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Space systems — Launch pad and integration site — Facility, system and equipment failure analysis

Systèmes spatiaux — Aire de lancement et site d'intégration — Analyse de défaillance des installations, du système et de l'équipement

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

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Introduction

Failure of the launch pad or integration site facility, system or equipment during acceptance testing or operation can be catastrophic. Failure of the facility, systems or equipment can damage flight or ground hardware and injure personnel. Failures need to be thoroughly investigated in order to prevent future failures, damage and injuries. In order to investigate failures of launch pad or integration site facilities, systems or equipment, adequate processes and procedures must be employed to thoroughly analyse and determine the cause of the failure. Identification of failure causes is necessary to implement changes to the facility, system and equipment in order to prevent a recurrence of the failure and the resulting damage or injury. This International Standard establishes procedures for determining the causes of facility, system and equipment failures and preventing such failures.

Space systems — Launch pad and integration site — Facility, system and equipment failure analysis

1 Scope

This International Standard establishes procedures for the analysis of failures that occur during the acceptance testing or operation of launch pad and integration site facilities, systems and equipment. The procedures define the processes for investigating, analysing and identifying the probable causes of failures, and for developing corrective actions to preclude future failures.

The purpose of this International Standard is to provide

— rules for investigating, analysing and identifying the causes of failures,

— sufficient information so that corrective action may be implemented to prevent failure recurrence, and

— a uniform method for maintaining records of the findings of all failure causes so as to provide information for other failure investigations.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
complex
launch pad or integration site

[ISO 26870:2009, definition 3.2]

2.2
discrepant component
first component of a facility, a system or equipment that manifests failure

NOTE The discrepant component may or may not be the primary or initial component to fail.

2.3
design documentation
documentation created by the developer and containing the requirements for the manufacture, fabrication, purchase or production of the components of the facility, system or equipment

2.4
failure
termination of the ability of an item to perform the function for which it was designed

[ISO 14620-2:2011, definition 3.5]

2.5
failure analysis
systematic approach to determine, as a minimum, the mode and mechanism of failure via investigative techniques, in order to identify and assess potential root causes and ultimately arrive at the most probable, and to identify and assess potential corrective actions and ultimately recommend/implement the most suitable

NOTE Investigative techniques can range from examination in the field to evaluation in the laboratory.

2.6
primary failed component
component, the failure of which resulted in the compromised functionality of the component itself, of additional components or of the associated facility, system or equipment

2.7
failure precondition
pre-existing conditions and circumstances that predispose a component to failure

NOTE Failure preconditions can include improper design, manufacture or service.

2.8
functional track
sequence of components on which energy (mechanical, electric, or pressure) is transferred from the primary failed component to the discrepant component

2.9
integration site
equipment and facility designed for launch vehicle storage, assembly, testing, preparation, maintenance, servicing and preparation for transportation to the launch pad

[ISO/TR 17400:2003, definition 3.1]

2.10
launch pad
equipment and facility designed to provide for the pre-launch and launch operations of spacecraft

[ISO/TR 17400:2003, definition 3.3]

2.11
normative documentation
specifications, standards, rules or instructions, to which adherence is required through citation in the design documentation or the construction, fabrication, manufacture, purchase or production documentation for the manufacture and operation of the facility, system or equipment

2.12
production documentation
documentation created by the facility, system or equipment contractor, which establishes the requirements for construction, fabrication, manufacture or purchase of the facility, system, equipment or component

2.13
root cause
primal condition, event or circumstance, or initiating cause, that is ultimately responsible for the occurrence of a failure

3 General provisions

3.1 For each component involved in the facility, system or equipment that failed, the following records shall be evaluated:

— design documentation;

— normative documentation;

— production documentation;

— acceptance test certificates and reports;

— cogent reports, log-books, schedules and certifications.

3.2 The failure analysis shall be carried out by a team of experts.

3.3 The failure analysis team shall be given the task of investigating a failure by

— the facility, system, equipment or component developer or manufacturer, if the failure occurred prior to the deployment of the facility, system or equipment, or

— the customer, if failure occurred after the facility, system or equipment was deployed.

3.4 The failure analysis team shall include representatives of the facility, system or equipment developer and manufacturer and typically also includes representatives of

— the operator,

— the component developer,

— the component manufacturer,

— the assembly organization,

— the maintenance organization,

— the expert on quality assurance, and

— the customer.

3.5 The following shall also be considered when selecting the failure analysis team experts:

— type of facility, system or equipment;

— type of discrepant component failure (e.g. structural, mechanical or electrical);

— symptoms of the failure;

— availability of information on the conditions prior to failure;

— environment and conditions at the failure site.

3.6 The operator and the customer shall jointly appoint one of the following to lead the failure analysis team:

— a representative of the developer, if the failure occurred during testing, or

— a representative of the customer, developer, or manufacturer, if the failure occurred during operations.

3.7 The failure analysis team shall include a safety representative of

— the manufacturer, if the failure occurred during acceptance testing, or

— the operational organization, if the failure occurred during operations.

4 Methods of analysis

4.1 The failure analysis process generally includes the following steps or actions:

a) gathering of information related to the failure, which applies not only to the failed component but also to the associated facilities, systems and equipment and which can include the following:

   1) facility, system or equipment;

   2) discrepant component failure (e.g. structural, mechanical or electrical);

   3) symptoms of failure;

   4) information on the conditions at the time of failure;

5) time and date the failure was discovered;

6) stage of operation or acceptance testing during which the failure occurred;

7) power system condition;

8) environmental conditions;

9) service age and guaranteed service life of the facility, system, equipment or component;

10) manufacturing and service history;

11) potential causes of the failure for related systems, equipment or components;

12) events or conditions that could cause a facility, a system, equipment, or a complex as a whole, to fail;

b) survey of the site where the failure occurred or was discovered;

c) documentation of the operating or performance indicators at the moment of failure;

d) selection of design documentation and production documentation that reveal the chain of events from the primary failed component to the last discrepant component and the operating parameters and conditions of any discrepant components and failed components;

e) selection of normative documentation, establishing the operating parameters and conditions of the discrepant components and the probable failed components (if parameters and conditions are standardized);

f) analysis of all the documentation so as to identify all the components in the functional track (and their parameters) whose malfunction or deviation from the documentation could have caused the failure;

g) analysis of failure preconditions discovered during acceptance testing or operation;

h) step-by-step disassembly (component by component according to an assembly drawing) of all prospective functional tracks so as to

1) examine the component,

2) record the failure indications,

3) measure component parameters,

4) compare component parameters and failure indications with documented requirements, and

5) document the discrepancies;

NOTE Disassembly can be stopped once the cause of failure has been found and verified.

i) definition of the failure and cause of the malfunction in the discrepant component;

j) definition of corrective actions;

k) definition of preventive actions.

4.2 The process outlined in 4.1 may be tailored or supplemented by other operations that are deemed necessary in order to respond more effectively to the particular facility, system, equipment or component.

Depending on the nature of the failure, the procedures established in this International Standard can be reduced.

4.3 Operations may be divided or combined depending on the characteristics of the facility, system, equipment or component.

5 Documentation and distribution of the failure analysis results

5.1 The final report of the failure analysis shall contain at least the following:

a) date of submission;

b) name of the organization where the analysis was performed;

c) name and part number of the facilities, systems, equipment and components subjected to the analysis;

d) document appointing a failure analysis team (number, date and name, position and signature of the appointing authority);

e) composition of the failure analysis team;

f) details of the failure, including

   1) the place, date and time the failure was discovered,

   2) the discrepant failure and its function,

   3) the symptoms of failure,

   4) the effects of failure on the facility, system, equipment or complex as a whole,

   5) the stage of operation or acceptance testing during which the failure occurred,

   6) the environmental conditions,

   7) the facility, system or equipment operating time,

   8) the guaranteed service life of the facility, system or equipment,

   9) the component operating time,

   10) the guaranteed service life of the component,

   11) the conditions at the time of failure,

   12) the probable cause (as assessed by the failure analysis team), and

   13) the applicable laboratory analysis and findings;

g) work products of the failure analysis team, including

   1) list of documentation analysed for each functional track,

   2) list of possible discrepant failures identified as a result of documentation analysis,

   3) records of results of the step-by-step disassembly of all functional tracks determined in 4.1 h), including the following information for each step:

      i) component examination results,

      ii) indications (those prescribed in the documentation and actual ones),

      iii) parameters (those prescribed in the documentation and actual ones), and

      iv) deviations or discrepancies,

   4) conclusions about the probable cause of the failure (e.g. type of failure and mode of failure),

   5) recommended corrective actions,

   6) recommended preventive actions,

7) any additional recommendations or data deemed necessary by the failure analysis team, and

8) determination of the root cause of the failure.

5.2 The report shall be signed by all members of the failure analysis team.

5.3 Any member of the failure analysis team who disagrees with the conclusions or recommendations expressed in the final report may attach a dissenting opinion as part of the final report. Such final reports shall clearly direct reviewers to those dissenting opinions.

5.4 Final failure analysis reports require the approval of the developer and manufacturer of the facility, system or equipment. Final analysis reports of failures occurring during operations require the additional approval of the operator. Final failure analysis reports are coordinated with the customer and, if necessary, with the developer and manufacturer of the primary failed component.

5.5 The final failure analysis report shall be distributed to

— the operator,

— the facility, system or equipment developer,

— the developer of the primary failed component (if other than the facility, system or equipment developer),

— the facility, system or equipment supplier,

— the manufacturer of the primary failed component (if other than the facility, system or equipment supplier), and

— the customer.

6 Preventive actions

6.1 The corrective and preventive actions recommended in the final failure analysis report shall be implemented by the affected organization

— in accordance with instructions from the customer, if the failure occurred during acceptance testing, or

— as specified in the final failure analysis report, if the failure occurred during operations.

6.2 Corrective and preventive actions for failures shall be approved by the developer. The implementation of corrective and preventive actions is coordinated with the customer.

6.3 Corrective and preventive actions shall directly address the probable cause of the failure and any incidental malfunctions discovered during the course of the analysis. Corrective and preventive actions may relate to the design and manufacture of hardware or software, the adequacy or applicability of current documentation, or the effectiveness of operational, maintenance, organizational or business processes.

6.4 Corrective and preventive actions shall be written as specific measures with parameters that can be achieved, quantified and verified. They shall state specific actions (e.g. “inspect the component at six-month intervals”) and shall not express vague goals (e.g. “improve inspection”).

NOTE Annex A deals with potential corrective actions.

6.5 The developer, supplier and customer may jointly revise the corrective and preventive actions in the course of implementation. Such revisions shall be approved in accordance with 5.4, distributed in accordance with 5.5, and stored with the final report.