REQUIREMENTS FOR TECHNOLOGY FLOW QUALIFICATION OF COILS, RF AND POWER, FIXED (INDUCTORS AND TRANSFORMERS)

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1 PURPOSE

This specification provides additional information and requirements for the Qualification Approval of Fixed RF and Power Coils (Inductors and Transformers) Technology Flows and Components, and their inclusion on the ESCC Qualified Manufacturer's List (QML). It outlines the additional specific requirements for the definition of Technology Flow and its boundaries, the establishment of a Quality Management Programme, the preparation of a Process Capability and Reliability Assessment Programme, an Evaluation Test Programme and Qualification Test Programme, and the performance of an On-site Validation Audit.

This specification shall be read in conjunction with ESCC Basic Specification No. 25400.

This specification does not directly define detailed requirements for a component manufacturer, but instead defines the points which the Manufacturer must address in his Quality Management Programme.

2 APPLICABLE DOCUMENTS

The following ESCC Specifications form part of, and shall be read in conjunction with, this specification. The relevant issues shall be those in effect at the date of commencement of the Technology Flow certification.

- ESCC No. 25400, Requirements for the Technology Flow Qualification of Electronic Components for Space Application.
- ESCC No. 3201, Generic Specification for Coils, RF and Power, Fixed (Inductors and Transformers).

3 TERMS, DEFINITIONS, ABBREVIATIONS, SYMBOLS AND UNITS

The terms, definitions, abbreviations, symbols and units specified in ESCC Basic Specification No. 21300 shall apply.

4 INTRODUCTION

ESCC Technology Flow qualification is the status granted to a Manufacturer's specified Technology Flow after successful completion of an evaluation, certification and qualification programme as defined in ESCC Basic Specification No. 25400, the relevant parts of ESCC Generic Specification No. 3201 and this specification. It is also the status granted to any component type which is both:

- Manufactured using, and within the boundaries defined for, a qualified Technology Flow,
- Defined by, and meets the requirements of, ESCC Generic Specification No. 3201 and the relevant ESCC Detail Specification.

5 DEFINITION OF TECHNOLOGY FLOW AND BOUNDARIES

5.1 GENERAL

The Manufacturer shall define the Technology Flow for which certification and qualification is sought as required by ESCC Basic Specification No. 25400.

This Technology Flow definition shall also form the basis of a Process Identification Document (PID) to be produced by the Manufacturer which shall fulfil all of the requirements of ESCC Basic Specification No. 21700 in terms of content and configuration control. This definition has to demonstrate that the Technology Flow and its corresponding boundaries represent a structured, properly controlled and monitored design methodology and manufacturing process for fixed RF and power coil technologies.

To meet these requirements, the definition should, as a minimum, address the areas listed in the following paragraphs at least to the extent detailed therein. The definition should cover all elements of the Technology Flow where a change could affect product performance and would therefore need to be reviewed by the Technology Review Board (TRB) before being introduced. Additional information should be supplied whenever necessitated by the particular nature of the technology under approval.

Within the definition of the Technology Flow, five areas are of particular concern:

- The physical, thermal and electrical design and procedures which are closely related to the manufacturing process (see Para. 5.2)
- The design system and procedures used to implement the component design methodology (see Para. 5.3)
- Component manufacture and assembly including materials, technologies, packages and processes applied (see Para. 5.4)
- Inspection and test requirements (see Para. 5.5)
- Traceability (see Para. 5.6)

These areas are addressed in the subsequent paragraphs.

5.2 PHYSICAL, THERMAL AND ELECTRICAL DESIGN

The physical, thermal and electrical design is governed by a set of technology specific rules and parameters, commonly called 'Design Rules'. These rules define the construction and composition of all structures foreseen for the design and manufacture of the component in a specific technology.

The description of the physical, thermal and electrical design requires the definition of at least the following characteristics:

(a) Physical, thermal and material design rule set which covers the following considerations:
- Magnetic circuit/technology type (e.g. Inductor, Transformer, Planar, Toroid, RM pots, etc.)
- Permeability and curie temperature of the magnetic circuit
- Induction of saturation
- Functions of the devices covered by the certified technology (e.g. signal transformer, current transformer, pulse transformer, fly-back transformer, converter transformer, specific inductors, etc.)
- Size (e.g. minimum/maximum width, length and height) and fastening mode.
- Class of each material
- Grade of the enamelled lead
- Finishing (e.g. coating, impregnation, moulding, transfer moulding, etc.)
- Terminals (e.g. nature and finishing)

(b) The electrical rule and parameter set in terms of:
- Maximum power dissipation of the packaging
- Rated voltage of windings.
- Current carrying capability of windings.
- Dielectric breakdown voltages.
- Other electrical and parameters design rules used during conception.

(c) Other relevant parameters or restrictions not covered in the previous points like suitability to implement particular component design techniques.

5.3 DESIGN SYSTEM

The design methodology is defined by the design system and all other procedures applied in the design of a component. The design system comprises all software, basic design data and the hardware platform.

Technology Flow Qualification of a design system requires as a minimum:

- The implementation of a configuration control system guaranteeing the traceability of all software and data forming part of the system.
- The application of a quality assurance system addressing at least documentation procedures, acceptance testing prior to system release and the organisation of error reporting and corrective action procedures.

Both systems shall be fully documented and their application has to be evident.

At least the following items shall be covered in the PID:

(a) The design flow-chart including a general description of the design system plus block diagrams representing:
- The software structure of the system.
- The design flow, distinguishing between interactive and automatic actions.
- The data flow within the system, with emphasis on the dynamics of the accumulated design data.

(b) A description of the hardware platform (e.g. work stations, memory requirements, LAN, host computers etc.).

(c) Software and associated data shall be described in terms of:
- The origin and version of the programme.
- A comprehensive description of its functional scope.
- The programming language and the amount of code.
- The memory requirement.
- Definition of data formats and description languages.
- Definition of programme interfaces.
- A description of the human interface with admitted or required interactivity and output format.
- All software serving simulation type purposes requires a detailed description of the underlying models and their parametric capability.

(d) A description of the configuration control system.

(e) A description of the quality assurance system.

For any components where a design group external to the Manufacturer is active in component design, the Manufacturer shall be responsible for ensuring that all design activities are completely within the boundaries defined for the qualified technology flow. To achieve this, the Manufacturer should produce a suitable Design Compliance Matrix (checklist) which will form part of the Technology Flow Description. For components with an external design input, the Design Compliance Matrix should be jointly completed by the Manufacturer and designer, and should then be formally approved by the Manufacturer as a basis for later issuing Certificates of Conformity for the components.

5.4 MANUFACTURE

The Technology Flow definition shall as a minimum cover the following areas with regards to the the manufacture of components within the boundaries of the Technology Flow.

5.4.1 Materials

The Manufacturer shall describe the procedures for selection, procurement and control of materials used for the manufacture of components. The description should include, but not be limited to, the following areas:

- The selection and approval of the materials and vendors used.
- A list of materials used and associated procurement specifications.
- A list of incoming inspection procedures and other documents used to ensure the consistent quality of materials used.
- Procedures for traceability and control of limited shelf life items.

5.4.2 Technologies

The Manufacturer shall describe the basic technologies used for the manufacture and assembly of components. The description should include, but not be limited to, the following areas:

- Type of technology (e.g. Planar, Toroid, RM pots, etc.).
- Range of packages.
- Finishing (e.g. coating, impregnation, moulding, transfer moulding, etc.).
- Terminals (e.g. nature and finishing).

5.4.3 Processes

The Manufacturer shall describe the processes for the manufacture and assembly of components. He shall also give reference to the documents specifying the processes. The description, which shall include a statement on the equipment used, should include, but not be limited to, the following areas:

- Physical location of the manufacturing facility
- Clean room conditions.
- Rework procedures.
- Assembly and finishing.
- Lot formation.

5.5 INSPECTION AND TEST

The test facility characteristics to be covered by the description should include, but not be limited to, the following areas:

- Implementation procedures for external visual or other test methods.
- Testing flow.
- Physical location of test facility.
- Sample plans (quantity and acceptance numbers).
- Test procedures.
- Lot formation.

The Manufacturer shall describe the inspection and test methods giving references to the documents specifying the methods. The description should include, but not be limited to, the following areas:

- Incoming inspection testing.
- In-process inspections.
- External and internal inspections.
- Production control testing
- Pre-Assembly Customer Source Inspection.
- Screening tests and associated electrical tests.
- Qualification testing.
- Periodic testing and Lot Validation Testing.

5.6 TRACEABILITY

The Manufacturer shall describe his traceability system that allows for traceability from the component to a specific production lot. The description should include, but not be limited to, the following areas:

- The use of purchase orders and specifications.
- The use of route sheets and travellers.
- The traceability of materials, test vehicles, and components.

6 QUALITY MANAGEMENT PROGRAMME

As specified in ESCC Basic Specification No. 25400.

7 TEST VEHICLES

Test vehicles which are required for evaluation shall be described in the PID. Production shall be to the highest level specified in the PID and shall use a manufacturing line which is intended to be, or already is, a certified ESCC QML line. The following requirements shall apply:

(a) Process and Device Characteristics
Test vehicles shall enable the verification of all relevant material, process and device parameters such as the following:
- Inductance of windings
- Turn ratios
- Operating temperature range.
- Isolation or Dielectric Withstanding Voltage.
- Other electrical characteristics according to the function of devices and the description in the PID

(b) Design Rules
Test vehicles shall enable the verification of the design rule set, and allow electrical, thermal and mechanical evaluation of the variability that might occur during manufacturing.

In order to magnify problems and to enhance the diagnostic capabilities, test vehicles with design rules beyond worst case should be selected when possible. These types of test vehicles will help to define process and device limits and help to assure reliability.

(c) Component Performance
Test vehicles shall be so selected to fully characterise the electrical performance of the range of components within the boundaries of the Technology Flow.

Particularly complex component designs shall be appropriately considered.

(d) Component Reliability
Test vehicles shall be so selected to establish component reliability by verifying the stability of the components when subject to stresses such as vibration, mechanical shock, temperature, humidity.

8 PROCESS CAPABILITY AND RELIABILITY ASSESSMENT PLAN, AND EVALUATION TEST PLAN

8.1 GENERAL

As part of evaluation, the Manufacturer shall build test vehicles, perform tests and analyses and run software benchmarks. These actions shall be designed to demonstrate, together with any existing information, the capabilities of the total manufacturing process with regard to quality, reliability and reproducibility, and its suitability for producing space level components. The necessary activities shall be described in either a process capability and reliability assessment plan, and/or an evaluation test plan, which should cover all design, manufacturing, assembly, test and control processes which comprise the total manufacturing process.

As a minimum the plans must generate sufficient information to allow for a process capability demonstration covering:

(a) Component design (see Para. 8.1.2)
(b) SPC and in-process monitoring programmes (see Para. 8.1.3)
(c) Assembly and packaging (see Para. 8.1.4)

8.1.2 Component Design

In the plan(s), the Manufacturer should address the methodology for the various areas of component design including electrical, mechanical, thermal and reliability (this is also applicable if a third party design centre is used). The design procedure and tools should be controlled in such a manner that the ensuing component design performs only with limits that have been shown to be reliable for the technology being used, within the constraints of established design rules.

8.1.2.1 Performance Verification

As part of evaluation, the Manufacturer shall perform testing to verify the performance of the component design. Testing shall be performed on test vehicles representative of the full range of components covered by the technology flow, to fully determine, as a minimum, the following critical characteristics and hence verify the maximum authorised losses based on operating temperature and size of the component:

- Operation at elevated temperature (see Para. 8.1.2.1.1)
- Dielectric strength (see Para. 8.1.2.1.2)

The test plan shall be proposed by the Manufacturer for agreement by the ESCC Executive.

8.1.2.1.1 Operation at Elevated Temperature

The component's operating temperature depends of the ambient temperature and the component's increase of temperature due to component losses. The temperature elevation can be calculated from the losses and thermal resistance, R_{th}:

$\Delta T = \text{Losses} \times R_{th}$

During evaluation, the Manufacturer shall determine the overall maximum operating temperature of the technology, and measure the individual R_{th} for each of the different sizes and product configurations of the components, covered by the technology flow, in order to determine their respective individual maximum operating temperature.

8.1.2.1.2 Dielectric Strength

During evaluation, a dielectric withstanding voltage (DWV) test up to breakdown shall be performed on different sizes and product configurations (wire sizes and type of isolation) of components covered by the technology flow in order to be able to define the respective voltage margin.

The evolution of the DWV breakdown limit should be studied during a test program that includes both environmental and mechanical testing. Samples shall be extracted during and at the end of an environmental and mechanical test sequence to perform the DWV tests up to breakdown.

8.1.3 SPC and In-Process Monitoring Programme

The Manufacturer should have an in-process monitoring system to control key processing steps to ensure component yield and reliability.

The critical operations to be monitored should be determined by the Manufacturer based on his experience and knowledge of his processes. The resulting data should be analysed by appropriate SPC methods to determine control effectiveness.

8.1.4 Assembly and Packaging

The Manufacturer should demonstrate the capability of the assembly and package processes by performing a qualification exercise on suitable test vehicles.

8.1.4.1 Assembly Processes

The Manufacturer should list the assembly processes that are expected to be used in ESCC QML component assembly and should then qualify these processes by the testing of fully assembled components in accordance with appropriate tests for the assembly technology used. The assembly process related tests given in ESCC Generic Specification No. 3201 can be used by Manufacturers as a baseline guide to suitable qualification tests. Sample sizes should be defined by the TRB.

8.1.4.2 Package Technology Styles

The Manufacturer should document how packages, as applicable, used in the manufacture of ESCC QML products are qualified. In particular, the Manufacturer should document his criteria for deciding which packages can be treated as similar and show how these are grouped together for qualification and change control purposes.

The package technology related tests given in ESCC Generic Specification No. 3201, can be used by Manufacturers as a baseline guide to suitable testing. Sample sizes should be defined by the TRB.

9 ON-SITE VALIDATION AUDIT

9.1 GENERAL

The on-site validation audit by the ESCC Executive shall be performed in accordance with the requirements of ESCC Basic Specifications No. 20200 and No. 25400.

The on-site validation audit will be performed only after a satisfactory review of the Manufacturer's QM plan and self-validation results.

9.1.1 Technology Validation

A satisfactory review of the following areas during validation by the ESCC Executive, where applicable, is seen as critical for ESCC QML certification and should cover:

- Design procedures.
- Design review procedures.
- Model verification.
- Software configuration and configuration management.
- Testability procedures.
- Archival system.
- Test vehicles tests and data.
- SPC and/or in-process monitoring programmes.
- Design rule documentation.
- Clean room procedures.
- Piece part traceability.
- Assembly rework procedures.
- Device traceability and travellers.
- Lot formation (device and inspection).
- Assembly area environmental control.
- Electrostatic discharge control and testing.
- Visual inspection.
- Human contamination prevention procedures.
- Equipment calibration and maintenance.
- Training policy and procedures.
- Electrical test procedures.
- Screening procedures.
- Periodic testing procedures.
- Third party design centre procedures.
- Encapsulation/moulding.
- Qualification test plan.

10 QUALIFICATION TEST PLAN

10.1 QUALIFICATION TEST VEHICLES

The qualification test programme should define the relevant number of qualification test vehicles to cover the certified Technology Flow which the Manufacturer will produce on the certified manufacturing line. The qualification test vehicles should be representative of the ESCC QML Fixed RF and Power Coils to be supplied by the Manufacturer. Each test vehicle should operate and perform in compliance with the device specification and should be suitable for space use.

10.2 QUALIFICATION TEST PLAN

The qualification test plan should detail the test flow, test limits, test data to be measured, recorded and analysed, test sampling techniques and traceability records. As a baseline, the test flow should be based on the qualification testing specified in ESCC Generic Specification No. 3201 and the electrical measurements should be those given in the appropriate Detail Specification. The qualification test plan must be agreed and approved between the Manufacturer and the ESCC Executive.

10.3 QUALIFICATION TEST REPORT

The Manufacturer should present to the ESCC Executive an analysis of the qualifying data. The aim of this analysis is to show that all process variables are under control and repeatable within the certified technology and that test vehicle data monitoring is adequate and can be correlated to the process. The ESCC Executive should be notified of any improvements/changes to the certified ESCC QML Technology Flow as a result of evaluation of the qualification test results. The following data, if applicable, should be addressed and retained by the Manufacturer to support the results:

- Simulation results from the design process.
- Parametric monitor test data.
- Results of each subgroup test conducted, both initial and any resubmissions.
- Number of devices tested and rejected.
- Failure mode and mechanism for each rejected component.
- Read and record variables data on all specified electrical parameter measurements.
- Where delta limits are specified, variable data, identified to the device serial number, should be provided for initial and final measurements.
- Physical dimensions are checked, the actual dimensions of three randomly selected components should be recorded, except where verification of dimensions by calibrated gauges, overlays, or other comparative dimensions verification devices has been approved.
- For terminal strength testing, the forces at the time of failure and the failure category, or the minimum and maximum readings of the components if no failures occur.

10.4 QUALIFICATION TEST FAILURES

If any particular testing results are not successful, the Manufacturer should perform failure analysis and take any necessary corrective action after consultation with the ESCC Executive. The Manufacturer should notify the ESCC Executive of any decision not to pursue qualification of any material or manufacturing construction technique previously certified. After corrective actions have been implemented, qualification testing should restart.

11 PROCUREMENT

Procurement of components manufactured within the boundaries of the qualified Technology Flow shall be in accordance with the requirements of ESCC Generic Specification No. 3201.