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Space product assurance — Generic procurement requirements for hybrids

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee ACE/68, Space systems and operations.

A list of organizations represented on this committee can be obtained on request to its secretary.

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English version

Space product assurance - Generic procurement requirements for hybrids

Assurance produit des projets spatiaux - exigences
génériques d'approvisionnement des composants hybrides

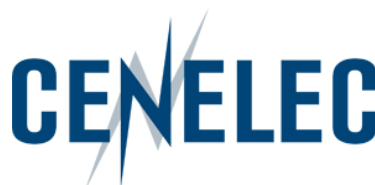
Raumfahrtproduktsicherung - Allgemeine
Beschaffungsanforderungen an Hybride

This European Standard was approved by CEN on 13 March 2014.

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Table of contents

Foreword	6
Introduction.....	7
1 Scope.....	8
2 Normative references	9
3 Terms, definitions and abbreviated terms.....	10
3.1 Terms from other standards.....	10
3.2 Terms specific to the present standard	10
3.3 Abbreviated terms.....	11
4 Sequence of procurement activities	13
5 Selection of hybrid microcircuit manufacturer	16
5.1 General.....	16
5.2 Hybrid microcircuit manufacturer categories	16
5.2.1 Category 1 manufacturer (preferred case)	16
5.2.2 Category 2 manufacturer (non-preferred case)	16
6 Validation procedure for a hybrid microcircuit manufacturer	17
6.1 General.....	17
6.2 Hybrid circuit technology identification form (HTIF)	17
6.2.1 General	17
6.2.2 HTIF for approved manufacturers (category 1).....	17
6.2.3 HTIF for manufacturer pending capability approval by the approving authority (category 1)	18
6.2.4 HTIF for manufacturer not approved by the approving authority (category 2).....	18
6.3 Validation of category 2 manufacturers.....	19
6.3.1 General	19
6.3.2 Construction analysis on representative samples.....	19
6.3.3 Quality and technical audit	19
7 Design requirements	21

7.1	General.....	21
7.1.1	Overview.....	21
7.1.2	Design activities	21
7.2	Detail specification for hybrid circuits	22
7.3	Design approval (circuit type approval)	22
7.3.1	General	22
7.3.2	Procedure for a new hybrid circuit which is “non similar” to a reference circuit	23
7.3.3	Procedure for a new hybrid circuit which is “similar” to a reference circuit	24
7.3.4	Procedure for a “recurrent” hybrid circuit	24
8	Procurement of passive and active chips	25
8.1	General.....	25
8.1.1	Introduction	25
8.1.2	Selecting chip suppliers	27
8.1.3	Specifications.....	27
8.1.4	Requirements for chip lots.....	27
8.2	Procurement of passive chips	28
8.2.1	General	28
8.2.2	Bondability test.....	28
8.2.3	Lot acceptance test (LAT)	28
8.3	Procurement of active chips.....	29
8.3.1	General	29
8.3.2	Bondability test.....	30
8.3.3	User LAT.....	30
8.4	Procurement of hermetically encapsulated chips	32
9	Procurement of materials and piece parts	33
9.1	Overview	33
9.2	Selection of materials and piece parts	33
9.3	Specifications	33
9.4	Requirements for materials and piece parts.....	34
10	Manufacturing and screening of hybrid circuit lots	35
10.1	Manufacturing	35
10.2	Marking.....	35
10.2.1	General	35
10.2.2	Special cases.....	36
10.3	Screening	36

10.3.1	General	36
10.3.2	Thermographic test	39
10.3.3	Pre-seal burn-in	40
10.3.4	Photograph of circuits	40
10.3.5	Conditions for constant acceleration and mechanical shock.....	40
10.3.6	Test condition for PIND	40
10.3.7	Leak tests	41
10.3.8	Physical dimensions.....	41
10.3.9	Burn-in test	41
10.3.10	Radiographic inspection.....	41
10.4	Lot rejection	41
10.4.1	Definition of failure modes.....	41
10.4.2	Criteria for lot rejection	42
10.4.3	Disposition of rejected lots	43
10.5	Repair provisions	43
10.5.1	General	43
10.5.2	Element replacement	43
10.5.3	Wire re-bonding	43
10.5.4	Compound bonding.....	44
10.5.5	Delidding of hybrid circuits	44
11	Customer inspection and review	45
12	Lot acceptance tests for hybrid circuits.....	46
12.1	General.....	46
12.1.1	Overview	46
12.1.2	Samples.....	46
12.2	Category 1 manufacturer	47
12.2.1	Option 1: Production lot control	47
12.2.2	Option 2: Lines under TRB management and statistical process control.....	48
12.3	Category 2 manufacturer (validated for the project)	49
13	Hybrid delivery and data package.....	53
13.1	General.....	53
13.2	Data documentation.....	53
13.2.1	General	53
13.2.2	Cover sheets.....	54
13.2.3	Certificate of conformity	54
13.3	Packaging and despatch.....	54

14 DPA test sequence	55
-----------------------------------	-----------

Bibliography.....	76
--------------------------	-----------

Figures

Figure 4-1: Sequence of activities in the procurement of hybrid microcircuits	14
Figure 4-2: Hybrids procurement flow	15
Figure 8-1: Flow of Procurement of Active and Passive components	26
Figure 10-1: Screening test sequence	37
Figure 12-1: Lot acceptance tests for the first production lot manufactured by a category 2 manufacturer	51

Tables

Table 8-1: Sample size and acceptance criteria for LAT of passive chips.....	29
Table 8-2: Sample size and acceptance criteria for user LAT on active chips.....	31
Table 10-1: Test conditions for constant acceleration and mechanical shock	40
Table 12-1: Sample size for hybrids lot acceptance tests	47
Table 12-2: Lot acceptance tests and sample size	47
Table 12-3: Production acceptance tests and sampling.....	50
Table 12-4: Definition of tests	51

Foreword

This document (EN 16602-60-05:2014) has been prepared by Technical Committee CEN/CLC/TC 5 "Space", the secretariat of which is held by DIN.

This standard (EN 16602-60-05:2014) originates from ECSS-Q-ST-60-05C Rev. 1.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2015, and conflicting national standards shall be withdrawn at the latest by March 2015.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

This document has been developed to cover specifically space systems and has therefore precedence over any EN covering the same scope but with a wider domain of applicability (e.g. : aerospace).

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

The objective of this Standard is to define the requirements for the procurement of hybrid microcircuits for use in space systems.

This Standard covers the following requirement domains:

- Validation procedure for a hybrid microcircuit manufacturer.
- Design of hybrid microcircuits.
- Procurement of active and passive chips.
- Procurement of materials and piece parts.
- Screening of hybrid microcircuit lots.
- Lot acceptance tests for hybrid microcircuits.
- Customer involvement, key inspection points.
- Repair provisions.
- Hybrids and data package delivery.

1

Scope

The procurement requirements for hermetic hybrid microcircuits for use in space projects are defined in this Standard.

This Standard also provides details concerning the documentation requirements and the procedures relevant to obtain approval for the use of hybrid microcircuits in the fabrication of space systems and associated equipment.

The provisions of this Standard apply to all participants in the production of space systems, at all levels and are applicable to manned and unmanned spacecraft, launchers, satellites, payloads, experiments, and their corresponding organizations.

This standard may be tailored for the specific characteristic and constraints of a space project in conformance with ECSS-S-ST-00.

2

Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Standard. For dated references subsequent amendments to, or revisions of any of these publications do not apply. However, parties to agreements based on this ECSS Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references the latest edition of the publication referred to applies.

EN reference	Reference in text	Title
EN 16601-00-01	ECSS-S-ST-00-01	ECSS system — Glossary of terms
EN 16602-60	ECSS-Q-ST-60	Space product assurance — Electrical, electronic and electromechanical (EEE) components
EN 16602-60-12	ECSS-Q-ST-60-12	Space product assurance - Design, selection, procurement and use of die form monolithic microwave integrated circuits (MMICs)
EN 16602-30-11	ECSS-Q-ST-30-11	Space product assurance — Derating - EEE components
EN 16602-70	ECSS-Q-ST-70	Space product assurance — Materials, mechanical parts and processes
	MIL-STD-883G	Tests methods and procedures for microelectronics
	MIL-STD-750D	Test method standard for semiconductor devices
	ESCC 20600	Preservation, packaging and despatch of ESCC components
	ESCC 2043000	Internal visual inspection of capacitors
	ESCC 2044000	Internal visual inspection of resistors
	ESCC 2045010	Internal visual inspection of microwave devices
	ESCC 2049010	Internal visual inspection of monolithic microwave devices
	ESCC 2053000	External visual inspection of capacitors
	ESCC 2054000	External visual inspection of resistors
	ESCC 2093000	Radiographic inspection of capacitors
	ESCC 2094000	Radiographic inspection of resistors

Terms, definitions and abbreviated terms

3.1 Terms from other standards

For the purpose of this standard, the terms and definitions of ECSS-S-ST-00-01 apply.

3.2 Terms specific to the present standard

3.2.1 approving authority

organization supplying approval certificate

NOTE In Europe the approving authority for space systems components is the ESCC system.

3.2.2 category 1 manufacturer

manufacturer with a technology domain approved or pending approval by the approving authority

3.2.3 category 2 manufacturer

manufacturer with a technology domain not approved by the approving authority

3.2.4 EM quality level hybrid

hybrid manufactured with the same parts (types, sources and design), materials, and processes as flight models but with acceptance of a lower quality level for visual inspection or screening during procurement or manufacturing

3.2.5 hybrid

see "hybrid microcircuit"

3.2.6 hybrid circuit

see "hybrid microcircuit"

3.2.7 hybrid microcircuit

combination of elements (interconnection substrate, added active or passive chips) sealed inside a package in order to perform an electronic function

NOTE 1 Interconnection substrate (e.g. thick film, thin film, co-fired, DBC) can be with or without integrated

passive components (e.g. resistors, inductors, capacitors).

NOTE 2 Active parts can be monolithic or discrete, chips or packaged components.

NOTE 3 Electronic functions that are performed by hybrids include digital or analog, low frequency or radiofrequency, low power or high power functions. These functions may be mixed according to the application.

NOTE 4 The terms “**hybrid circuits**” and “**hybrids**” are synonymous for “Hybrid microcircuits”.

3.2.8 process identification document

document that defines the approved technology domain, the reference of approval status, and one that freezes the configuration of the manufacturing line and the approved domain

3.2.9 process performance index

the long-term capability of the process which reflects the process centering and the variability with respect to specification requirements

3.2.10 production lot

number of units of a single device type manufactured on the same production line using the same production techniques, in one uninterrupted period, according to the same component or part design and having the same chips lots and the same materials

3.2.11 representative production lot

lot that represents several **production lots** grouping products from the same family, covered by one SEC type, manufactured on the same production line, in one uninterrupted period, using the same materials and processes

3.2.12 standard evaluation circuit

device that represents a family of products using the same materials and processes and which is processed on the same production line with the same manufacturing equipment and tools

3.2.13 technology review board

formal group at manufacturer level where design, materials and parts procurement, manufacturing, testing, reliability, and quality assurance functions are represented

3.3 Abbreviated terms

For the purpose of this Standard, the abbreviated terms from ECSS-S-ST-00-01 and the following apply:

Abbreviation	Meaning
CECC	CENELEC Electronic Components Committee
CTA	circuit type approval
COC	certificate of conformance
DCL	declared component list
DRD	document requirements definition
DBC	direct bonded copper
DPA	destructive physical analysis
EM	engineering model
ESA	European Space Agency
ESCC	European Space Components Coordination
ESD	electrostatic discharge
FM	flight model
FMECA	failure modes effects and criticality analysis
HTIF	hybrid circuit technology identification form
LAT	lot acceptance test
MMIC	monolithic microwave integrated circuit
MIP	mandatory inspection points
NCR	nonconformance report
PA	product assurance
PAD	part approval document
PDA	percent defective allowable
PDR	preliminary design review
PID	process identification document
PIND	particle impact noise detection
Ppk	process performance index
RFD	request for deviation
RFW	request for waiver
SAM	scanning acoustic microscope
SEC	standard evaluation circuit
SEM	scanning electronic microscope
SPC	statistical process control
TCV	technological characterization vehicle
TRB	technology review board

4

Sequence of procurement activities

The sequences of activities involved in the procurement of hybrid microcircuits are illustrated in Figure 4-1. A more detailed illustration is further provided in Figure 4-2.

The initial steps in the process are the selection and validation of the manufacturer and the technology.

The technology of a hybrid circuit is defined as the set of processes and materials used to manufacture the hybrid, i.e.

- the substrate network and material: thick film or thin film;
- integrated components, i.e. resistors, capacitors and inductors used in the network;
- processes and materials for the attachment and connection of the added-on components (active and passive chips);
- packaging type and material.

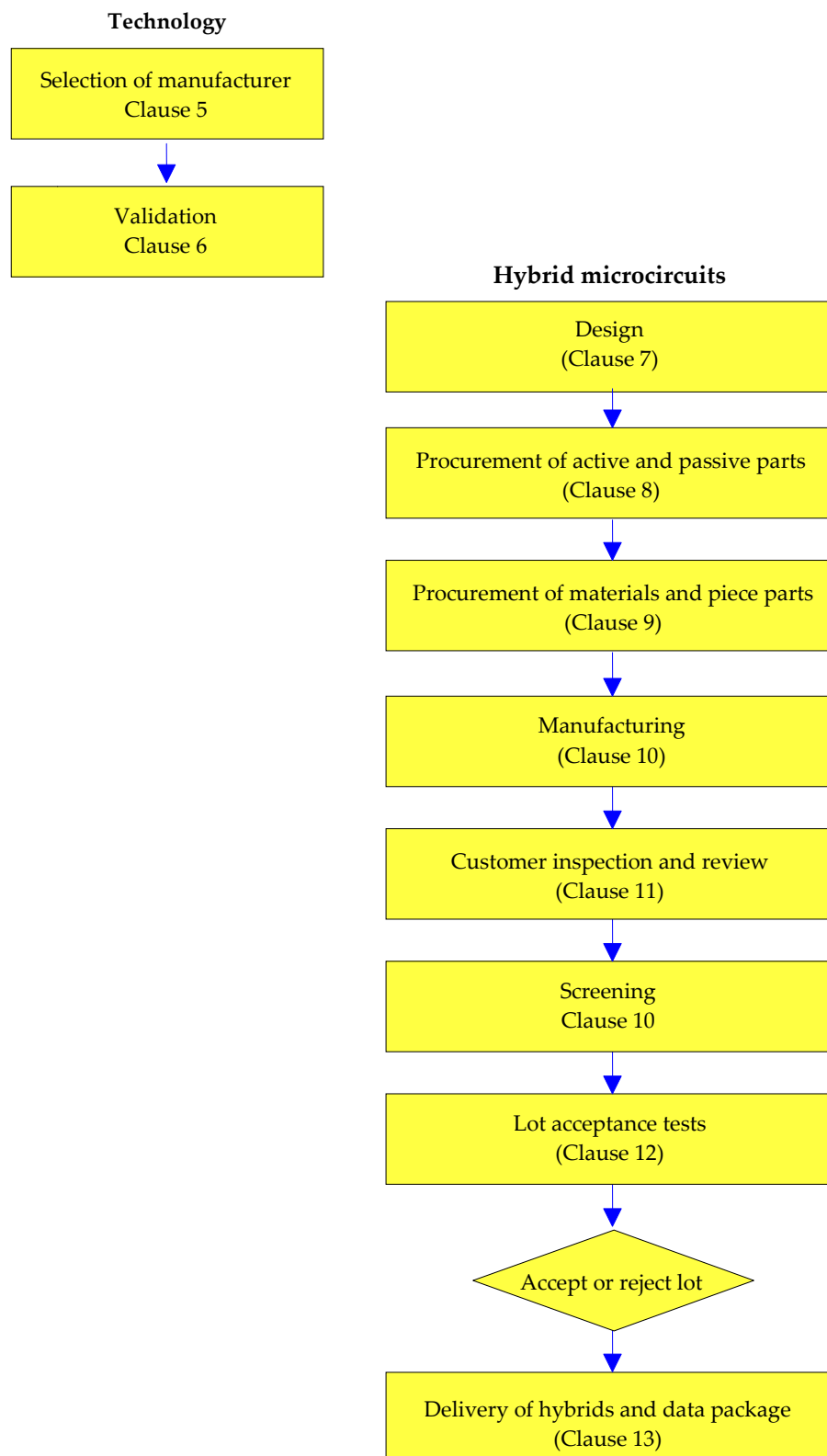


Figure 4-1: Sequence of activities in the procurement of hybrid microcircuits

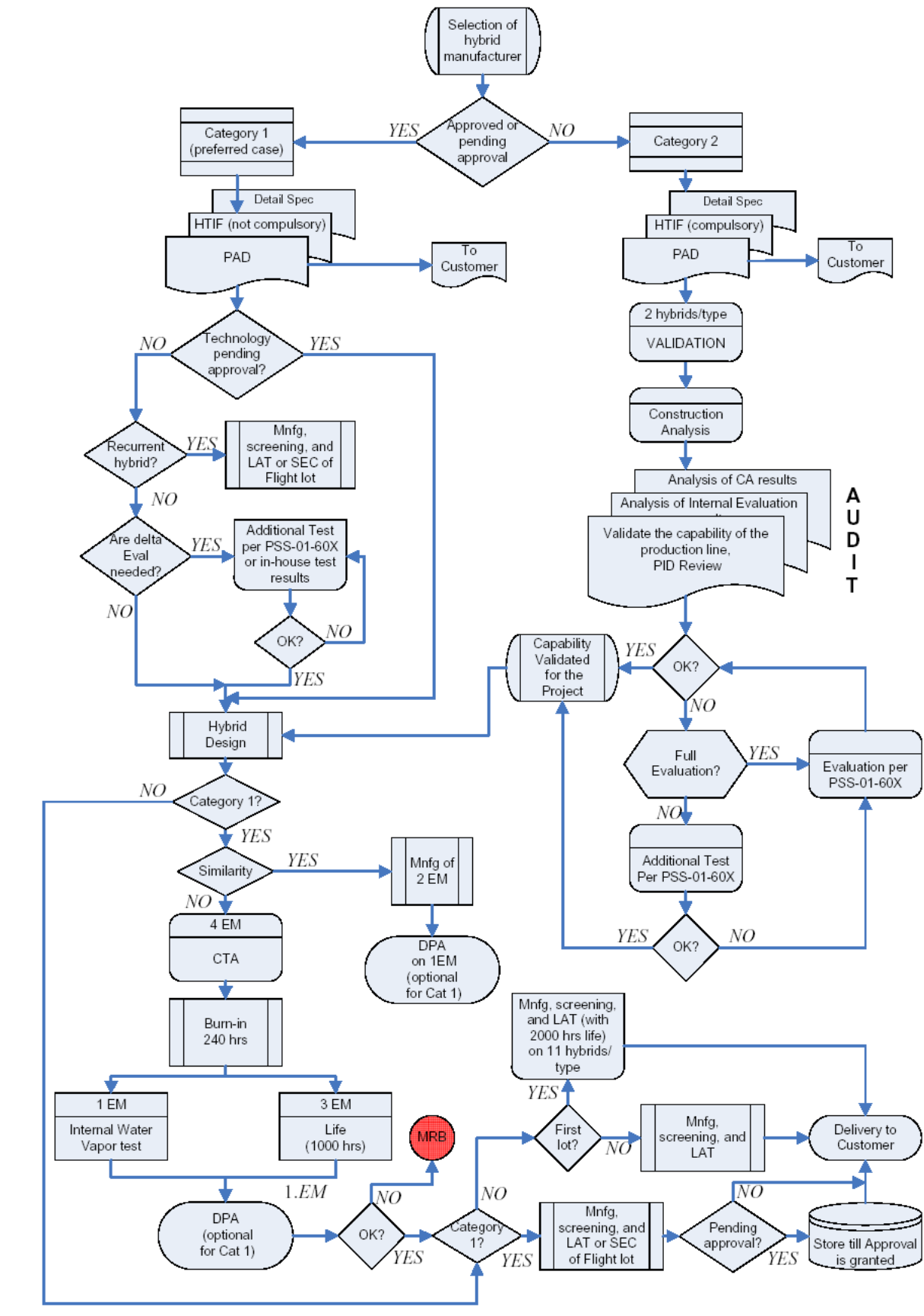


Figure 4-2: Hybrids procurement flow

5

Selection of hybrid microcircuit manufacturer

5.1 General

- a. All manufacturers that are selected for producing hybrids shall be validated as described in Clause 6.

5.2 Hybrid microcircuit manufacturer categories

5.2.1 Category 1 manufacturer (preferred case)

- a. A supplier who wishes to use (or manufacture) hybrid circuits for a space project shall procure (or produce) them from a production line that has been approved or is pending approval by the approving authority.
- b. All hybrid circuits shall be manufactured using the basic processes and materials, and in conformance with the manufacturing and inspection procedures as described in the PID that has been approved by the approving authority.
- c. The PID shall contain as a minimum:
 - 1. the manufacturing and inspection flow chart;
 - 2. the list of applicable documents with approved revision;
 - 3. the general organization of the production line;
 - 4. the approved domain: authorized parts, materials, processes and reworks;
 - 5. the list of manufacturing, inspection and failure analysis equipment;
 - 6. the list of hybrids manufactured in conformance with the approved PID.

5.2.2 Category 2 manufacturer (non-preferred case)

- a. A supplier wishing to use (or manufacture) hybrid circuits from a production line that has not been approved by the approving authority shall:
 - 1. justify its requirements to the customer (especially if this involves developing a new circuit), and
 - 2. satisfy the validation conditions described in Clause 6.

6

Validation procedure for a hybrid microcircuit manufacturer

6.1 General

- a. Validation of manufacturers and production lines shall be conducted jointly by the supplier using the hybrid circuit and the customer, and involving upper level customers where relevant.
- b. In the case of confidential information, these activities may be conducted with the support of the approving authority.

6.2 Hybrid circuit technology identification form (HTIF)

6.2.1 General

- a. Whatever his status (category 1 or 2) regarding the capability approval, a manufacturer wishing to produce or use hybrid circuits shall complete a hybrid circuit technology identification form (HTIF) for each circuit, in conformance with Annex A.
- b. For category 2 manufacturers, this form shall be included with the part approval document (PAD) as described in 6.2.4.

NOTE The format of the PAD is defined in ECSS-Q-ST-60, Annex A.

6.2.2 HTIF for approved manufacturers (category 1)

- a. With justification, it is not mandatory, for a category 1 manufacturer, to deliver the HTIF to the customer.
- b. A category 1 manufacturer shall issue a CoC to the customer to confirm that the proposed hybrid circuit conforms to the domain approved by the approving authority.
- c. As a minimum, the HTIF reference and CoC shall be included in the PAD with reference to the applicable PID.

- d. If the technologies used are not entirely covered by the applicable PID, the manufacturer shall carry out additional (delta-)evaluation tests or prove that he has adequate in-house test results.

NOTE See the relevant PSS evaluation plans in ESA-PSS-01-605, ESA-PSS-01-606, and ESA-PSS-01-612.

- e. This (delta-)evaluation programme shall be referenced in the PAD.
- f. The test results shall be approved by the first level supplier.
- g. The manufacturer shall supply these circuits according to the procurement rules defined for the project as per the requirements in this standard.

6.2.3 HTIF for manufacturer pending capability approval by the approving authority (category 1)

6.2.3.1 Overview

Manufacturers of hybrid circuits are considered to be pending capability approval by the approving authority when:

- they have successfully completed the “evaluation” phase,
- their PID has been approved, and
- they have begun the “approval” phase (see ESA-PSS-01-605, ESA-PSS-01-606, and ESA-PSS-01-612).

6.2.3.2 Requirements

- a. Manufacturers shall only use the technologies that have been tested in the evaluation phase and are referenced in the PID.
- b. Manufacturers may manufacture circuits while the approval phase is being carried out in conformance with the PID.
- c. Manufacturers shall not deliver these circuits until capability approval has been formally acquired.

6.2.4 HTIF for manufacturer not approved by the approving authority (category 2)

6.2.4.1 Overview

For category 2 manufacturers, the review and validation activities for the production lines are described in clause 6.3.

6.2.4.2 Requirements

- a. The review and validation activities for the production lines for category 2 manufacturers shall be implemented at the PDR milestone of the project.

- b. A category 2 manufacturer shall supply an HTIF in conformance with Annex A and include it as part of the PAD.
- c. In case of confidentiality of particular materials or processes, claimed by category 2 manufacturers, the HTIF attached to the PAD may leave undisclosed the confidentiality elements, provided that these aspects are covered and discussed during the quality and technical audit as described in clause 6.3.3.
- d. The HTIF shall be in conformance with the technological domain validated for the project.
- e. The manufacturer shall produce the hybrid circuits for the project which conform to the same common requirements as for category 1 manufacturers and additional requirements as defined in this Standard.

6.3 Validation of category 2 manufacturers

6.3.1 General

- a. Category 2 manufacturers shall be validated in conformance with the requirements in this clause 6.3.

6.3.2 Construction analysis on representative samples

- a. Two circuits per hybrid type shall be supplied by the supplier for construction analysis.
- b. The quality level of these circuits shall be the same as the one specified by the project.

6.3.3 Quality and technical audit

- a. After construction analysis, a quality and technical audit shall be carried out by the supplier as follows:
 - 1. Present the results of the construction analysis.
 - 2. Analyse the results of internal evaluations of the technologies implemented by the manufacturer. Compare these previously obtained results to the tests defined in the evaluation plans (see ESA-PSS-01-606, ESA-PSS-01-605, and ESA-PSS-01-612), and apply the following criteria.
 - (a) If the results of the tests are successful, consider the manufacturer “validated”, but only for the project.
 - (b) If only some of the results are successful, perform additional tests pertaining to the failures (see the evaluation plans ESA-PSS-01-606, ESA-PSS-01-605, and ESA-PSS-01-612).

- (c) If all the results are unsuccessful, draw up a completely new evaluation plan (see ESA-PSS-01-606, ESA-PSS-01-605, and ESA-PSS-01-612).
- 3. Judge the validity of manufacturer's in-house data in conformance with the following criteria:
 - (a) Equivalence of the test structure(s) subjected to the in-house evaluation tests and the hybrid circuits proposed by the project, this "equivalence" including assessment of the following:
 - technology of the circuit,
 - circuit function,
 - circuit complexity,
 - power dissipation.
 - Comparison between the in-house evaluation tests and the reference evaluation plans with respect to the severity of the tests (e.g. level, duration, temperature) and the accept or reject criteria applied.
- 4. Validate the capability of the production line to meet the quality requirements of the project and ensure the following:
 - (a) The components, materials and processes used are governed by specifications written, approved by the manufacturer's quality control departments and that this documentation is applied at the time of the manufacturer's in-house evaluation tests.
 - (b) The quality control operations on the production line conform in frequency and severity to the "high reliability" requirements.
 - (c) The traceability of the finished product and its component parts is guaranteed by the manufacturer and can be used by the customer.
 - (d) All the documentation relating to production and quality assurance specified in the process identification document (PID) is approved by the customer.

NOTE For guidelines for carrying out such audits see ESA-PSS-01-607 and ESA-PSS-01-611.

Design requirements

7.1 General

7.1.1 Overview

The “design” of a hybrid circuit includes the initial activities to be undertaken by a manufacturer in order to implement specific electrical functions, derived from a circuit diagram, in a finished hybrid.

7.1.2 Design activities

- a. The design activities of a hybrid circuit shall, as a minimum, include the following:
 1. Selection of technology.
 2. Selection of added-on components, i.e. defining the types of chip components used in the hybrid and their manufacturers.
 3. Definition of the physical layout of the hybrid circuit, i.e. the interconnections in the hybrid to enable the electrical function.
 4. Application of the derating requirements in conformance with ECSS-Q-ST-30-11.
 5. Implementation of the thermal management criteria in the case of power circuits.
 6. Mechanical, dimensional verification.
 7. Verification of the radiation related requirements for the added-on components and the whole hybrid circuit.
 8. The activities requested by the customer to ensure that the predicted failure rate of the hybrid circuit is compatible with the reliability target of the equipment concerned (FMECA, reliability calculation and worst case analysis).
- b. When selecting the technology in conformance with 7.1.2a.1, the technology shall be as specified in the PID and described in the hybrid technology identification form (HTIF) specified in Annex A.
- c. When selecting the added-on components in conformance with 7.1.2a.2, the selection shall conform to the requirements specified in the PID.

- d. When defining the physical layout of the hybrid circuit in conformance with 7.1.2a.3, the layout of the hybrid circuit shall conform to the design rules defined in the specification called up by the approved PID.

7.2 Detail specification for hybrid circuits

- a. A detail specification for each type of hybrid circuit shall be drawn up in conformance with Annex B.
- b. The maximum rating and drifts of electrical parameters shall be established from the following:
 - 1. the detail specification for the chip components,
 - 2. the results obtained on prototypes and engineering models.
- c. The manufacturer shall demonstrate the consistency between the maximum ratings and drifts specified for the hybrid circuit and those for each of the chip components.
- d. Any deviations in the burn-in and life test temperatures as specified in the detail specification (Annex B) shall be subject to a request for deviation.

7.3 Design approval (circuit type approval)

7.3.1 General

7.3.1.1 Overview

The procedure for design approval of a hybrid circuit depends on the following:

- Its “non similarity” to a circuit developed or being developed for the project, or a circuit already developed and approved within the framework of a previous project.
- Its “similarity” to a circuit developed or being developed for the project, or a circuit already developed and approved within the framework of a previous project.
- The “recurrence” of a circuit which has already been used (developed, approved, manufactured) within the framework of a previous project.

7.3.1.2 Requirements

- a. Similarity shall be proposed by the manufacturer to the customer by using a similarity form in conformance with Annex C.

NOTE Similarity is assessed on the basis of the HTIF and this similarity form.

- b. The similarity form shall be enclosed with the request for use (PAD).