BOMBARDIER
Toronto Site
PROPRIETARY INFORMATION

PPS 10.51

PRODUCTION PROCESS STANDARD

CERTIFICATION OF OVENS

Issue 6
- This standard supersedes PPS 10.51, Issue 5.
- Vertical lines in the left hand margin indicate technical changes over the previous issue.
- Direct PPS related questions to christie.chung@aero.bombardier.com or (416) 375-7641.
- This PPS is effective as of the distribution date.

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Signed original on file. Validation of paper prints is the responsibility of the user.

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1 SCOPE

1.1 The purpose of this Production Process Standard (PPS) is to identify the equipment and operating requirements of ovens used by Bombardier Toronto or its subcontractors for fabrication of composite structures.

1.1.1 This PPS complements the engineering drawings that specify its use as an authorized instruction. The procedure specified in this PPS shall be followed to ensure compliance with all applicable specifications. In general, if this PPS conflicts with the engineering drawing, follow the engineering drawing. The requirements specified in this PPS are necessary to fulfil the engineering design and reliability objectives.

1.1.2 Refer to PPS 13.26 for the subcontractor provisions applicable to this PPS.

1.1.3 Procedure or requirements specified in a Bombardier BAPS, MPS, LES or P. Spec. do not supersede the procedure or requirements specified in this PPS. Similarly, the procedure and requirements specified in this PPS are not applicable when use of a BAPS, MPS, LES or P. Spec. is specified.

2 HAZARDOUS MATERIALS

2.1 Before receipt at Bombardier Toronto, all materials shall be approved and assigned Material Safety Data Sheet (MSDS) numbers by the Bombardier Toronto Environment, Health and Safety Department. Refer to the manufacturer's MSDS for specific safety data on any of the materials specified in this PPS. If the MSDS is not available, contact the Bombardier Toronto Environment, Health and Safety Department.

3 REFERENCES

3.1 PPS 10.28 - Assembly of Wire Thermocouples.

3.2 PPS 13.26 - General Subcontractor Provisions.

3.3 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

3.4 QAPI 3.8.7.20 - Control of Inspection, Measuring and Test Equipment - *Bombardier Toronto internal Quality procedure*.

4 MATERIALS, EQUIPMENT AND FACILITIES

4.1 Materials

4.1.1 Thermocouples prepared according to PPS 10.28.

4.2 Equipment

4.2.1 Leather gloves (e.g., DSC 422-3).

4.3 Facilities

4.3.1 This PPS has been categorized as a Controlled Special Process according to PPS 13.39 and as such only facilities specifically approved according to PPS 13.39 are authorized to utilize the oven specified herein for fabrication of composite structures according to the applicable fabrication PPS (i.e., PPS 10.xx series).

4.3.2 Bombardier subcontractors shall direct requests for approval to Bombardier Aerospace Supplier Quality Management. Bombardier Aerospace facilities shall direct requests for approval to the appropriate internal Quality Manager.

4.3.3 Facility approval shall be based on a facility report, a facility survey and completion of a qualification test program, if required. The facility report shall detail the materials and equipment to be used, the process sequence to be followed and the laboratory facilities used to show compliance with the requirements of this PPS. Any deviation from the procedure or requirements of this PPS shall be detailed in the facility report. Based upon the facility report, Bombardier Toronto Materials Technology may identify additional qualification and/or process control test requirements. During the facility survey, the facility requesting qualification shall be prepared to demonstrate their capability. Once approved, no changes to subcontractor facilities may be made without prior written approval from Bombardier Aerospace Supplier Quality Management.

4.3.3.1 Unless otherwise specified by Bombardier Aerospace Toronto Materials Technology, for approval of subcontractor facilities utilizing the oven specified herein for fabrication of composite structures according to the applicable PPS's, completion of a test program and submission of suitable test samples representative of production parts is required. Test samples shall meet the requirements of the applicable fabrication PPS (i.e., PPS 10.xx series). Certification and re-certification of the oven shall be as specified in section 6.

5 PROCEDURE

5.1 General

5.1.1 Ovens meeting the requirements of this standard will be certified for curing composite parts.

5.1.2 Ovens may receive a partial certification to a 270°F or 290°F maximum cure temperature capability, if the ovens will not be used for curing parts requiring a cure temperature above its certification temperature.

5.1.3 The oven control mode may be either manual or automatic, or combinations thereof. The control mode selected to run operational tests shall also be used in production. If a different control mode is later implemented, test and certify the oven to that mode.

5.1.4 The oven interior shall be clean and free from dirt, oil or any material detrimental to bonded structure.

5.1.5 Prepare and calibrate thermocouples according to PPS 10.28.

5.2 Oven Equipment Checks and Calibration

5.2.1 General

5.2.1.1 The thermal input and cooling capacity of the oven shall be adequate to meet the cure schedules specified in the applicable fabrication PPS when operating in a fully loaded condition.

5.2.2 Temperature

5.2.2.1 Calibrate the oven temperature set-point controller and monitoring equipment (hardware and software) according to QAPI 3.8.7.20.

5.2.2.2 Equip the oven with a sufficient number of thermocouple connectors (12 minimum) to monitor part temperatures according to the requirements of the applicable fabrication PPS.

5.2.2.3 Temperature recording equipment shall be capable of continuously recording each operating thermocouple throughout the cure cycle. However, multi-point recorders are acceptable, providing that each operating thermocouple is monitored at least once every 5 minutes.

5.2.2.4 The combined accuracy of the thermocouple, junction box, and recorder, shall be ± 5°F from 100°F to 365°F.

5.2.3 Vacuum

5.2.3.1 Calibrate the oven vacuum set-point controller and monitoring equipment (hardware and software) according to QAPI 3.8.7.20.

5.2.3.2 Equip each vacuum line with a vacuum gauge. If the oven will be used to cure any Class 1, 2 or 3 parts, equip the oven with a sufficient number of independent vacuum monitor lines to accurately monitor the vacuum under each vacuum bag and to permit checking for leaks on Class 1, 2 or 3 parts according to the requirements of the applicable fabrication PPS.

5.2.3.3 Vacuum monitoring equipment shall register over a range from at least 0 to 30" Hg vacuum. Sensor accuracy shall be certified as ± 0.6" Hg.

5.2.3.4 Equip the oven with a sufficient number of vacuum sources to maintain a minimum vacuum of 24" Hg on the parts according to the requirements of the applicable fabrication PPS.

5.2.4 Elapsed Time Measurement Equipment

5.2.4.1 Equip the oven with elapsed time measurement equipment capable of continuously monitoring and logging the lapsed time during the heat-up, curing period, and cool-down of the oven cycle. However, the heat-up rates of leading and lagging thermocouples may be determined by a multi-point recorder printout.

5.2.4.2 Chart timing accuracy shall be within ± 2% of the actual elapsed time.

5.2.4.3 Calibrate elapsed time measuring equipment according to QAPI 3.8.7.20.

5.3 Operational Test - Empty Oven

5.3.1 Perform the empty oven operational test as follows:

Step 1. Except as noted, position thermocouples within the working zone as shown in Figure 1. Alternative placement to that shown in Figure 1 is acceptable provided that the thermocouple placement is such that a representation of the entire working zone is obtained. When using an alternative placement, use at least 9 thermocouples in ovens with a volume **up to** 10,000 ft^3 and at least 14 thermocouples in ovens with a volume **over** 10,000 ft^3.

Step 2. Perform a leak test as follows:

(a) Attach the oven vacuum sources to the corresponding vacuum monitor connectors

(b) Apply full vacuum (24" Hg minimum).

(c) Close all vacuum lines.

(d) Monitor the line vacuum sensors for 5 minutes. If a vacuum drop in any vacuum monitor greater than 5" Hg over the 5 minute period is observed, abort the test and correct the leaks before re-testing.

(e) Open the vacuum lines.

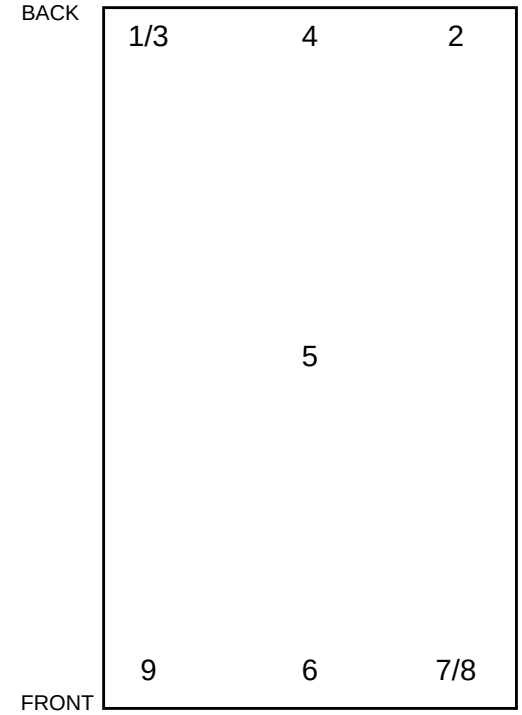
Step 3. Heat the oven at approximately 10°F per minute to 260°F. Within 10 minutes after the leading thermocouple has reached the 260°F dwell temperature, each thermocouple shall read 260°F ± 10°F.

Step 4. If certification to 280°F cure is required, continue heating at approximately 10°F per minute to 280°F. Within 10 minutes after the leading thermocouple has reached the 280°F dwell temperature, each thermocouple shall read 280°F ± 10°F.

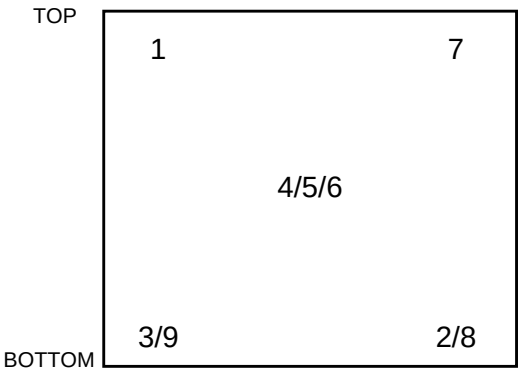
Step 5. If certification to 350°F cure is required, continue heating at approximately 10°F per minute to 355°F. Within 10 minutes after the leading thermocouple has reached the 355°F dwell temperature, each thermocouple shall read 355°F ± 10°F.

Step 6. Cool the oven down to ambient temperature using normal operating procedures.

OVEN VOLUME UP TO 10,000 FT^3

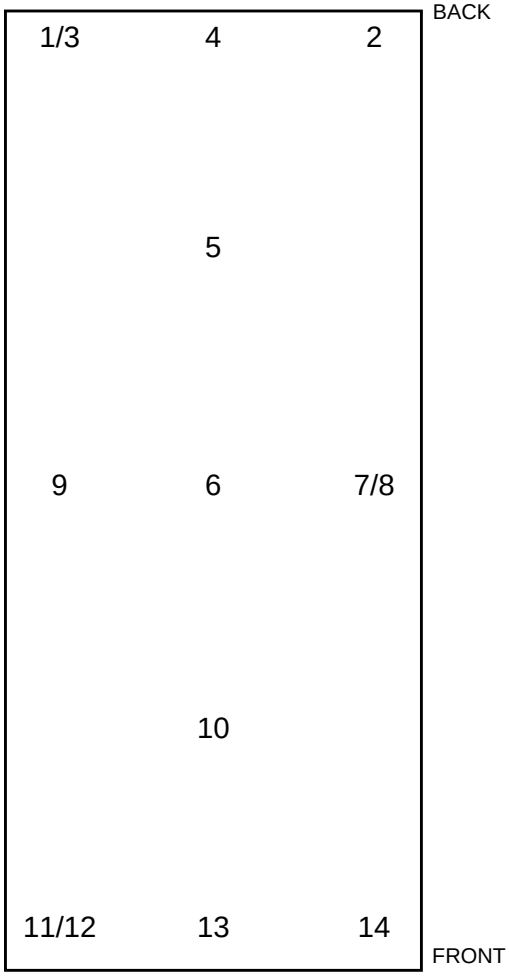


TOP VIEW

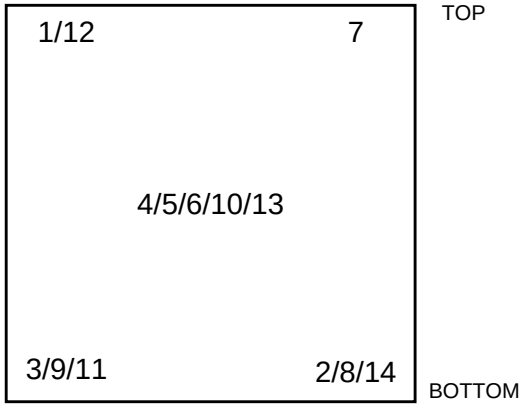


END VIEW

OVEN VOLUME OVER 10,000 FT^3



TOP VIEW



END VIEW

FIGURE 1 - STANDARD DISTRIBUTION OF OVEN TEST THERMOCOUPLES

5.4 Operational Test - Dummy Load

5.4.1 Prepare a dummy load for the operational test that will meet the following:

- The heat sink capacity of the dummy load shall be at least equal to the maximum heat sink capacity that could occur under production conditions and the thermal conductivity of the dummy load shall be similar to the thermal conductivity of the parts that will be made at that facility.
- The material of the dummy load shall consist of cured or uncured fiberglass or composite structure or scrap that would represent a typical construction.
- Included in the dummy load there shall be at least 2 vacuum bag assemblies. Form the vacuum bag assembly using standard bagging film, release film and bleeder cloth materials according to the applicable fabrication PPS. Each vacuum bag assembly shall contain at least one vacuum monitor outlet. Position at least 6 thermocouples, connected to the oven recorder, under each vacuum bag. Place the thermocouples in actual or simulated edge breathers and part excesses. Position thermocouples within the vacuum bags in the oven so that the structures with the greatest and the least mass (including the tool) are measured.

5.4.2 Perform the dummy load operational test as follows:

Step 1. Place the dummy load in the oven.

Step 2. Connect the thermocouples to the oven recorder.

Step 3. Connect vacuum lines to vacuum outlets.

Step 4. With the vent lines open or under vacuum, heat the oven, ensuring that the following requirements are met:

- Minimum permissible heat-up rates calculated from lagging part thermocouple data are as follows:

  130°F to 250°F . . . . . .2°F/minute

  250°F to 280°F . . . . . .2°F/minute

  280°F to 345°F . . . . . .1°F/minute
- For certification to 260°F capability, the leading part thermocouple shall not exceed a heat-up rate of 8°F per minute.
- For certification to 280°F or 355°F capability, the leading part thermocouple shall not exceed a heat-up rate of 5°F per minute.
- Calculate heat-up rates for each 5 minute interval.

After the leading part thermocouple reaches 250°F, allow up to 60 minutes for the remaining thermocouples to reach 260°F ± 10°F. Each part thermocouple shall then maintain 260°F ± 10°F for a minimum of 30 minutes.

Step 5. If certification to 280°F capability is desired, continuing heating the oven and once the leading part thermocouple reaches 270°F, allow up to 60 minutes for the remaining thermocouples to reach 280°F ± 10°F. Each part thermocouple shall then maintain 280°F ± 10°F for a minimum of 30 minutes.

Step 6. If certification to 355°F capability is desired, continue heating the oven and once the leading part thermocouple reaches 345°F, allow up to 60 minutes for the remaining thermocouples to reach 355°F ± 10°F. Each part thermocouple shall then maintain 355°F ± 10°F for a minimum of 30 minutes.

Step 7. Cool the oven to 125°F using a cooling rate not exceeding 5°F per minute.

Step 8. Save temperature and vacuum plots. Maintain adequate records to clearly document the results of the test run.

6 REQUIREMENTS

6.1 Refer to Table I for a listing of the checks and operational tests required for initial certification and re-certification.

TABLE I - CERTIFICATION AND RE-CERTIFICATION REQUIREMENTS

	SECTION	INITIAL CERTIFICATION	RE-CERTIFICATION (Note 1)
Oven Equipment Checks and Calibration	5.2	yes	every 6 months
Operational Test - Empty Oven	5.3	yes	every 6 months
Operational Test - Dummy Load	5.4	yes	not required

Note 1. When the oven has been overhauled or there has been an increase in the maximum production heat sink load, re-certify the oven by the performance of the oven equipment checks and calibration and both operational tests before further fabrication of production parts.

7 SAFETY PRECAUTIONS

7.1 Safety precautions applicable to the materials and procedures specified herein shall be defined by the subcontractor performing the work for Bombardier Toronto.

8 PERSONNEL REQUIREMENTS

8.1 This PPS has been categorized as a Controlled Special Process according to PPS 13.39. Refer to PPS 13.39 for additional personnel requirements. Certified and/or qualified personnel shall have a good working knowledge of the following, as applicable:

- have a working knowledge of oven equipment checks and calibration requirements
- understand the requirements for thermocouple placement for empty oven operational tests
- understand the requirements for preparing and placing dummy loads
- know how to vacuum bag dummy load parts for the operational test
- have a working knowledge of the operation of the oven during certification tests