Process Specification for the Assembly of Composite Sandwich Structures

Engineering Directorate

Structural Engineering Division

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REVISIONS		
VERSION	**CHANGES**	**DATE**
--	Original version	7/21/97
A	Reviewed due to ISO requirements. Added section on process qualification and renumbered accordingly. Changed training instruction call-out to 6002 series TI.	12/1/99
B	Reviewed per QMS requirement. Removed references to old division name. Updated training requirements to TI-6001-03 and TI-1001-01.	12/13/02
C	Reviewed per QMS requirements. Specified ancillary materials as consumables.	4/7/05
D	Updated reference to JPR 8500.4 and JPR 5322.1	5/17/07
E	Updated requirements for cold storage of materials in paragraph 5.4. Updated tool requirement to include a thermal survey of tools that weight more than 50 lbs. Updated requirements for potting in paragraph 6.3.~~3~~9. Updated requirements for core splicing in paragraph 6.3.10. Update section on laminated ply joints and splices to better clarify acceptable limits for unidirectional and fabric prepregs in paragraph 6.3.11. Updated demolding requirements to allow non-metallic tools only in paragraph 6.3.15. Added paragraph to include steps required to prevent contamination during processing in paragraph 6.3.18. Updated division name in document. Signature updates	5/15/20

1.0 SCOPE

This document provides the standard requirements for the assembly of sandwich structures.

2.0 APPLICABILITY

This specification shall be applicable whenever a sandwich assembly manufacturing process is invoked per Section 3.0, “Usage”.

3.0 USAGE

This section gives the requirements for the proper use of this process specification.

In accordance with the drawing and part definition requirements of JPR 8500.4, “Engineering Drawing System Manual”, the standard sandwich assembly composite part manufacturing process shall be invoked by providing a process note in the applicable drawing or CAD model as is exemplified in Figure 1.

MANUFACTURE SANDWICH ASSEMBLY PER JSC PRC-6002, LEVEL 1, TYPE 2.

Figure 1. Example of a process note for sandwich assembly manufacture.

3.1 LEVEL

The "Level" designator governs the extent to which quality assurance provisions are applied and shall be specified in the process note on the basis of the following definitions:

a. Level 1 — Level 1 processes shall include the practice of the quality assurance provisions as required by Section 8.1. Whenever invoking these Level 1 provisions, the designer should also consider calling out an NDE process specification on the drawing or CAD model.

b. Level 2 — Level 2 processes shall include the practice of the quality assurance provisions as required by Section 8.2.

3.2 TYPE

The “Type” designator governs the manufacturing process with which the sandwich panel will be fabricated. This type shall be specified in the process note based on the following definitions:

a. Type 1 – will invoke a one-step cure process that bonds pre-cured facesheet details and core simultaneously using a supported film adhesive (i.e., all components are pre-cured, this is tantamount to a simple secondary bond and PRC-1001, “Process

Specification for Adhesive Bonding", requirements shall be applied).

b. Type 2 – will invoke a multi-step curing process whereby uncured material is laid up with supported film adhesive and a core onto a pre-cured facesheet. This process may require intermediate bonding cycles for core positioning and core stabilization (i.e., partial co-curing of assembly).

c. Type 3 – will invoke a one-step co-cure process that bonds facesheet details and core simultaneously using supported adhesive (i.e., full co-curing of assembly).

3.3 CURE AND POST-CURE SCHEDULES

Unless otherwise stated on the drawing or CAD model, standard cure and post- cure schedules will be applied to the material in accordance with Section 6.3.14. Add special cure or post-cure instructions, if necessary, to the process note on the applicable drawing or CAD model.

3.4 NON-DESTRUCTIVE EVALUATION (NDE)

This specification does not address the application of non-destructive evaluation (NDE) methods. However, when calling for Level 1 processing, the designer should also consider the use of NDE inspection by calling out a separate NDE process specification and test area on the drawing or CAD model.

3.5 POTTING MATERIALS

Honeycomb core may be densified using potting foam or adhesive to improve panel manufacturability and strength. Potting shall be applied per Section 6.3.9.

3.6 METALLIC HONEYCOMB CORE

Note that metallic honeycomb cores may require special preparation, handling, and/or storage prior to bonding. Special procedures for such items shall be specified on the drawing or CAD model.

3.7 ADHESIVES

Only film adhesives shall be defined as part of the sandwich panel assembly per the drawing or CAD model.

4.0 REFERENCES

The following documents were used in developing this specification:

JPR 5322.1 *Contamination Control Requirements Manual*

JPR 8500.4 *Engineering Drawing System Manual*

The following document is invoked as part of this specification:

ANSI/NCSL Z540-1 *Calibration Laboratories and Measuring and Test Equipment General Requirements*

ASTM D 2240 Standard Test Method for Rubber Property – Durometer Hardness

5.0 MATERIAL REQUIREMENTS

5.1 PRECURSOR PART MATERIALS

Precursor part materials (e.g., pre-impregnated composite materials, honeycomb core, neat resins, or reinforcement materials) shall satisfy the requirements of any applicable material specifications given on the applicable drawing or CAD model.

5.2 ANCILLARY MATERIALS

Ancillary materials including vacuum sealants, vacuum bagging, tapes and mold releases shall remain chemically inert with respect to the part material (or materials) throughout the extent of processing. These materials are non- deliverable process consumable items.

5.3 PEEL PLY MATERIALS

Peel ply fabrics are unique ancillary materials that may be included in the sandwich panel lay-up to produce a textured faying surface for second stage bonding.

5.4 STORAGE & MATERIAL LIFE REQUIREMENTS

Raw materials used for sandwich panel fabrication shall be stored in an environment as specified by an applicable Material Data Sheet (MDS) or, if an applicable MDS does not exist, per the vendor's published recommendations. For materials with specified life limits, storage/shelf life and material "out-time" (for cold storage materials) shall be managed in compliance with applicable Material Data Sheets. Out-time for a cold storage material is cumulative, and includes all the time a material is removed from refrigeration. Traceable storage temperature records shall be kept by the Manufacturer for materials with specified storage temperature limits.

All cold temperature storage materials shall be sealed in a vapor barrier bag and stored at 0°F or below. Uncured part details or ply kits should be supported by a flat surface, lay-up template, or curing tool to prevent damage or distortion. Prepreg rolls should be supported by core inserts, saddles, or equivalent. Before opening a sealed vapor barrier bag, the refrigerated material shall be allowed to warm sufficiently at room temperature in an environmentally controlled area until there is no reformation of condensate on the bag surface when the exterior

surface is wiped dry, or alternatively, when the outside surface temperature measures 60°F or above. During thaw, prepreg and adhesive rolls shall be properly supported such that the material is not deformed. When returning materials to refrigerated storage after use, the material and any desiccant provided in accordance with the applicable material specification, shall be resealed inside the vapor barrier bag.

Contractors shall obtain applicable MDS's from JSC Manufacturing before processing.

6.0 PROCESS REQUIREMENTS

6.1 WRITTEN PROCEDURES AND STANDARDS

The Manufacturer shall use the most up-to-date procedures for the manufacturing of sandwiched composite parts.

For contracted work, refer to the contract for requirements concerning the use of written procedures. Contractors shall also obtain applicable Material Data Sheets (MDS) from JSC Manufacturing before processing.

For work performed at JSC facilities, written procedures shall be used consisting of Detailed Process Instructions (DPI's) selected from the DPI-6000, and DPI-6002 series of work instructions. MDS's shall also be used internally.

6.2 TYPE 1 REQUIREMENTS

The requirements for the assembly of Type 1 sandwich structures shall be that of PRC-1001, "Process Specification for Adhesive Bonding".

6.3 TYPE 2 AND 3 REQUIREMENTS

6.3.1 Facilities

Composite lamination facilities shall be continuously maintained between 67°F and 75°˚F with a relative humidity below 55%. All work surfaces shall be free of particulate matter visible to the unaided eye (corrective lenses are acceptable). Airborne particles shall be constantly limited in number according to the distribution given in Table I.

Table 1: Particle Size Requirement for Lamination Facility.

Particle Size:	Number of Particles per Cubic Foot:
$<$ 0.5 micron	Not measured or accounted
$\geq$ 0.5 micron	100,000
$\geq$ 5.0 microns	700

6.3.2 Equipment

For contracted work, refer to ANSI/NCSL Z540-1 or any applicable contractual requirements concerning the maintenance and calibration of equipment. For JSC in-house work, all applicable temperature and pressure measurement instrumentation shall be calibrated by the JSC Measurement Standards and Calibration Laboratory (MSCL).

6.3.3 Tools

Tools shall be designed and manufactured so that the final part shall possess the intended dimensional accuracy (see section 6.3.4) and specified surface finish.

The tool design shall also be created such that the chemical inhibition of the prepreg part material is minimized (i.e., the finished tool surface is compatible with the part material). A unique alphanumeric identification shall be placed directly on each tool. Tools used for autoclave processing shall be vacuum leak tested to an acceptable rate of no more than 5 in. Hg. over a period of 5 minutes.

A thermal mapping heat survey shall be conducted on each new or extensively altered tool weighing more than 50 lbs. A minimum of one thermocouple per 20 square feet is required for this evaluation, resulting in a maximum temperature difference between the hottest and coldest regions of the tool of no more than 20°F. The heat survey must represent tool location and orientation within the curing equipment and may be used to determine optimal placement of both leading and lagging temperature indicators for oven cure control during production. The addition of insulation and/or supplemental heating equipment on the tool may be required to meet cure profile requirements. Alternately, the target cure profile may be adjusted by M&P engineering to better accommodate the tool thermal characteristics.

6.3.4 Dimensional Accuracy of Parts

Finished parts shall not violate the dimensional limits prescribed by an applicable drawing or CAD model, contract, or work order. If any dimensional errors are found, then a discrepancy report shall be generated, and a corrective course of action shall be determined.

6.3.5 Mold Release Materials

Mold release materials shall be chosen (according to the MDS when available) in order to ensure its compatibility with the part material and the proper demolding or separation of the part and tool after curing. Great care should be taken to avoid cross-contamination of these materials during processing.

6.3.6 Material Out-Time and Shelf Life

The out-time and shelf-life of the adhesive/prepreg material shall not exceed the shelf-life requirements specified by an applicable MDS or, if one does not exist, the vendor's specifications. Traceable out-time and shelf-life records shall be kept for materials for which out-time and shelf-life limits are specified. If the material out-time or shelf life exceeds the

specification, then requalification steps may be performed in accordance with an applicable MDS.

6.3.7 Core

Forming and trimming of core shall be accomplished so as not to damage the dimensional characteristics of the structure as specified on the drawing or CAD model.

For honeycomb core, the cell geometry and ribbon direction shall be held constant at all times. Potting of honeycomb core for the purposes of densification shall be performed in areas of the assembly specified by the drawing or CAD model. Potting procedures shall be defined in detailed procedures.

6.3.8 Adhesives

Only film adhesives shall be defined as part of the sandwich panel assembly per the drawing or CAD model. Film adhesive application and lay-up shall be explained in detailed procedures.

6.3.9 Potting

The mixing and pot life of potting materials shall be controlled according to the material MDS. For epoxy paste potting compounds, correct mixing of adhesive and pot life shall be verified by completing a durometer hardness test at room temperature on a 0.25 inch “control” coupon in accordance with ASTM D 2240. Five determinations shall be taken upon completion of the cure, with each measurement exceeding the manufacturer’s specified minimum

The application of potting materials to core details shall be accomplished according to the potting material MDS or, in the absence of an MDS, vendor’s specifications. All core cells with potting material shall be filled completely. A technique to ensure that cells are completely filled without damaging the surrounding core or adjacent laminate & film adhesive shall be documented in the detailed manufacturing process instructions. Potting of inserts which require holes in the facesheet material shall be accomplished without delaminating the facesheet(s).

6.3.10 Core Splicing and Bonding

Splicing of honeycomb core details is acceptable using adhesive/foam when the gap tolerance between details is less than 0.100 inches. Panel design integrity must be maintained by adhering to engineering allowables of ribbon direction, density and contour.

Properly trimmed and spliced honeycomb core may be bonded in place to the inner mold line of the pre-cured outer facesheet using a supported film adhesive. Procedures for trimming, splicing and locating of the honeycomb core to the pre- cured composite outer facesheet shall be outlined in detailed procedures. For pre-cured face sheets with contoured geometries and/or ply drops, special consideration shall be given to the need for “fit-checking” core details against the pre-cured face sheets before completing the bonding operation (e.g., Verifilm).

Areas of mismatch, such as tool-side face sheet ply drop areas that fail bond contact verification or core-to-core height tolerance mismatch, may be covered with a second layer of film adhesive.

The vacuum bagging and curing of the adhesive during this procedure shall be defined in the adhesive MDS.

6.3.11 Laminated Ply Joints and Splices

The following requirements apply to all splices unless specified otherwise on the Engineering Drawing. Splicing of fabric plies shall be accomplished with an overlap from 0.5 to 1.0 inch. As shown in Figure 2, splices of uni-tape perpendicular to the fibers shall be accomplished with an end-to-end overlap from 1 to 2 inches. Splicing of uni-tape parallel to the fibers shall be accomplished with a butt splice.

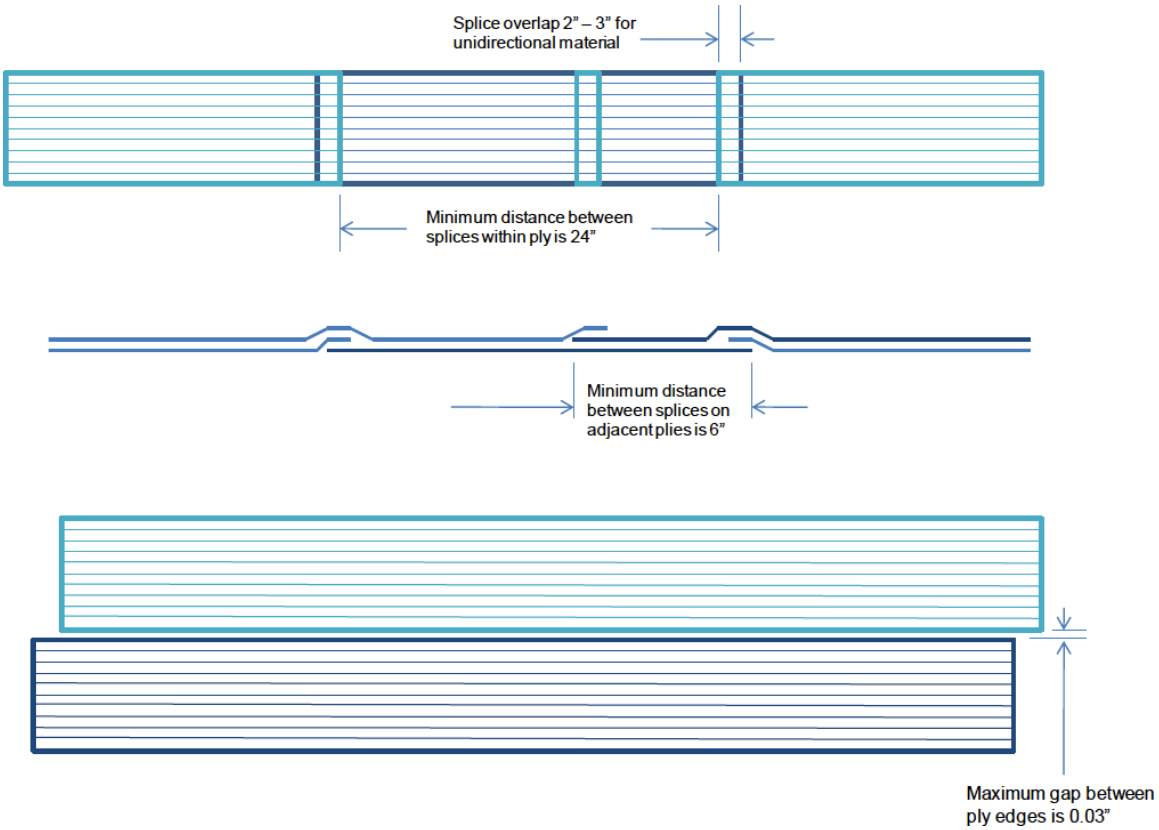

Figure 1: Splicing of Uni-Directional Tape

Film adhesives shall be spliced with a butt splice. Butt splices (if allowed) for uni- tape, fabric, and film adhesives shall have no gaps wider than 0.03 inch along its length. Splice locations in like-oriented plies shall not repeat more than every six plies through thickness. The minimum distance between splices within a ply is 24 inches. The minimum distance between splices from one ply to the next is 6 inches.

Any deviations from the above splicing requirements requires full development testing to

establish the properties of the new splicing configurations.

6.3.12 Debulking/Vacuum Compaction

In most circumstances, bagging the sandwich panel for consolidation at intervals during the lay-up process is required. Perform debulking steps at a frequency and procedure determined by the principally used prepreg material MDS, or every 7 plies, whichever is smaller. More frequent debulking is allowed.

6.3.13 Vacuum Bag Assemblies

Vacuum bag assemblies are to be used to aid in the consolidation of the sandwich panel. All vacuum bag assemblies shall be airtight to preclude underpressurization of the sandwich panel. Sufficient amounts of bagging material should be used during lay-up in order to prevent material bridging which would result in serious vacuum leaks during cure. Leaks in vacuum bag assemblies shall not exceed 5 inches Hg over a 5-minute period.

The materials used in vacuum bag assemblies shall be chosen to meet the requirements of the particular cure schedule, including temperature and pressure.

6.3.14 Cure and Post-Cure Schedules

The curing and post curing of sandwich structures shall be controlled by the film adhesive/prepreg material MDS, drawing, CAD model, or applicable contractual document.

6.3.15 Demolding (Tool/Part Separation)

Demolding (i.e., the removal or separation of the part from the tool) shall be accomplished in a manner that is safe and prevents damage from occurring to both part and tool. Only nonmetallic/plastic tools shall be used to preclude part and tool damage.

6.3.16 Identification

Hardware shall be identified with the correct part number and serial number.

6.3.17 Handling and Storage

All raw materials (honeycomb core, prepreg fabric, unidirectional tape, adhesives, mold releases, etc.) shall be handled and stored in accordance with applicable Material Data Sheets (MDS's).

Finished composite panels require extreme care when handling due to sharp edges caused by excess resin (flash). Wearing of suitable hand protection is required. Composite parts shall be handled safely and stored in a room temperature air-conditioned environment that prevents any possible damage from occurring.

6.3.18 Contamination

Disposable gloves should be worn only once. Gloves which become soiled during normal manufacturing operations should be discarded immediately. Cleaning & mold release cloth should be discarded immediately following any sanding, cleaning and mold release application operations. Materials, tools, and parts shall be investigated to ensure visible cleanliness levels are maintained throughout production. If contamination is suspected and cannot be dispositioned, the discrepancy shall be documented per the appropriate non-conformance procedures. Where possible, cleaned detail parts and tools should be handled by the edges only. To avoid contamination of surfaces to be bonded, silicone type pressure-sensitive tape materials shall never contact any end item materials directly.

7.0 PROCESS QUALIFICATION

For work performed within the Structural Engineering Division, written procedures shall be used, and they shall consist of Detailed Process Instructions (DPI's) selected for use from the DPI-6002 series of work instructions. The DPI-6002 series of work instructions shall be validated on non-flight hardware. No untested DPI shall be used to manufacture flight hardware.

8.0 PROCESS VERIFICATION

8.1 LEVEL 1 PROCESS VERIFICATION

Detailed procedures for Level 1 processing shall contain defined Mandatory Inspection Points (MIP's). These MIP's shall describe or refer to specific second- party inspection methods and criteria with which to verify the quality of the composite part. MIP's shall, at a minimum verify:

a. The out-time and shelf life of adhesive and prepreg part materials satisfy Section 6.3.6.

b. Material Certificates of Compliance are kept by Quality Assurance.

c. Lay-up sequence and orientation of honeycomb core and composite ply details conform to the part design.

d. Proper execution of the part cure and post-cure operations per Section 6.3.14.

e. The dimensional accuracy of the part per Section 6.3.4.

f. The structural integrity of the part as determined by an NDE method, if one is employed (see Section 3.4).

8.2 LEVEL 2 PROCESS VERIFICATION

There are no special process verification requirements for Level 2 processing. Therefore,

inspection points are not required.

8.3 VERIFICATION RECORDS

Traceable records for all MIP's shall be kept as quality assurance records.

9.0 TRAINING AND CERTIFICATION OF PERSONNEL

Training requirements for sandwich structure assembly operators shall be those of PRC-6002, "Process Specification for the Manufacture of Composite Sandwich Structures". Trainees shall be certified following the successful fabrication/verification of both a laminate and sandwich assembly Level 1 contoured test article. Training and certification records shall be kept.

For work performed at JSC facilities, these requirements shall be satisfied by the training and certification of personnel per TI-6001-03, *Manufacture of Composite Laminate Prepreg Parts*, and TI-1001-01, *Adhesive Bonding*.

10.0 DEFINITIONS

Ancillary Materials	Typically, these materials are used during the cure cycle to permit vacuum, contamination, and resin flow control i.e., bagging materials. These materials are non-deliverable process consumable items.
Co-cure	The simultaneous autoclave curing of sandwich panel adhesive and composite materials.
Mandatory Inspection Point (MIP)	A second-party inspection process designated during a manufacturing operation.
Lay-up	An assembly consisting of the laminated material laid on a tool in its final configuration together with any associated vacuum bag enclosures.
Potting	The densification of honeycomb core using structural or foaming adhesives.
Prepreg	A raw material form of polymer-matrix composite material in which the polymer matrix is provided in a partially cured state.