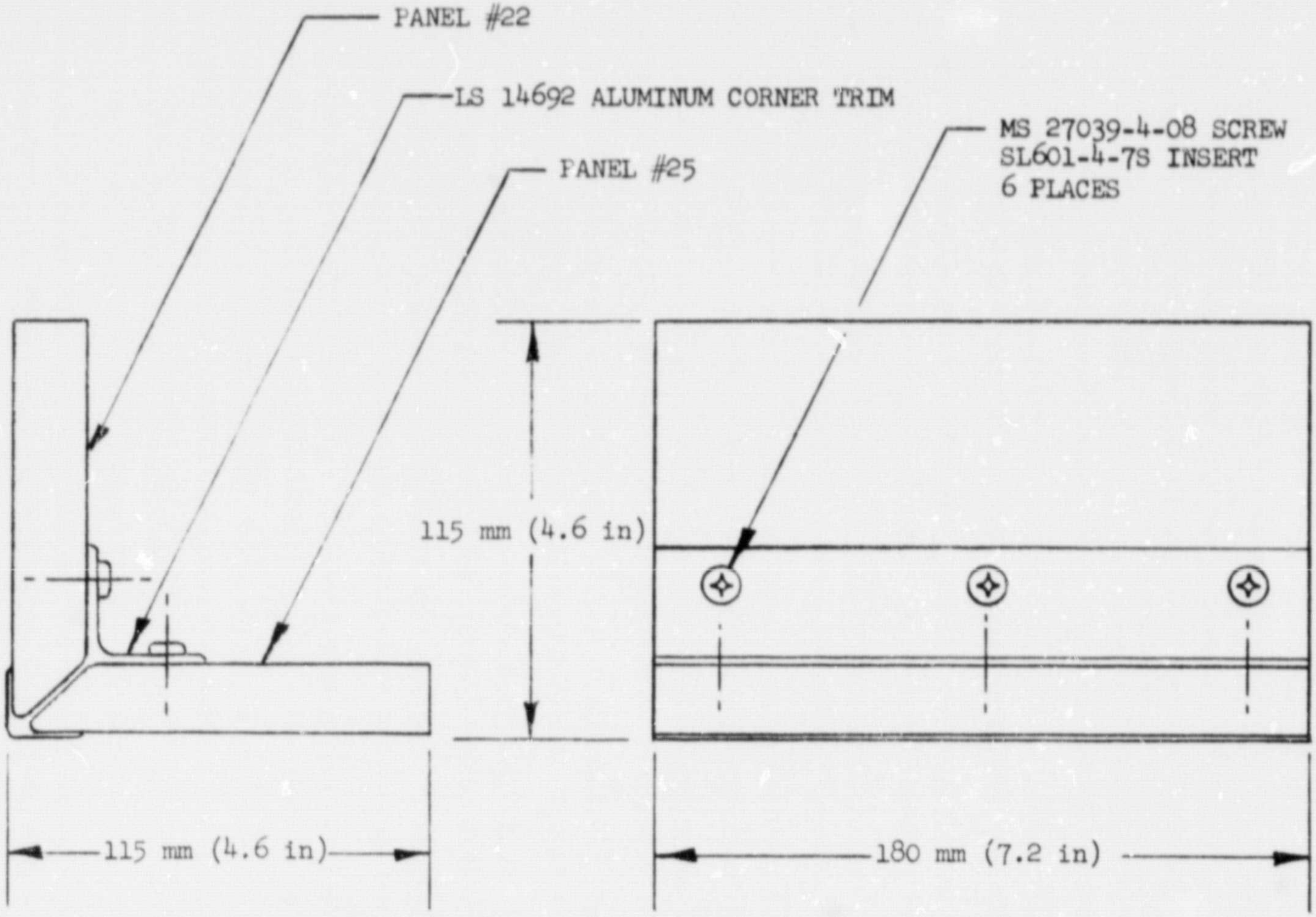
Figure 12 Corner Joint Test in Progress

FIGURE 13 - CORNER JOINT SPECIMEN UTILIZING PANELS #22 AND #25



NOTES: 1. POT INSERTS PER HITCO HPD P-195044

2. PREPARE SANDWICH PANELS #22 AND #25 FOR ASSEMBLY BY BEVELING FAYING EDGE AT 45°, BRUSHING AWAY SURFACE FOAM AT THE BEVEL, AND POTTING THE EDGE WITH A PACKING COMPOUND TO THE FOLLOWING FORMULATION:

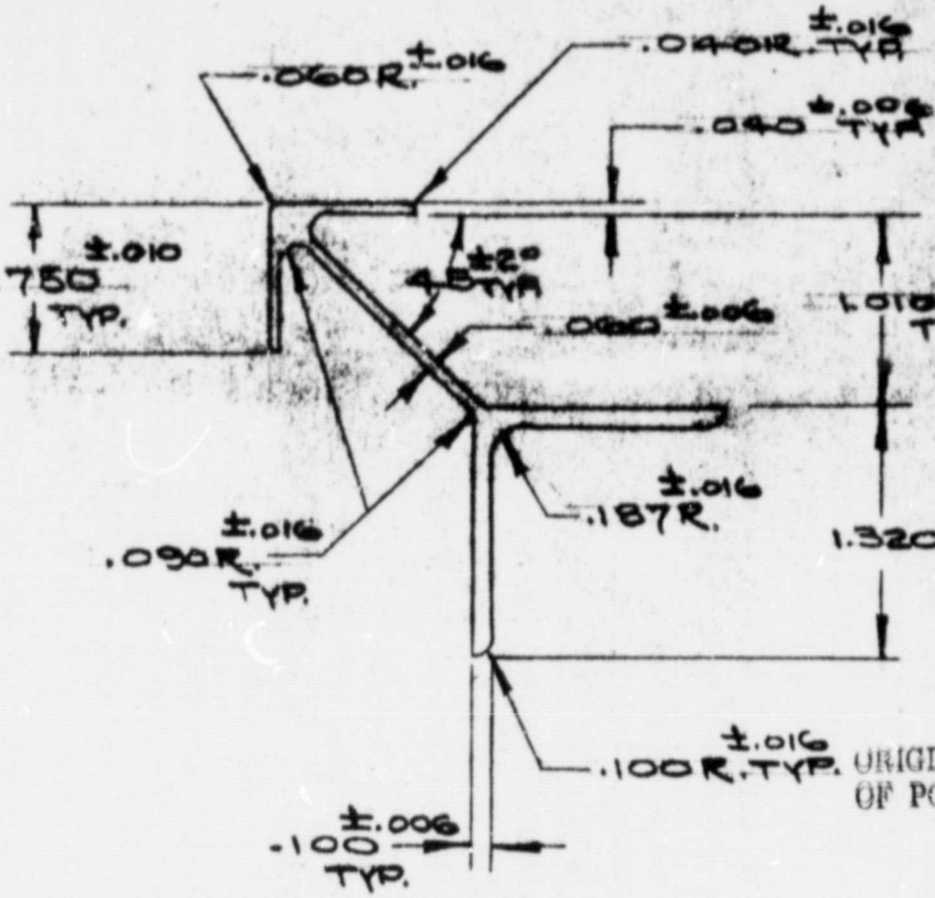
SKYBOND 703 RESIN	30 PARTS BY WEIGHT
ACETONE	20 PARTS BY WEIGHT
B40A GLASS BUBBLES	17 PARTS BY WEIGHT
#731-1/32 MILLED FIBERS	18 PARTS BY WEIGHT

OVEN CURE:
60 MINUTES AT 322°K (120°F)
60 MINUTES AT 339°K (150°F)
120 MINUTES AT 355°K (180°F)
120 MINUTES AT 450°K (350°F)

FINISH THE EDGING BY SANDING WITH 120 GRIT ABRASIVE PAPER

DIE NO.

UNLESS OTHERWISE SPECIFIED STANDARD ALUMINUM ASSOCIATION TOLERANCES APPLY.



UNLESS OTHERWISE SPECIFIED:
TYP. WALL THICKNESS TO BE ________
BREAK ALL CORNERS & FILLETS. ________

NOTE:
QQ-A-200/8 SPEC.

REVISIONS		CALIFORNIA CUSTOM SHAPES	
ESTIMATED AREA	.425 SQ. IN.		
ESTIMATED WT/FT	.510 LBS.	HITCO	
ESTIMATED PERIMETER	10.546 IN.	CUST. PART NO. OR NAME CORNER TRIM	
FACTOR	21	SCALE FULL	CUST. DWG. NO. SK-0800
CIRCUMSCRIBED CIRCLE DIA.	2 1/2-3	ALLOY & TEMPER 6061-T6	DATE 7-18-77
SOLID ✓ SEMI HOLLOW	HOLLOW CL.	DR. B.D. CK.	DIE NO. REV.

Figure 14 SK0800 Corner Trim Extrusion

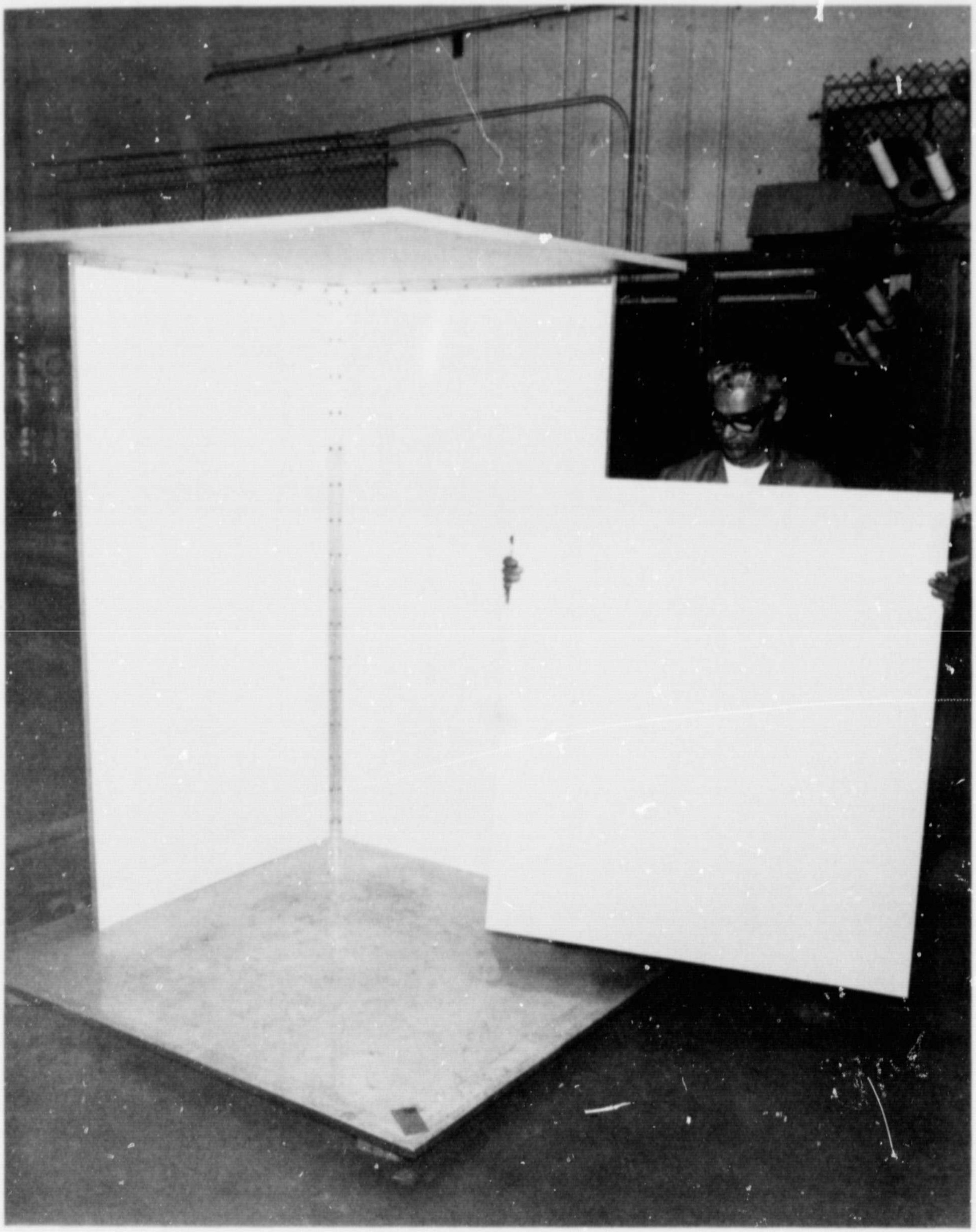


Figure 15 Lavatory Test Structure

Table I. QDO (Quinone Dioxime) Foam Samples Prepared in Phase I Work

Sample No	Size cm (in)	Coating Depth mm (in)	Wet Pickup g/cm^2 (g/in^2)	Foam Only Density k/m^3 (pcf)	Quality of Foam	Foamed Core Used On
F1	20 x 51 (8 x 20)	3.6 (.14)	.33 (2.1)	26 (1.6)	Good	Panel H2
F2	20 x 51 (8 x 20)	3.2 (.13)	.27 (1.7)	44 (2.7)	Good but too dense	Scrapped
F3	20 x 51 (8 x 20)	3.2 (.13)	.25 (1.6)	26 (1.6)	Good	Sales Sample
F4	20 x 51 (8 x 20)	2.4 (.09)	.19 (1.2)	25 (1.6)	Fair, some voids	Panel H1
F5	66 x 81 (26 x 32)	3.2 (.13)	.25 (1.6)	27 (1.7)	Good	Panels H9, H10, H12 and H17
F6	20 x 51 (8 x 20)	3.2 (.13)	.32 (2.1)	37 (2.3)	Some voids, too dense	Panel H18
F7	20 x 51 (8 x 20)	3.2 (.13)	.28 (1.8)	23 (1.4)	Good but light	Panel H4
F8	66 x 81 (26 x 32)	3.2 (.13)	.25 (1.6)	27 (1.7)	Good except for edges	Panels H5-H7 and H13-H16
F9	56 x 81 (22 x 32)	3.2 (.13)	.27 (1.7)	28 (1.7)	Good	Panel 1
F10	56 x 81 (22 x 32)	3.2 (.13)	.25 (1.6)	21 (1.3)	Good but light	Panel 2
F11	56 x 81 (22 x 32)	3.2 (.13)	.27 (1.7)	22 (1.4)	Good but light	Panel 3
F12	56 x 81 (22 x 32)	3.2 (.13)	.25 (1.6)	24 (1.5)	Good	Panel 10
F13	66 x 81 (26 x 32)	3.2 (.13)	.26 (1.7)	19 (1.2)	Good but light	Panels 14, 17, 18, 21, 22 and 25

Notes: 1. All core used was 18.2 mm (.72 in) thick HRH 10-1/8-1.8 Nomex honeycomb.

2. All samples were foamed in a batch oven with platens preheated to 423°K (302°F) except for Sample F2, where cold platens were used.

Table II. Heat Resistance Test Results

Specimens: 15 cm x 15 cm x 19 mm thick (5.9 in x 5.9 in x .75 in thick) composite sandwich panels, all with wet laminated skins, either one ply of 1581/703 polyimide or 3 plier of 120/9251 phenolic with no adhesive added. The cores were either bare or filled with QDO or ICU foam as described in the text. All sandwich specimens were oven cured with no postcure.

Method: Hitco Insulated Hot Plate (similar to ASTM Guarded Hot Plate) stabilized at 760°K (909°F) using a spare foam filled sandwich panel over the top prior to loading the specimen. Exposure time was 20 minutes. Both hot side and cold side temperatures were monitored with manual readout thermocouples. The samples did not reach steady state in the 20 minute period. The calculated thermal conductivities shown are for an extrapolated steady state condition.

Panel No.	Type Core	Type Skins	Sandwich Weight kg/m^2 (psf)	Thermal Conductivity W/m·K (BTU-in/hr-ft^2-°F)	Appearance of the Cold Side Skin	Condition of the Bond
1	Bare	Polyimide	1.65 (.338)	.268 (1.86)	No discoloration	No apparent damage
2	QDO	Polyimide	2.22 (.455)	.101 (.700)	No discoloration	No apparent damage
3	ICU	Polyimide	2.11 (.432)	.105 (.728)	No discoloration	No apparent damage
4	ICU	Phenolic	2.39 (.490)	.104 (.721)	Somewhat discolored	Hot skin delaminated one corner

Table III. Sandwich Bonding Study Panel Fabrication and Test Summary

Type A Construction (Precured Face Sheets) Panels

Panel No.	Core Foamed With QDO	Type of Adhesive: Applied to Each Precured K601 Bismaleimide Face Sheet	Type of Adhesive: Rolled on Each Side of the Core	Type Cure	Cured Sandwich Density kg/m^2 (lb/ft^2)	Postcure After Bonding °K (°F)	Flatwise Tensile Tests: No. of Spec. Tested	Flatwise Tensile Tests: Average Strength kPa (psi)	Flatwise Tensile Tests: Type of Failure
H1	Yes	2 Plies FM 34	None	Press	2.5 (.51)	472 (390)	5	649 (94)	Bond
						522 (480)	5	540 (78)	Bond
H3	No	2 Plies FM 34	None	Press	2.0 (.41)	None	4	1120 (162)	Bond
						522 (480)	4	1160 (168)	Core
H4	Yes	2 Plies FM 34	None	Press	2.4 (.49)	None	5	487 (71)	Bond
H5	Yes	2 Plies FM 34	None	Oven	2.4 (.49)	None	5	760 (110)	Bond
H6	Yes	1 Ply FM 34	BR 34	Oven	2.2 (.45)	None	4	626 (91)	Bond
H7	Yes	BR 34	BR 34	Oven	2.3 (.47)	None	3	1040 (151)	Core

Table IV. Sandwich Bonding Study Panel Fabrication and Test Summary

Single Stage Processed Panels

Panel No.	Core Foamed With QDO	Face Sheet Prepreg Material	Adhesive	Maximum Oven Cure Temp. °K (°F)	Cured Sandwich Density kg/m^2 (lb/ft^2)	Postcure After Bonding °K (°F)	Flatwise Tensile Tests: No. of Spec. Tested	Flatwise Tensile Tests: Average Strength kPa (psi)	Flatwise Tensile Tests: Type of Failure	Peel Tests: No. of Spec. Tested	Peel Tests: Average Strength N·m/7.5 cm (lb-in/3 in)
H2	Yes	K601 Bismaleimide	1 Ply FM 34	455(360)	2.3(.47)	522(480)	4	602(87)	Core	-	-
H8	No	K601 Bismaleimide	K601 Rolled on Core	455(360)	1.9(.39)	None	3	1410(204)	Core	-	-
						472(390)	3	1020(148)	Core	-	-
H9	Yes	K601 Bismaleimide	K601 Rolled on Core	472(390)	2.2(.45)	None	5	993(144)	80% Bond	-	-
H10	Yes	K601 Bismaleimide	K601 Rolled on Core	505(450)	2.2(.45)	None	5	566(82)	Core	-	-
H13	Yes	703 Polyimide	703 Rolled on Core	455(360)	2.2(.45)	None	5	1200(174)	Core	-	-
H14	Yes	703 Polyimide	1 Ply FM 34	455(360)	2.3(.47)	None	5	1130(164)	Core	-	-
H15	Yes	703 Polyimide	1 Ply FM 34	455(360)	2.3(.7)	None	-	-	-	2	1.41(12.5)
H16	Yes	703 Polyimide	703 Rolled on Core	455(360)	2.2(.45)	None	-	-	-	2	0.88(7.8)
H18	Yes	9251 Phenolic	None	397(255)	2.4(.49)	None	5	1080(157)	Core	2	1.36(12.0)

Table V. Sandwich Bonding Study Panel Fabrication and Test Summary
Vinyl Acetate Modified Polyimide Resin Panels

Panel No.	Type Resin	Type Vinyl Acetate	Resin: Vinyl Solids Ratio	% Cab-O-Sil	Type Fabric	Prepreg Resin Solids Content	Cure Hrs at 450°K (351°F)	Flatwise Tensile Tests			Peel Tests	
								No. of Spec. Tested	Average Strength kPa (psi)	Type of Failure	No. of Spec. Tested	Average Strength N·m/7.5 cm (lb-in/3")
H20	703	F15/95E	90:10	6	7781/Volan	50%	16	5	1324 (192)	Core	-	-
H21	703	F15/95E	90:10	6	1581/A-1100	55%	2	5	565 (82)	Bond	2	1.22(10.8)
H22	703	B-72	90:10	6	7781/Volan	62%	8	5	896 (130)	Core	2	2.54(22.5)
H23	703	F15/95E	85:15	6	7781/Volan	66%	8	5	945 (137)	Core	2	2.54(22.5)
H24	703	F15/95E	90:10	6	1581/A-1100	66%	12	-	-	-	2	3.16(28.0)
H26	703	B-72	90:10	6	1581/A-1100	66%	12	-	-	-	2	2.60(23.0)
H27	703	F15/95E	95:5	10	1581/A-1100	66%	12	-	-	-	2	2.03(18.0)

Notes: 1. All panels constructed with bare Nomex honeycomb type HRH 10-1/8-1.8 and single stage laminated and cured in a circulating air oven under full house vacuum. No postcure.

Table VI. Hitco Potting Compound Formulations

Formula No.	Ingredients	Proportions	Cure	Remarks
1	DEN438A85/37-620/DMP-30/B35A	30/25/1/11	1 hr @ 340°K (153°F)	Flammable as cured
2	DEN438A85/390/DMP-30/B35A	30/15/2/11	1 hr @ 340°K (153°F)	Flammable as cured
3	DEN438A85/400/DMP-30/B35A	30/12.5/2/10	1 hr @ 340°K (153°F)	Flammable as cured
4	DEN438A85/V140/DMP-30/B35A	30/25/2/13	1 hr @ 340°K (153°F)	Flammable as cured
5	K601/NMP/B35A	70/30/12.5	1 hr @ 450°K (351°F)	Flammable as cured. Self extinguishing after postcure of 16 hrs @ 475°K (396°F Mix somewhat soupy
6	703/B35A	100/36	1 hr @ 450°K (351°F)	Blew up during cure
7	703/Acetone/B35A	30/20/20	1 hr @ 450°K (351°F)	Mix somewhat soupy. Cured foam 300 kg/m^3 (19 pcf) density. Compressive strength 5590 kPa (811 psi)
8	K601/NMP/B35A	70/30/15	2 hrs @ 450°K (351°F)	Good potting consistency. Cured foam 826 kg/m^3 (52 pcf) density.
9	703/Acetone/B35A	30/15/20	2 hrs @ 450°K 9351°F)	Good potting consistency. Cured foam 320 kg/m^3 (20 pcf) density.

Notes:
1. DEN438A85 is a Dow Chemical novolac resin, 85% solids in acetone.
2. 37-620 is a Reichhold Chemical amido-amine curing agent.
3. DMP-30 is Rohm and Haas' dimethylaminomethyl phenol accelerator.
4. B35A are 3M glass bubbles.
5. 390 and 400 are Pacific Anchor low viscosity polyamides.
6. V140 is a General Mills low viscosity polyamide.
7. K601 is a Rhodia bismaleimide resin, 100% solids.
8. 703 is a Monsanto polyimide resin, 70% solids in NMP.

Table VII. Potting Compound Screening Test Results

Specimen No.	Tensile Pull-Out Load - Newtons (Pounds) Epoxy Syntactic Epocast 8675	Bismaleimide Syntactic Formulation #8	Polyimide Syntactic Formulation #9
1	552 (124)	774 (174)	721 (162)
2	525 (118)	569 (128)	694 (156)
3	596 (134)	658 (148)	774 (174)
4	600 (135)	729 (164)	641 (144)
5	543 (122)	743 (167)	792 (178)
6	574 (129)	672 (151)	747 (168)
Average	565 (127)	691 (155)	728 (164)
Standard Deviation	30 (7)	74 (17)	55 (12)

Notes:
1. All specimens cut from Panel H17.
2. NAS 1832-3-4 blind inserts used for all tests.
3. All potting compounds as cured. No postcure was done on any of the specimens.

TABLE VIII. INSERT TEST RESULTS

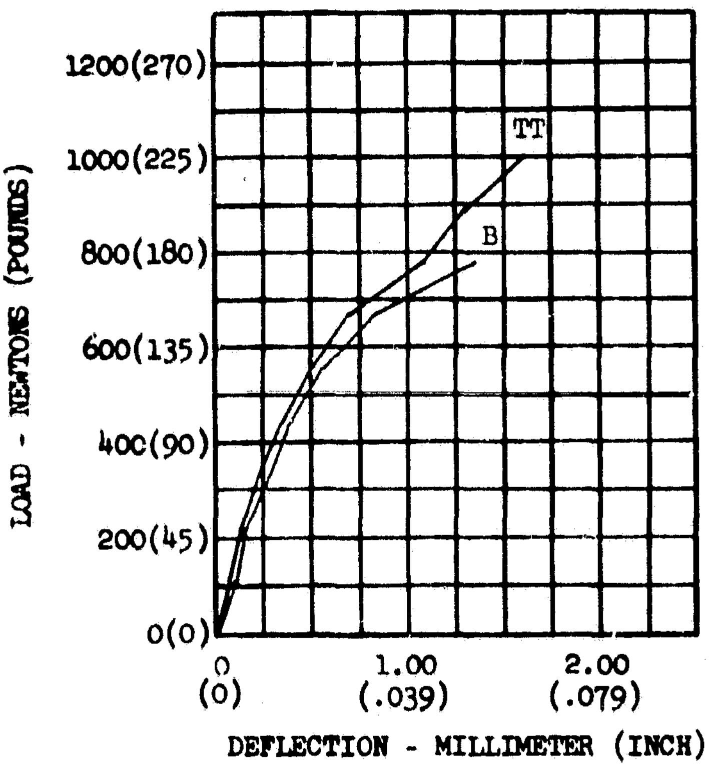
TYPE A PANEL NO 1

TYPE OF POTTING COMPOUND EPOXY SYNTACTIC (EPOCAST 8675)

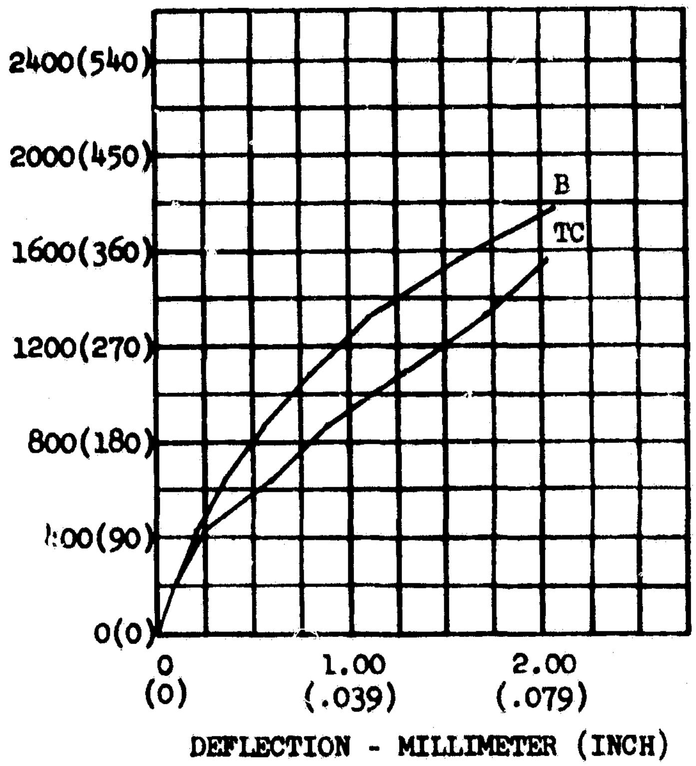
FASTENER CODE: B = BLIND = NAS 1832-3-4
TT = THRU THREADED = NAS 1833-3-750
TC = THRU CLEAR = NAS 1834-3-750

TYPE OF BOLT USED FOR TEST NAS 1303 (TORQUE-OUT TESTS)

TENSILE TEAR-OUT



SHEAR TEAR-OUT



SPECIMEN NO.	ULTIMATE LOADS AT FAILURE					
	TENSILE TEAR-OUT NEWTONS (POUNDS)		SHEAR TEAR-OUT NEWTONS (POUNDS)		TORQUE-OUT METER-NEWTONS (LB-IN)	
	B	TT	B	TC	B	TT
1	689(155)	707(159)	1690(380)	1700(382)	9.0(80)	12.2(108)
2	592(133)	547(123)	1870(420)	2030(456)	6.8(60)	14.9(132)
3	725(163)	1094(246)	1840(414)	1620(364)	11.3(100)	*21.2(187)
4	876(197)	823(186)	1780(400)	1830(411)	9.6(85)	*20.9(185)
5	801(180)	934(210)	1870(420)	1390(313)	9.6(85)	14.7(130)
AVERAGE	737(166)	821(185)	1810(407)	1710(384)	9.3(82)	16.8(149)
STD. DEV.	108(24)	209(47)	80(18)	240(54)	1.6(14)	4.0(35)

*BOLT FAILURE

TABLE IX. INSERT TEST RESULTS

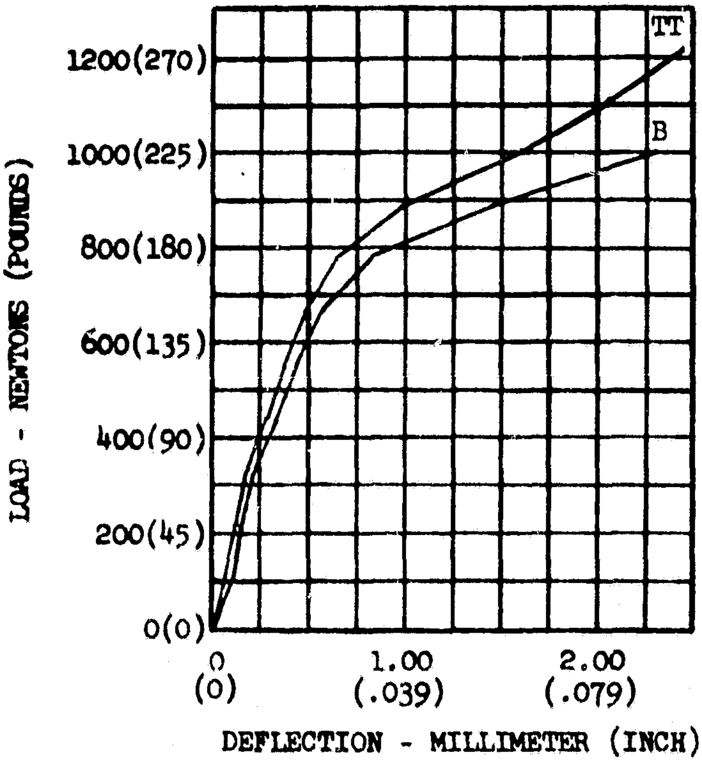
TYPE A PANEL NO 2

TYPE OF POTTING COMPOUND BISMALEIMIDE (K601) SYNTACTIC (HITCO FORMULATION #8)

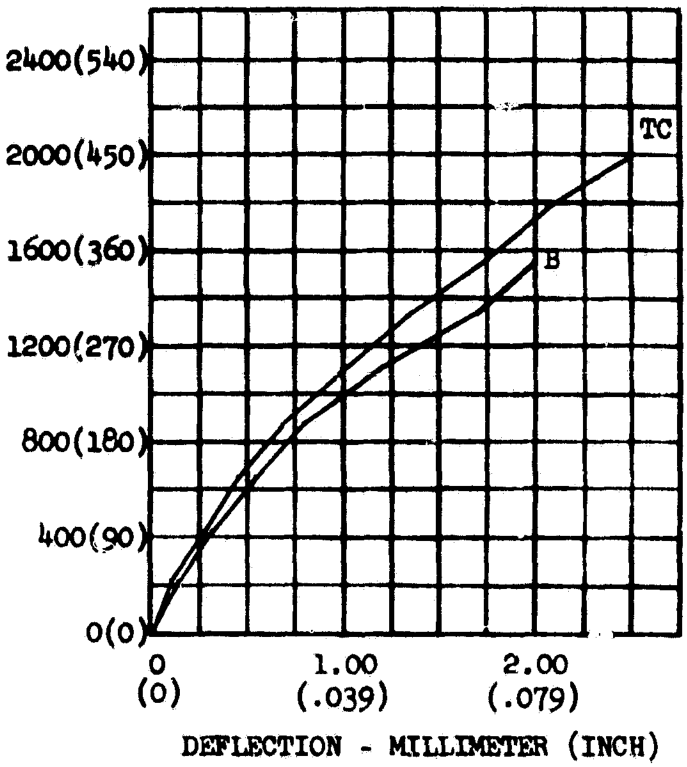
FASTENER CODE: B = BLIND = NAS 1832-3-4
TT = THRU THREADED = NAS 1833-3-750
TC = THRU CLEAR = NAS 1834-3-750

TYPE OF BOLT USED FOR TEST NAS 6103 (TORQUE-OUT TESTS)

TENSILE TEAR-OUT



SHEAR TEAR-OUT



SPECIMEN NO.	ULTIMATE LOADS AT FAILURE					
	TENSILE TEAR-OUT NEWTONS (POUNDS)		SHEAR TEAR-OUT NEWTONS (POUNDS)		TORQUE-OUT METER-NEWTONS (LB-IN)	
	B	TT	B	TC	B	TT
1	974(219)	1277(287)	1460(328)	2200(495)	*13.3(118)	*15.6(138)
2	1005(226)	1152(259)	1660(373)	2160(486)	*15.8(140)	*16.0(142)
3	841(189)	983(221)	1440(324)	2080(468)	*16.4(145)	*17.2(152)
4	907(204)	987(222)	1700(382)	2130(479)	*16.0(142)	*17.0(150)
5	850(191)	827(186)	1690(380)	2000(450)	14.9(132)	16.7(148)
AVERAGE	915(206)	1045(235)	1590(357)	2110(474)	15.3(135)	16.5(146)
STD. DEV.	73(16)	173(39)	130(29)	80(18)	1.2(11)	0.7(6)

*BOLT FAILURE

TABLE X. INSERT TEST RESULTS

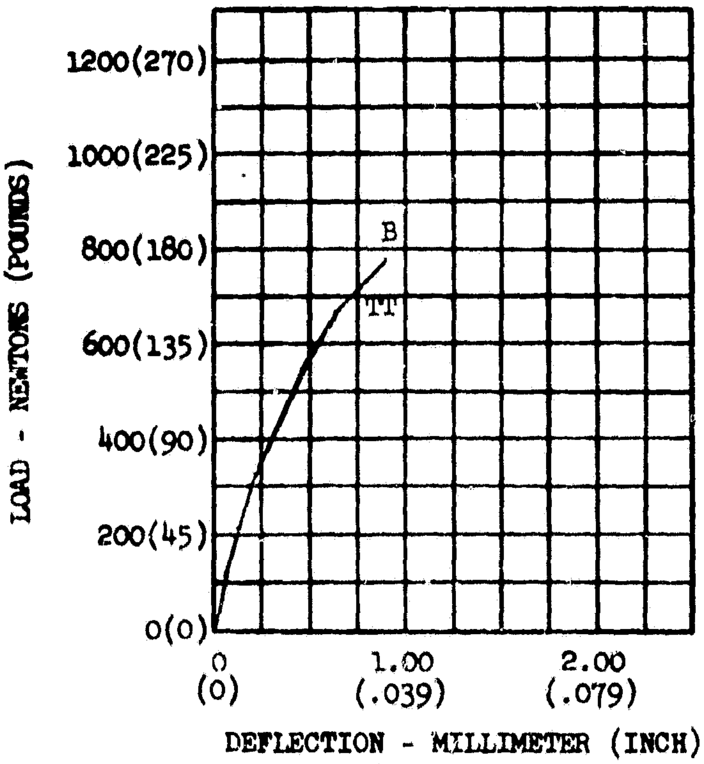
TYPE A PANEL NO 3

TYPE OF POTTING COMPOUND POLYIMIDE (703) SYNTACTIC (HITCO FORMULATION #9)

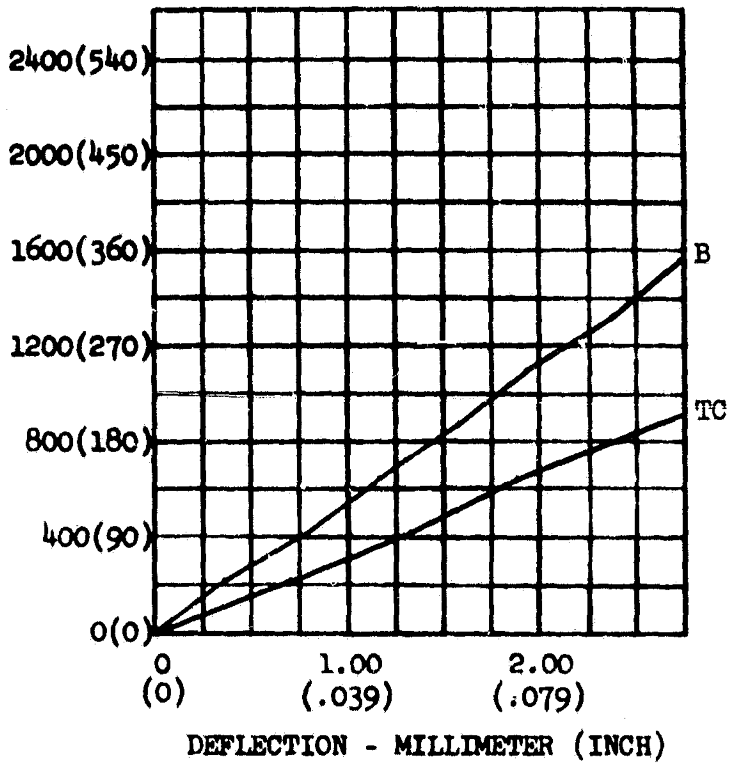
FASTENER CODE: B = BLIND = NAS 1832-3-4
TT = THRU THREADED = NAS 1833-3-750
TC = THRU CLEAR = NAS 1834-3-750

TYPE OF BOLT USED FOR TEST NAS 6103 (TORQUE-OUT TESTS)

TENSILE TEAR-OUT



SHEAR TEAR-OUT



SPECIMEN NO.	ULTIMATE LOADS AT FAILURE					
	TENSILE TEAR-OUT NEWTONS (POUNDS)		SHEAR TEAR-OUT NEWTONS (POUNDS)		TORQUE-OUT METER-NEWTONS (LB-IN)	
	B	TT	B	TC	B	TT
1	725(163)	743(167)	1470(330)	1070(241)	3.2(28)	4.9(43)
2	716(161)	463(104)	1350(304)	1330(299)	4.0(35)	4.4(39)
3	783(176)	627(141)	1360(306)	870(196)	2.7(24)	3.6(32)
4	738(166)	512(115)	1590(357)	1170(263)	3.2(28)	3.7(33)
5	765(172)	614(138)	1520(342)	1230(277)	3.2(28)	4.6(41)
AVERAGE	745(167)	592(133)	1460(328)	1130(254)	3.3(29)	4.2(37)
STD. DEV.	28(6)	109(25)	100(22)	180(40)	0.5(4)	0.6(5)

Table XI. Summary of Insert Study Test Results

Test	Property	Units	Type Insert	Panel #1 Epoxy (Control)	Panel #2 Bismaleimide Syntactic		Panel #3 Polyimide Syntactic	
				Average	Average	% Control	Average	% Control
Density		kg/m3 (lb/ft3)		1520(95)	826(52)	54	320(20)	21
Tensile Tear-out	Strength	N (lb)	Blind	737(166)	915(206)	124	745(167)	101
			Thru Threaded	821(185)	1045(235)	127	592(133)	72
	Initial Slope of Load/Defl. Curve	N/mm (lb/in)	Blind	1300(7420)	1440(8220)	111	1600(9140)	123
			Thru Threaded	1600(9140)	1680(9590)	105	1600(9140)	100
Shear Tear-out	Strength	N (lb)	Blind	1810(407)	1590(357)	88	1460(328)	81
			Thru Clear	1710(384)	2110(474)	123	1130(254)	66
	Initial Slope of Load/Defl. Curve	N/mm (lb/in)	Blind	2200(12560)	1300(7420)	59	525(3000)	24
			Thru Clear	1800(10280)	1600(9140)	89	300(1710)	17
Torque-out	Strength	N·m (lb-in)	Blind	9.3(82)	15.3(135)	165	3.3(29)	35
			Thru Threaded	16.8(149)	16.5(146)	98	4.2(37)	25

Table XII

Tag End Testing of Insert Study Panels

Test	Units	Specimen No.	Panel No. 1	Panel No. 2	Panel No. 3	Panel No. 10
Density	kg/m^2(psf)		2.5(.51)	2.4(.49)	2.5(.51)	2.5(.51)
Flatwise Tension	kPa (psi)	1	690(100)	1103(160)	1170(170)	607(88)
		2	434(63)	1062(154)	1100(160)	655(95)
		3	427(62)	621(90)	1210(175)	662(96)
		4	827(120)	972(141)	1230(178)	558(81)
		5	1179(171)	965(140)	1140(165)	558(81)
		Average	711(103)	945(137)	1170(170)	608(88)
		Std. Dev.	312(45)	190(28)	52(8)	50(7)
Peel	N·m/7.5 cm (lb-in/3 in)	1	1.16(10.3)	1.16(10.3)	0.86(7.6)	1.13(10.0)
		2	1.40(12.4)	1.16(10.3)	1.22(10.8)	0.96(8.5)
		Average	1.28(11.3)	1.16(10.3)	1.04(9.2)	1.05(9.3)

Notes: 1. Test Method - Mil-Std-401B for Flatwise Tension and Peel.

2. Density was calculated from physical and weight measurements.

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HITCO PROCESS DOCUMENT P-195044

FABRICATION OF LAVATORY TEST STRUCTURE UTILIZING NASA/AMES TYPE A FIRE RESISTANT AIRCRAFT INTERIOR PANELING

PRELIMINARY RELEASE

MARCH 7, 1978

BY S. Lee 3/2/78 CHECK ENG.	MFG. QUAL.	Fabrication of Lavatory Test Structure Utilizing NASA/Ames Type A Fire Resistant Aircraft Interior Paneling HITCO PROCESS DOCUMENT	HPD P-195044

6046-1-A-DF-1

FABRICATION OF LAVATORY TEST STRUCTURE UTILIZING NASA/AMES TYPE A FIRE RESISTANT AIRCRAFT INTERIOR PANELING

1.0 SCOPE

This process document covers the materials and procedures for the fabrication of a lavatory test structure utilizing NASA/Ames Type A fire resistant aircraft interior paneling, in response to Task 9 of the Statement of Work of Contract NAS 2-9153.

2.0 APPLICABLE DOCUMENTS

Unless otherwise specified, the following documents of the issue in effect on the date of issue of this document are applicable to the extent referenced herein:

Military Documents

Mil-Std-401	Sandwich Constructions and Core Materials; General Test Methods

Federal Documents

MMM-A-132	Adhesives, Heat Resistant, Airframe Structural, Metal to Metal

3.0 REQUIREMENTS

This process document establishes the fabrication techniques for manufacture of a lavatory test structure utilizing NASA/Ames Type A fire resistant aircraft interior paneling. Included are materials, tooling, fabrication procedures, design details, and quality control criteria.

3.1 Materials

3.1.1 Productive Materials

Productive materials are those materials incorporated into the product during fabrication and shall be limited to those described below:

	Description	Source
a.	Nomex Honeycomb Type HRH-10-1/8-1.8 24 mm (.95 in) thick	Hexcel Corp. Dublin, California
b.	Phosphoric Acid, 85% concentration	Commercial
c.	Quinone Dioxime Powder	Commercial
d.	Kerimid 601/1581/A1100 bismaleimide/ glass prepreg broadgoods, 32-38% resin solids, 4-8% volatiles, 12-18% flow	U.S. Polymeric, Inc. Santa Ana, California (or equivalent)
e.	Kerimid 601/120/A1100 bismaleimide/ glass prepreg broadgoods, 36-42% resin solids, 4-8% volatiles, 12-18% flow	U.S. Polymeric, Inc. Santa Ana, California (or equivalent)
f.	FM 34 adhesive film, .15 kg/m^2 (.03 psf) density, per MMM-A-132 Type IV	American Cyanamid Corp. Havre de Grace, Maryland
g.	BR 34 paste adhesive per MMM-A-132 Type IV	American Cyanamid Corp. Havre de Grace, Maryland
h.	Kerimid 601 resin	Rhodia, Inc. New York, New York
i.	N-Methyl Pyrrolidone	Commercial
j.	Acetone per O-A-51	Commercial
k.	No. 731-1/32 milled glass fibers	Thalco, Inc. Los Angeles, California
l.	Type B35A glass bubbles	The 3M Company St. Paul, Minnesota
m.	Skybond 703 resin	Monsanto Company St. Louis, Missouri
n.	Type SL601-4-7S inserts	Shur-Lok Corp. Santa Ana, California
o.	Type SL2748-08S inserts	Shur-Lok Corp. Santa Ana, California
p.	No. LS10134-1205 angle extrusion	Commercial
q.	No. 60-2355 channel extrusion	Tiernay Metals Redondo Beach, California

r.	No. SK0800 corner trim extrusion	California Custom Shapes Garden Grove, California
s.	MS27039-4-08 screw	Commercial
t.	MS24693-S46 screw	Commercial
u.	Texturized 2-mil tedlar sheet with thermoactivating adhesive backing	Polyplastex United, Inc. Los Angeles, California
v.	Epocast 8675 potting compound	Furane Plastics, Inc. Los Angeles, California
w.	Epocast 1835/9816 resin system	Furane Plastics, Inc. Los Angeles, California

3.1.2 Non-productive Materials

Non-productive materials are those materials not incorporated into the product, but are typical of those used and consumed during the fabrication process.

a. Films and Release Agents

(1)	3-mil Mylar film	E.I. Dupont & Co. Wilmington, Delaware
(2)	2-mil FEP film	E.I. Dupont & Co. Wilmington, Delaware
(3)	Type 23PB teflon coated glass	Chemical Fabrics Corp. Bennington, Vermont
(4)	Type 225 mold release	Ram Chemicals Gardena, California
(5)	Type 1B301/F54 pink release fabric	Trevarno Div of Hexcel Corp. Dublin, California

b. Bleeders and Breathers

(1)	Style 7781 glass fabric	Commercial
(2)	Style 1534 glass fabric	Commercial
(3)	Style 39705/9 dacron fabric	Burlington Industries, Inc. Greensboro, North Carolina

(4)	Aluminum screen door wire screen	Commercial
(5)	Perforated steel sheet, 23% open, 16 gauge, 1/16 diameter holes on 1/8 staggered centers	Commercial
(6)	Aluminum honeycomb Type 3/8-.003P (ACG), 25 mm (1 in) thick	Hexcel Corp. Dublin, California

c. Vacuum Bagging Materials

(1)	2-mil Capran (Nylon) film	Allied Chemical Corp. Morristown, New Jersey
(2)	Type 8282-4 vacuum sealant	Fiber Resin Corp. Burbank, California

d. Miscellaneous Materials

(1)	Toluene per TT-T-548	Commercial
(2)	Methyl Ethyl Ketone per TT-M-261	Commercial
(3)	Glass fabric, teflon & masking tape	Commercial
(4)	80 & 180 grit abrasive papers	Commercial

3.2 EQUIPMENT AND FACILITIES

3.2.1 Oven

A circulating air batch oven capable of controlling temperatures up to 522°K (480°F) is required for processing of the core, postcuring of the skins, bonding of the sandwich, and bonding of the decorative tedlar. The oven must be of a sufficient size to handle the large layup plates, and must be equipped with a suction fan to vent the exhaust gases to the outside atmosphere.

3.2.2 Autoclave

An autoclave capable of a minimum temperature of 455°K (360°F) and a pressure of 690 kPa (100 psi) is required for cure of the skins.

3.2.3 Tools

The only tools required are flat aluminum layup platens of a size sufficient to handle the largest panels. Platens 1.2 m x 2.1 m (4 ft x 7 ft) will suffice. A handling cart which will support the platens flat and level is required.

3.3 Materials Storage and Handling

3.3.1 Kerimid 601/7781/A1100, Kerimid 601/120/A1100 and FM 34 prepregs shall be stored at or below 241°K (0°F). These materials shall be allowed to warm to room temperature in their sealed containers prior to removal to prevent moisture condensation.

3.3.2 Honeycomb shall be stored flat in its original shipping containers until required for fabrication.

3.4 Materials Preparation

3.4.1 Fabrication of Precured Skin Stock

Precured skin stock shall be laminated a minimum of two inches (51 mm) larger on a side than required per the engineering drawing (Figure 1) per the following procedure.

a. Allow a roll of the Kerimid 601/7781/A1100 and a roll of the Kerimid 601/120/A1100 prepregs to warm to room temperature prior to unspooling.

b. Cut patterns for the following and layup on an aluminum platen. All patterns are to be splice free.

Platen
2-mil FEP film
1 ply K601/7781/A1100
1 ply K601/120/A1100
1 ply 23PB teflon coated glass
1 ply dacron fabric

c. Bag layup for autoclave cure using Capran film and vacuum sealant.

d. Autoclave cure as follows:

Raise temp, press rapidly to 394°K (250°F), 690 kPa (100 psi), 584 mm Mercury (23 in Mercury) minimum
Raise temp at 1°K/min (2°F/min) to 455°K (360°F)
Hold temp, pressure, vacuum for 4 hours
Cool to 339°K (150°F) under pressure and vacuum

e. Debag cured skin stock, hang in a circulating air oven and postcure as follows:

Raise temp rapidly to 422°K (300°F)
Raise temp at 1°K/min (2°F/min) to 522°K (480°F)
Hold 522°K (480°F) for 16 hours
Cool to 339°K (150°F)

f. Repeat sequences 3.4.1 a through e as required to obtain the required number of skins. Store the precured skin stock flat until ready for use in the sandwich bonding operations.

3.4.2 Fabrication of Core Stock

The core stock shall be fabricated a minimum of 25 mm (1 in) larger on a side than required by the engineering drawing (Figure 1). The core as foamed shall be unjointed; any joints required during sandwich bonding will be butt joints bonded during assembly.

a. Cut the 24 mm (.95") thick Nomex core into the required sizes. Weigh and record.

b. Rig a dipping frame consisting of 4.8 mm (.19") thick steel bar stock double back taped to a flat level surface. The frame shall be approximately 12.5 mm (.50") larger than the core on a side.

c. Mix .65 grams/cm^2 (4.2 grams/in^2) of foaming solution to the following recipe:

    37.46% Quinone Dioxime powder
    62.54% Phosphoric acid (85% concentration)

   Stir well to assure that all the powder goes into solution. Workers should wear protective clothing such as acid resistant rubber gloves and aprons when handling the acid or acid solution.

d. Pour the solution into the dipping frame and sweep with a steel bar to give a uniform layer 4.8 mm (.19") deep.

e. Immerse the core in the solution for 10 minutes, remove and flip the core over (dipped side up). Check the wet pickup. It should be .31-.34 g/cm^2 (2.0-2.2 g/in^2). If necessary the core can be redipped to increase the pickup.

f. Air dry the core for 60 minutes minimum at room temperature.

g. Preheat the oven and two 12.5 mm (.50") thick aluminum plates to 423°K (302°F).

h. Lay up the core as follows:

    Mylar film
    Style 1534 glass fabric
    Aluminum wire screen
    Core - dipped side down
    Aluminum wire screen
    Perforated steel sheet (23% open)
    3/8-.003P(ACG) honeycomb
    Mylar film

The mylar should be approximately 100 mm (4") larger on a side than the core, and the lower and upper sheets stapled together to hold the layup together for convenience of handling.

i. Load the layup in the oven between the preheated aluminum plates. Apply approximately .10 N/cm^2 (.15 lb/in^2) load to the layup with shot bags uniformly distributed over the top plate.

j. Intumescense begins in approximately 5 minutes. Hold for 10 minutes at 423°K (302°F) after the foaming action stops (Onset on the foaming can be detected by observing the oven exhaust).

k. Remove the layup, extract the foamed core and clean up as required. Weigh and record.

l. Postcure the foamed core for 3 hours at 423°K (302°F) followed by 3 hours at 455°K (360°F).

m. Check the density of the foamed core, and calculate the foam only density from the weights recorded during processing. The density of the foam itself should be 24-32 kg/m^3 (1.5-2.0 lb/ft^3).

3.4.3 Fabrication of the Edging Stock

The stock used for edging shall be precured cast polyimide syntactic foam fabricated as follows:

a. Prepare a low pressure casting form with lid by cleaning with solvent and releasing with Ram 225.

b. Prepare 1.7 g/cm^2 (11 g/in^2) of syntactic foam mix per the following recipe:

3 parts Skybond 703 resin
2 parts Acetone
2 parts No. 731-1/32 milled glass fibers
2 parts type B35A glass bubbles

Mix well. The end mix will be of the consistency of a heavy grout.

c. Pack the mix into the casting form, taking care to tamp the material well into the corners while packing.

d. Place the lid over the mold leaving a gap of approximately 1.5 mm (.06") at each end as vents. Secure the lid to the mold.

e. Cure the casting in an oven as follows:

2 hours at 322°K (120°F)
2 hours at 339°K (150°F)
2 hours at 355°K (180°F)
4 hours at 455°K (360°F)

f. Remove the casting from the form and postcure under restraint as follows:

Raise temp rapidly to 422°K (300°F)
Raise temp at 1°K/min (2°F/min) to 522°K (480°F)
Hold 522°K (480°F) for 16 hours
cool to 339°K (150°F) under restraint

g. Repeat sequences 3.4.3 a through f to obtain the required amount of stock. Cut the stock into strips 24 mm (.95") thick by the width and length required by the engineering drawing (Figure 1).

h. Check the density of the precured edging stock by weights and measurements. It should be 300-400 kg/m^3 (19-25 lb/ft^3).

3.4.4 Bonding of the Basic Sandwich Stock

Because of the use of precured skins, NASA/Ames Type A panels must utilize a solid type edge band; the common beveled edge/doubler type close-out is impractical. The sandwich layup shall allow for approximately 6.4 mm (.25") of overstock for trim on each side.

a. Cut the core to the size required by the engineering drawing (Figure 1) allowing for the precured edging stock. Prepare the core for bonding by cleaning the surface foam away with a stubby bristled brush so that .5-1 mm (.02"-.04") of the honeycomb webs are exposed. Be sure that no foam is clinging to the tops of the webs; use adhesive tape to pick off loose pieces clinging statically to the core.

b. Prepare the precured skins for bonding by thoroughly sanding the 120 fabric side with 80 grit paper, then cleaning with MEK.

c. Tape the outer skin to the platen with glass tape. Apply a very thin coating of BR 34 adhesive (thin with N-Methyl Pyrrolidone if required) to the bond surface.

d. Position a ply of FM 34 adhesive film onto the primed precured skin and heat tack. If joints are required, they are to be butt joints.

e. Position the trimmed core per the engineering drawing requirements. If joints are required, they shall be butt joints with BR 34 adhesive applied to each faying edge of the joint.

f. Cut the precured edging to the proper lengths. Coat 3 sides of each strip with BR 34 adhesive and position onto the layup.

g. Trim the inner skin (prepared for bonding as in -b- above) to the layup size and heat tack a ply of FM 34 film adhesive to the faying side. Position over the layup adhesive side down.

h. Surround the layup with an edge dam using 25 mm (1") square aluminum tubing cut to the proper lengths. The tubing shall be covered with teflon tape for release on the sides where it touches the layup. The tubing must be positioned to the layup flush to a maximum gap of 1.6 mm (.06"). Tape the ends of the tubing to hold in position.

i. Pad the sharp corners of the edge dam with stockinette. Cover the layup with one ply of mylar film followed by a 1.6 mm (.06") thick aluminum caul plate and a ply of pink release fabric. Tape the film, caul plate and release fabric to the edge dam.

j. Apply a Capran bag over the layup with vacuum sealant and draw a minimum vacuum of 584 mm (23") Hg. Arrange the bag as the air is being drawn out such that all bridging is eliminated, and the bag over the skin is wrinkle free. Check the bag for leaks.

k. Cure the layup in a circulating air oven as follows:

Raise temp rapidly to 394°K (250°F)
Raise temp at 1°K/min (2°F/min) to 455°K (360°F)
Hold 455°K (360°F) for 4 hours
Cool under pressure to 338°K (150°F)

l. Debag the layup and clean up as required.

3.4.5 Trimming and Installation of Inserts

a. Trim the sandwich panels to size per the engineering drawing (Figure 1) using a table saw with a 60 grit diamond blade, and touch up as required with 180 grit abrasive paper.

b. Machine the SK0800 corner trim and LS10134-1205 angle extrusions to the engineering drawing (Figure 1).

c. Dry fit the panels with the matching hardware to assure proper fit. Transfer the hole patterns from the corner trim and mounting angles to the panels. Lay out the outside hole patterns per the engineering drawing (Figure 1).

d. Attachment of the hardware to the panels is by means of SL601-4-7S blind inserts. The outside hole patterns, which are for mounting the test structure to the test fixture, will also use the same type of blind inserts. To install these inserts, use a 17.4 mm (.69 in) diameter diamond counterbore mounted in a microstop unit set for a depth of 22.3 mm (.88") to prepare the holes in the sandwich. Use a pair of tweezers to clean out the core at the bottom of the holes to the back side skin. Align a Shur-tab mask support to each insert and install. The mask has contact cement on it; Be sure that it is making good contact with the skin. Mix the following potting compound:

70 parts Kerimid 601 resin powder
30 parts N-Methyl Pyrrolidone
15 parts type B35A glass bubbles

Load the mix into a Semco model 250 sealant gun equipped with a nozzle with a 1.6 mm (.06") orifice. Inject each insert with potting compound. "Wiggle" each mask to be sure the insert is properly seated, then tape around each mask with glass tape. Place the panel on an aluminum platen and lightly clamp to hold flat. Cure the potting compound as follows:

Raise temp rapidly to 455°K (360°F)
Hold 455°K (360°F) for 4 hours
Cool down slowly to 338°K (150°F)

Remove the masks and grind off any resin overflow flush to the skin. Note that in the above procedure the inserts can be installed on one side at a time only. Any paneling that has inserts on both skins will have to be done in two operations.

3.4.6 Application of the Decorative Tedlar

a. Cut the decorative Tedlar, which is adhesive backed, approximately 12.5 mm (.50") larger on a side than the panel. Clean the panel skins with MEK. Air dry.

b. The Tedlar will be applied to both skins in a single operation. Lay up a ply of 7781 fabric (joint free) on top of an aluminum platen and smooth out any wrinkles. Tape to the tool. Lay up the outer sheet of decorative Tedlar, adhesive side up and tape in place. Position the panel, the second sheet of Tedlar and a second ply of 7781 fabric on top of the layup. Tape a thermocouple to the edging at the lower bond line. Install a Capran film bag over the layup with vacuum sealant and draw 254 mm (10") of Mercury. Arrange the bag so that it is wrinkle free over the top of the layup. Cure the layup in a circulating air oven for one hour at 377°K (220°F) as determined by the thermocouple.

c. Debag the layup. Use a razor blade to neatly trim the Tedlar flush to the edges of the skins. Use an Exacto knife to trim away the Tedlar covering the inserts.

3.4.7 Application of Edge Finish to Ceiling Panel

The ceiling panel has two edges that are finished with an aluminum channel extrusion.

a. Machine the trim to the engineering drawing (Figure 1). Dry fit the trim to the ceiling panel, beveling the edges of the panel as required for a good flush fit. Transfer the hole pattern from the trim to the syntactic foam edging.

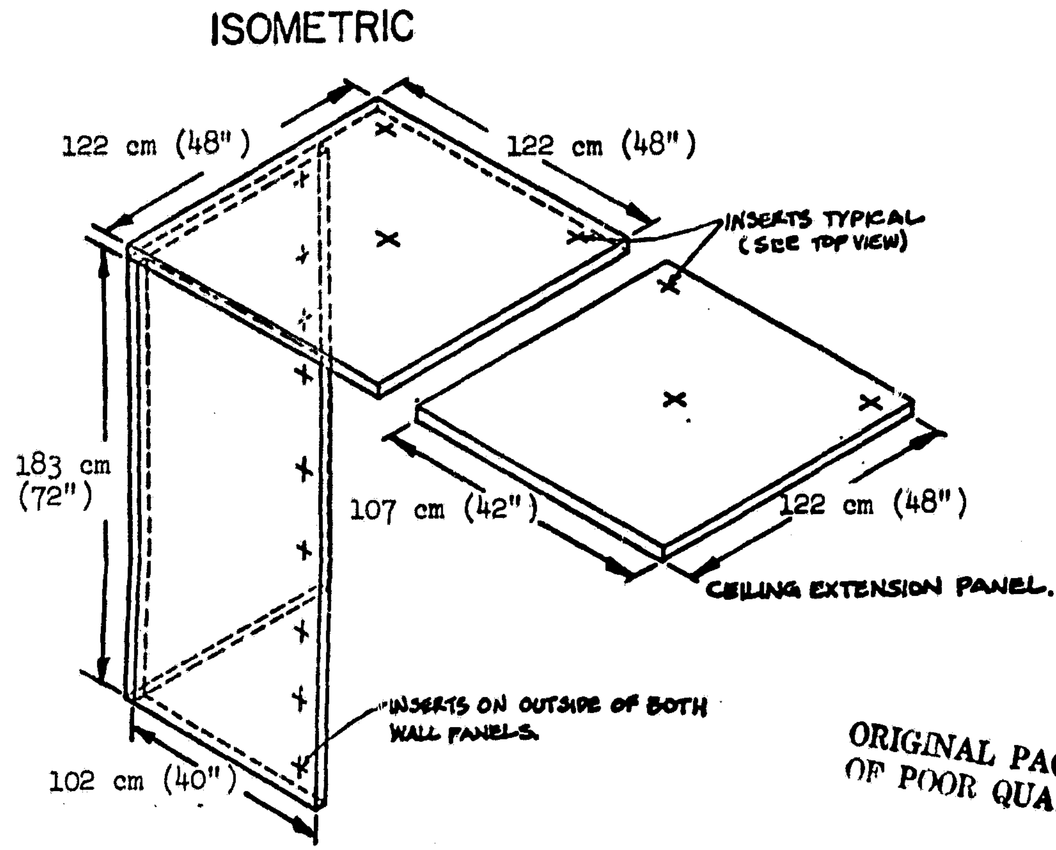
b. The trim will be attached to the panel edging with SL2748-08S inserts and MS 24693-S46 flat head screws. Drill the syntactic foam edging 8.7 mm (.344") diameter x 9.5 mm (.38") deep. Install the inserts with Epocast 8675 mixed per the manufacturer's instructions and cure overnight at room temperature.

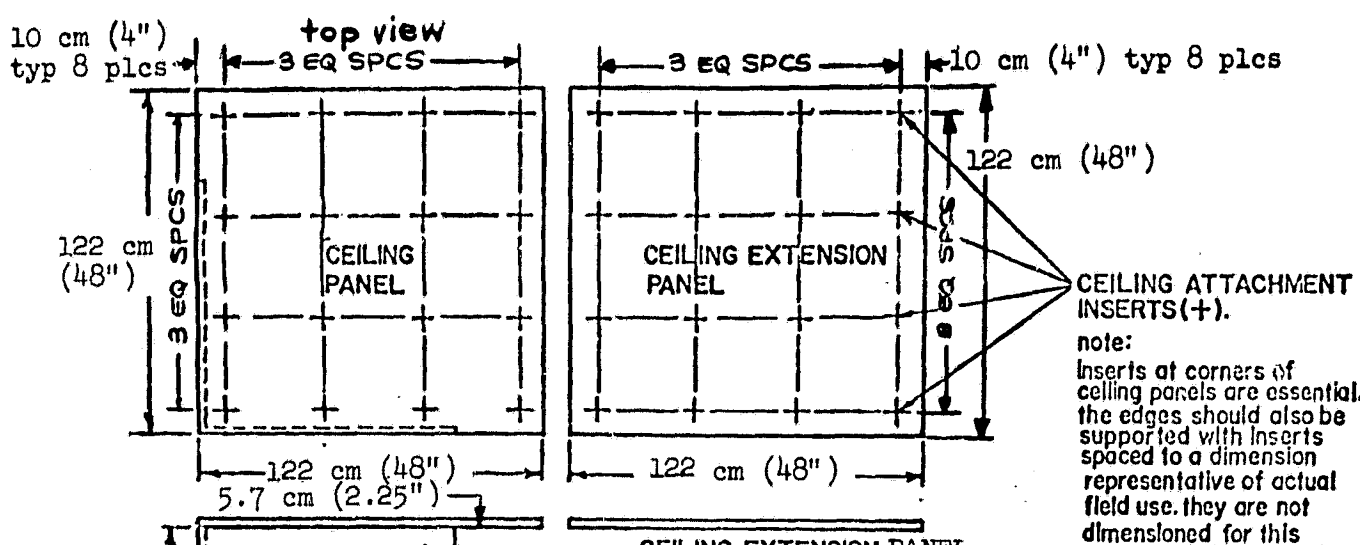
c. Install the aluminum channel trim to the panel with MS 24693-S46 screws, taking care to get a smooth corner at the mitered intersection.

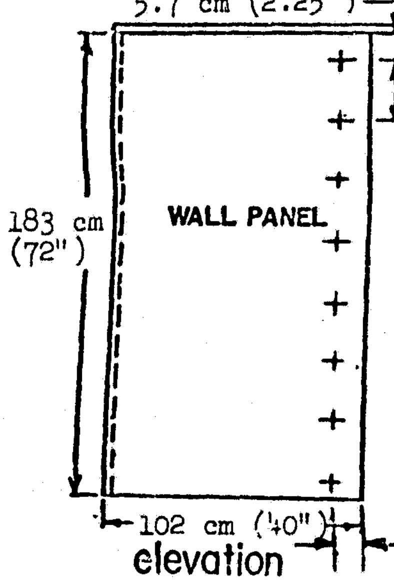
3.4.8 Final Assembly

Bolt the lavatory test structure together using MS 27039-4-08 screws, taking care to align the pieces to obtain a square corner and perpendicular sides. Torque each screw 2.3 N·m (20 lb-in).

Figure 1 - NASA/AMES LAVATORY TEST STRUCTURE





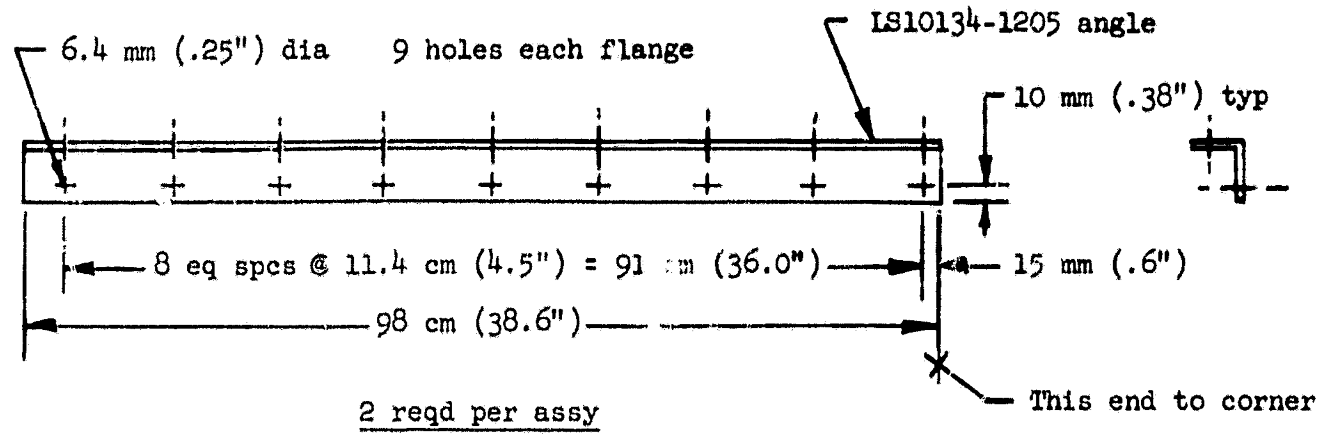


Symetrical on both sides

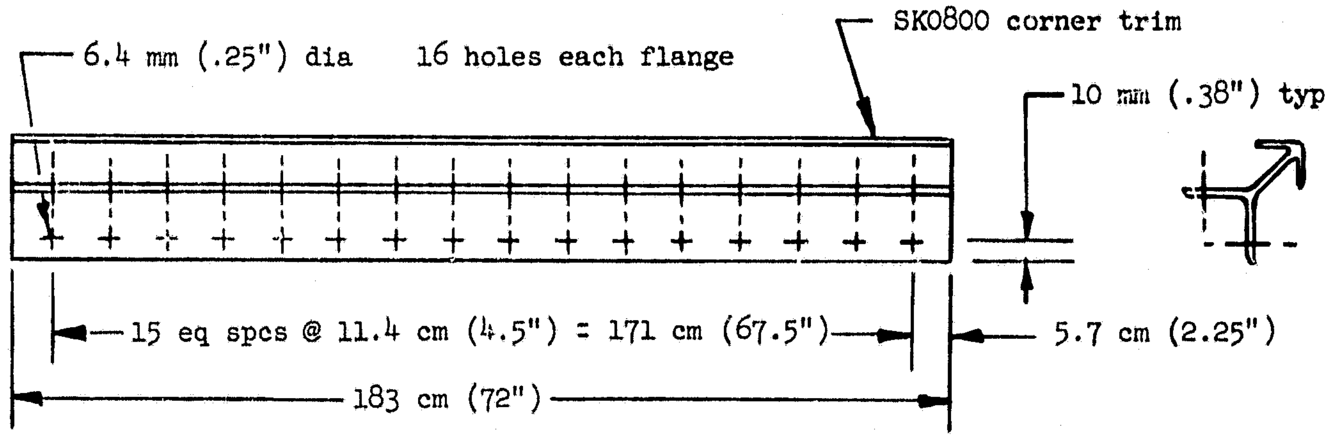
1. One inch thick
2. 2 Mil Tedlar on both sides.
3. Area density, 0.55 to 0.67 lb./ft^2 w/out inserts & potting.
4. 1/8" cell Nomex honeycomb with QDO foam. 1.8 PCF
5. One layer K601/181 glass cloth and one layer K601/120 glass cloth on each side.
6. Edges and corners consist of epoxy/phenolic microballoons or equivalent. All panels to have edge close outs,
7. FM-34 adhesive to bond facesheets to honeycomb.
8. Insert definition - blind, installed on outside of structure, insert size shall be NO 10. (Report #2) or larger size as required.
9. Adhesive used to bond Tedlar to face skins shall be heat activated, commonly supplied with std Lockheed L-1011 Tedlar.

Figure 1 - NASA/AMES LAVATORY TEST STRUCTURE

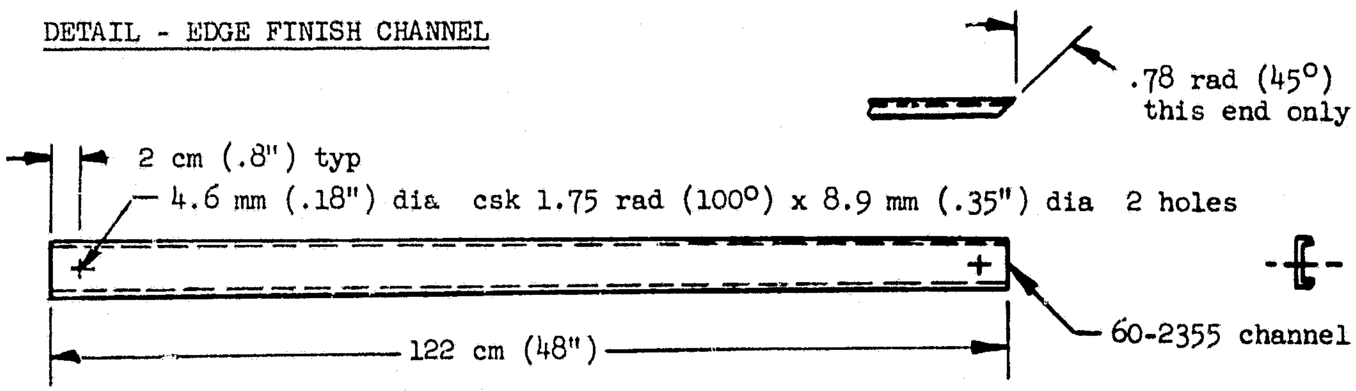
DETAIL - CEILING MOUNTING ANGLE



DETAIL - CORNER TRIM



DETAIL - EDGE FINISH CHANNEL



3.5 In-Process Repair Procedures

In-process repairs may be made on any of the panels that exhibit certain defects after bonding or assembly as follows:

3.5.1 Repair of Delaminated or Unbonded Areas

a. Prior to application of the decorative Tedlar, unbonded areas between the skin and core less than 64 cm^2 (10 in^2) in size may be repaired by drilling .8 mm (.03") diameter holes in the unbonded area through the skin only and injecting BR 34 adhesive (cut with NMP). Cover the repair with one ply of pink release cloth and an aluminum caul plate. Apply approximately 13.8 kPa (2 psi) load with weights. Cure per paragraph 3.4.4.k.

b. If any unbonded areas exceed 64 cm^2 (10 in^2), or are profuse (more than one unbonded area per 1000 cm^2 (1.1 ft^2) of surface), the skin must be removed and relaminated. Follow the procedure outlined in paragraph 3.4.4 for relamination. Note that all the original FM 34 must be ground off the precured skin and picked off the honeycomb prior to relamination.

c. Edge delaminations between the skin and precured foam edging, prior to application of the decorative Tedlar, may be repaired by working BR 34 adhesive into the separation, clamping, then curing per paragraph 3.4.4.k.

d. If any delaminations are found after application of the decorative Tedlar, repair shall be accomplished as per paragraphs a, b and c above, except that Epocast 1835/9816 mixed per the manufacturer's instructions shall be substituted for BR 34, and cure shall be overnight at room temperature. The substitution is required because the adhesive backing of the decorative Tedlar will not withstand the cure temperature of BR 34. Delaminations repaired with 1835/9816 shall be limited to the cold side (outside) skin and to the panel edges.

3.5.2 Replacement of Defective Inserts

Inserts that cure misaligned must be drilled out and replaced. Follow paragraph 3.4.5 for repotting procedure.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 Surveillance

Sufficient surveillance shall be exercised to ensure that the provisions and requirements of this document are met.

4.2 Raw Material Testing and Inspection

All purchased raw materials shall be certified by the vendor to the Hitco purchase order requirements and to the requirements of any applicable material specifications. Hitco inspection shall verify receipt, completeness and compliance of materials and certifications to the purchase order requirements.

4.3 Process Control Panel

One process control test panel will be layed up and cured together with each production batch of sandwich panels. The test panel shall be 200 mm (8") x 400 mm (16") in size and utilize tag end pieces of precured skin and foamed core stock used in the lavatory structure paneling being cured. The core ribbon shall be aligned in the 200 mm (8") direction; the skin warp shall be aligned in the 400 mm (16") direction. The FM 34 adhesive and BR 34 primer shall be of the same lot as used to bond the production paneling. Decorative Tedlar is not required for this test panel. Edge dams are to be used in laying up the process control test panel; these are especially important since the precured foam edgings are not being used.

a. Check the cured process control test panel for surface density by trimming to a uniform size, then weighing and measuring it. The cured panel must have a density between 2.7 and 3.3 kg/m^2 (.55 and .67 lb/ft^2).

b. Prepare and test two climbing drum peel and 3 flatwise tensile test specimens per Mil-Std-401. The minimum average peel strength is 1.0 N·m/7.5 cm (9 lb-in/3 in). The minimum average flatwise tensile strength is 700 kPa (100 psi).

4.4 Documentation

Hitco shall maintain all raw material, process, dimensional and test records as stipulated above and shall be responsible for traceability of this documentation for a period of 3 years.