ABRADABLE APS COATING PROCEDURE FOR STATOR PARTS OF ROTATING MACHINES

1. SCOPE

This document covers the procedures, quality requirements and relevant checks on abradable coating applied by air plasma spraying on stator parts and rotating machines. In case of conflict between documents, the following priority will apply:

- Part drawing;
- Part specification;
- This specification.

2. APPLICABLE DOCUMENTS

ITN07771; ASTM C633

3. TYPEOFCOATING

According to table No. 1.

4. COATING PROCESS

The supplier shall submit the Manufacturing Process Plan (MPP) to GE O&G – Nuovo Pignone.
The following general requirements will be taken into account:

- Steel shots cannot be used for blasting parts made of titanium and titanium alloys nor silicon carbide shots for parts made of nickel and nickel alloys.
- When spraying a 90° angle must be maintained between the torch and surface to be coated. When spraying liners the torch must be held at around 70° + 0° -5° to the axis of the liner, considering an increasing angle in the direction of the hot gas flow.

The equipment, operators and procedure should be qualified in accordance with the provisions of section 6 here below.
Once qualification is obtained, the above must be considered frozen for execution of the coating operation contemplated herein.

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5. COATING SPECIFICATION

Table No. 1

BOND COAT			
Type	Interface contamination	Oxides	Porosity
AMDRY 956	<15%	<7%	<5%

TOP COAT			
Type	Porosity + Oxides	Hardness	Adhesion (N/mm2)
METCO601NS	50÷60%	R15Y 73 ±5	≥10

Equivalent products may be used only after written approval by GE O&G - Nuovo Pignone Engineering Department which should receive all necessary information to identify proposed materials, how they are produced, their chemical and granulometric composition.

5.1. Coating Thickness

On Qualification Samples:
- bond coat: 50÷150µm
- top coat: 200÷250µm

On Production Parts:
- bond coat: 100÷200µm
- total: according to Drawing Requirement.

6. PROCESS QUALIFICATION

Prior to processing production parts, the Supplier shall prove its ability to accomplish quality requirements requested by applicable specifications, through the Process Qualification.

A “Qualification Requirements” document will be issue by BHEL MPE Dept. Document shall be follow by vendor to finalize qualification activity.

The Process Qualification generally requires the issue and the approval of the MPP (Manufacturing Process Plan), the execution of the FPQ (First Piece Qualification), and the PLQ (Pilot Lot Qualification).

BHEL - MPE is responsible for the process approval from the metallurgical standpoint. What above stated is applicable to both the FPQ and PLQ.

6.1. Manufacturing Process Plan

Prior to starting production, the Supplier shall submit for approval to GE O&G - MPE the Manufacturing Process Plan (MPP). The MPP shall define all the steps and the applicable procedures needed to obtain the coated part.

As minimum the MPP shall include the following:
- Supplier name and supplier code;
- Date;
- MPP number and revision;
- Applicable drawing numbers and revision level (either GE or supplier);
- All materials and process specifications, including revision number (GE, ASTM, Other);
- All supplier documents used to realize components (indicate whether proprietary or non-proprietary);
- Identification of all Sub-tier suppliers, as applicable;
- List of all materials used directly in manufacture of the coating;
- List of all support materials (masking, grit blast media, etc.);
- List of all equipment used during processing of part;
- Detailed description of the steps used during processing of the part;
- Quality Control Plan describing the methods and frequencies of inspections and tests used to ensure that coated parts meet the minimum requirements of the GE drawing.

Once approved, the MPP shall be considered frozen.Any significant MPP modification shall be previously submitted to GE O&G - MPE for approval.

GE O&G – Nuovo Pignone shall have the right to revoke the qualification, and request its repetition, depending on the production trend and/or the length of time during which the coating is not applied

6.2. Qualification Roadmap

6.2.1. Sprayability Demonstration

The purpose of the sprayability demonstration is to ensure that the coating vendor can meet coating requirements before spraying a production part. Spray parameters shall be adjusted accordingly until all requirements are fulfilled. Once the spray parameters are defined, it shall be documented in the MPP and used subsequently for the FPQ and PLQ spraying.

Test samples shall be fixed onto a flat plate and sprayed with the same spray and robotic equipment as the production part. Minimum test sampling requirements and dimensions are defined below.

Material of samples shall be similar to a production parts.

- 3 coupons 100 x 25 x 1.5 mm for bend testing
- 1 coupon 100 x 25 x 1.5 mm for micrographic check
- 3 disks 25 mm in diam., 6 mm thick, for bond testing
- 1 coupon 50 x 25 mm, 5 mm thick, for hardness testing

A total coating thickness of 250÷400µm will be applied on the above samples (bond coat thickness 50÷150µm).
Hardness check sample shall be coated with appropriate coating thickness.
The coating vendor shall proceed to the FPQ phase only after all requirements per paragraph 6.2.1. of this specification were met on samples.

6.2.2. First Piece Qualification (FPQ)

The purpose of the FPQ phase is to demonstrate the ability of the chosen spray process and equipment to deposit a coating (same thickness specified on drawing) on production part.
For this purpose one mock up (representative for geometry and material to a production part) shall be sprayed with the same spray equipment, parameters & robotic equipment used for spray ability demonstration phase.
In addition, tests samples must be sprayed and checked according to para. 6.2.1.
Definitions of mock-up sampling scheme for destructive checks shall be agreed between GE O&G - MPE and the Supplier.

The coating vendor shall proceed to the PLQ phase only after all requirements were met on Samples

6.2.3. Pilot Lot Qualification (PLQ)

The purpose of the PLQ phase is to demonstrate the ability of the chosen spray process and equipment to deposit an acceptable coating (in terms of quality and thickness) on an actual part.
To successfully complete a PLQ phase, the supplier shall coat a whole lot of production parts with the equipment's and tooling used for the FPQ phase using the approved MPP parameters.
In addition, tests samples must be sprayed according to para. 6.2.1.
The definition of the parts to be destructively checked shall be agreed between GE O&G - MPE and the Supplier.
Supplier shall successfully complete all inspections and record results according to applicable specification and MPE Dept. requirements.
At this stage of inspections, quality of the coating on coupons and disks shall be checked in relation to the quality of coated production parts considering that they will be used for coating quality check during normal production.

If pilot lot component and specimens meet all specification requirements, supplier shall have successfully completed the Qualification Process.

6.3. Requalification of operators and equipment

If production of a specific coating is interrupted for more than one year, the process should be requalified according to para 6.2.2. and 6.2.3.
GE O&G - Nuovo Pignone reserves the right to revoke qualification and to require its repetition depending on the operating conditions and condition of the equipment.

6.4. Requalification of the coating process

Requalification of the coating process should follow the indication given on para 6.2.2. and 6.2.3. and may be required when changes are made to the MPP or when the test pieces do not meet the required specifications.

7. CHECKS

7.1. Checks Requisitions

7.1.1. Visual Examination

No cracks, peeling, flaking and non-bonding parts are allowed.

7.1.2. Dimensional Inspection

Dimensional inspection shall be conducted using a 0 • 100 • m scale.
Uniformity of thickness shall be checked.

7.1.3. Bend Tests

Samples must be bent to 175°-180° on a 12.5 mm diam. chuck.
Bend must be made in 2÷5 seconds.
Coating Cracks parallel to the bending axis are acceptable, detachment of coating from base material (on bent area only) within 3 mm from the edge is acceptable.

7.1.4. Micrographic Examinations

Micrographic examination shall be carried out using a dedicate sample or the straight part of a bend test piece.
The examination shall be carried out on a transversal section of coated sample.

The following aspects shall be examined:
- porosity + oxide

- interface contamination
- coating thickness
-Hardness

The results must comply with the values indicated in table 1

7.2. Checks during Qualification

7.2.1. Coupons

- Visual examination (see para. 7.1.1.)
- Dimensional test (see para. 7.1.2.)
- Bend tests (see para. 7.1.3.)
- Micrographic examination (see para. 7.1.4.).

7.2.2. Bond Test Discs

When required, the bond test must be carried out in according to ASTM C633 using 3M Regular, Plasmatex Klebbi or FM1000 adhesive.
Test results must meet the requirements of table 1.

7.2.3. Mock-upandProductionPart Inspection

- Visual examination (see para. 7.1.1.)
- Micrographic examination (see para. 7.1.4.)
- Dimensional check (if required) according to drawing requirements
- Hardness

7.3. Checks during Production

Coating application modalities shall be those adopted during qualification. Quantity and location of test samples shall be defined and agreed by Vendor and GE O&G - Nuovo Pignone during Process Qualification activity.

The Supplier shall perform the following checks on the test pieces/production parts:

a. Visual examination: to be performed on 100% of products. Coating should cover the entire surface specified in the drawing. It should also meet the requirements specified on para. 7.1.1.

b. Required test samples must be coated in a representative way at beginning of every production lot. Supplier shall apply the coating on coupons referring to Para. 7.2.1. in order to verify process set-up.

Samples must be checked by Vendor according to Para. 7.1.3. and 7.1.4. requirements.

c. Ultrasonic Inspection: to be performed with the general requirements written in the ITN02151 and ITN07049 with the following modification:

- Probes and examination frequency: 10mm diameter longitudinal wave double crystal probe with frequency 4MhZ.
- Examination: the inspection shall be performed from the surface opposite to the coated side in order to detect both the interface echo between the base material and the coating and the back wall echo.
- Calibration: the amplitude of the interface echo between the base material and the coating shall be set at 100%FHS.
- Acceptance criteria: the amplitude of the interface echo between the base material and the coating and the amplitude of the back wall echo shall be recorded and any drop and/or rise of both echo is not acceptable.

8. CUSTOMER INSPECTION

GE O&G - Nuovo Pignone, under its own responsibility, on the basis of the experience it acknowledges to the supplier, is entitled to verify the quality of the production by conducting the laboratory tests mentioned in this specification.

9. DOCUMENTATION

9.1. Qualification Documentation

The Supplier shall provide to GE O&G - MPE Dept. a complete Report for Spayability Demonstration, FPQ and PLQ phases on electronic report model, resuming the documentation specified in para. 6.1. and 6.2. and all certificates relating to inspections performed on the first production and pilot lot production. The reports shall be submitted to the approval of the GE O&G - MPE personnel responsible for qualification. It shall be kept available on the Supplier’s premises for a minimum of 5 years from the date of order fulfilment and a copy shall be sent to GE O&G – Nuovo Pignone.

9.2. Production Documentation

Unless otherwise indicated in the order, the certifications, type 3.1 according to ITN 07771, regarding the tests required during series production shall be furnished upon shipment of the materials.

10. PACKING

Coated parts are highly sensitive to coating damage (chipping and cracking). Handling of parts during production process and shipment must be carefully performed using suitable protections.
Pluriball plastic sheet and appropriate wooden box shall be used for parts protection during shipment.

11. DEVIATIONS

All deviation and non conformity from the contractual requirements shall be submitted to the approval of GE O&G – Nuovo Pignone according to the internal procedures for the “manufacturing Activity" or to the orders for external suppliers

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COMP. FILE
Ref. Doc.
NAME