INTERNATIONAL STANDARD

ISO 18238

First edition
2015-11-01

Space systems — Closed loop problem solving management

Systèmes spatiaux — Gestion de résolution du problème de boucle fermée

Reference number
ISO 18238:2015(E)

International Organization for Standardization

COPYRIGHT PROTECTED DOCUMENT

ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

Introduction

This International Standard is useful to promote a method to identify the root causes of problems including failures, defects, accidents and other undesirable conditions, and to implement corrective actions and preventive actions.

The intent of this International Standard is to define the best practices dealing with root causes analysis and problem solving, prevent recurrence of the problem, and achieve quality improvement. It provides a standard process flow method to identify the root causes and improve the process and achieve quality improvement. It applies to all space products and organizations, at all levels and phases.

The process described in this International Standard is created by comparing and mixing root cause analysis and problem solving methodologies used by main actors of aerospace industry around the world. The process flow chart can be used to find root causes and to solve the problem thoroughly.

This International Standard provides a method for finding the root causes mainly against failures, defects, and accidents. As for non-conformance, ISO 23461 “Programme Management - Nonconformance control system” is usually applied.

When necessary, the problem solving process method in this International Standard should also be used for processing of major non-conformance in ISO 23461.

Space systems — Closed loop problem solving management

1 Scope

This International Standard provides basic procedures and requirements of closed loop problem solving against product quality problems including failures, defects, accidents, and other undesirable conditions for organizations.

This International Standard is intended to improve the closed loop problem solving management which covers the impact mitigation of the problem, root causes identification and problem containment, and lessons learned.

This International Standard is applicable to problem solving management of all space products, starting from engineering development phase.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 10795, *Space systems — Programme management and quality — Vocabulary*

ISO 16192, *Space systems — Experience gained in space projects (Lessons learned) — Principles and guidelines*

ISO 23461, *Space systems — Programme management — Non-conformance control system*

3 Terms and definitions

For the purpose of this Standard, the terms and definitions given in ISO 10795 and the following apply.

3.1
root cause
original event, action, and/or condition resulting in an actual or potential undesirable condition, situation, nonconformity or failure

Note 1 to entry: There are often several root causes for one problem.

3.2
root cause analysis
process of identifying all root causes that have or may have resulted in an undesirable condition, situation, nonconformity or failure

3.3
lessons learning
process of distributing the problem information to the whole project and organization as well as other related projects and organizations, warning if similar failure modes or mechanism issues exist and taking preventive actions

4 Basic elements for closed loop problem solving management

4.1 Implemention time

The organization shall implement closed loop problem solving management according to this International Standard when the following problems are detected and the root causes are not obvious.

a) Problems in design which might delay development schedule, create interface design change with other business units, lower performance index, and result in production rework.

b) Problems in design and production which might result in major economic losses.

c) Problems in production which might occur repeatedly and in batch due to technology causes.

d) Problems in EEE components and raw materials which might occur in batch due to technology causes.

e) Problems in test technology which might result in test failure or product damage.

f) Problems which might occur due to technology causes after the parts, subsystem, or system were delivered.

g) Problems which might occur due to technology causes in shooting range or launching site.

h) Problems which might occur due to technology causes after the final product had been delivered for use.

i) Problems which might occur in orbit operation and return of satellite and spacecraft, due to failure or other technology causes which can affect mission completion.

j) Problems which might affect cost, schedule, or performance and could jeopardize intended system use.

4.2 Implemention plan

The organization shall prepare an implementation plan for closed loop problem solving with sufficient resource support and incorporate the plan into the organization's quality management activities.

4.3 Problems summary

The organization shall summarize and classify problems at the following key decision points. Inspection and review should be conducted if necessary

a) before transferring to next development phase,

b) before acceptance of components, subsystem, or system,

c) before exfactory of satellites, launch vehicles, and space crafts,

d) before transferring to shooting range or launching site,

e) before launching,

f) cefore the delivery of satellites and space crafts on orbit, and

g) after the return of satellites and space crafts.

4.4 Review

At the end of closed loop problem solving, the organization shall review whether corrective actions are appropriate and effective.

4.5 Records maintenance

The organization shall maintain all records.

5 Procedures of closed loop problem solving management

The organization should use closed loop management of problems in the development phase and the production phase of contractually specified products. In order to ensure that the problem is solved and will not happen again, the organization shall locate the problem accurately, define root causes by theoretical analysis or experiments, conduct problem recurrence experiments when necessary, take corrective actions against the root causes, and implement lessons learning in the whole organization and project. Figure 1 gives the procedures of closed loop problem solving management.

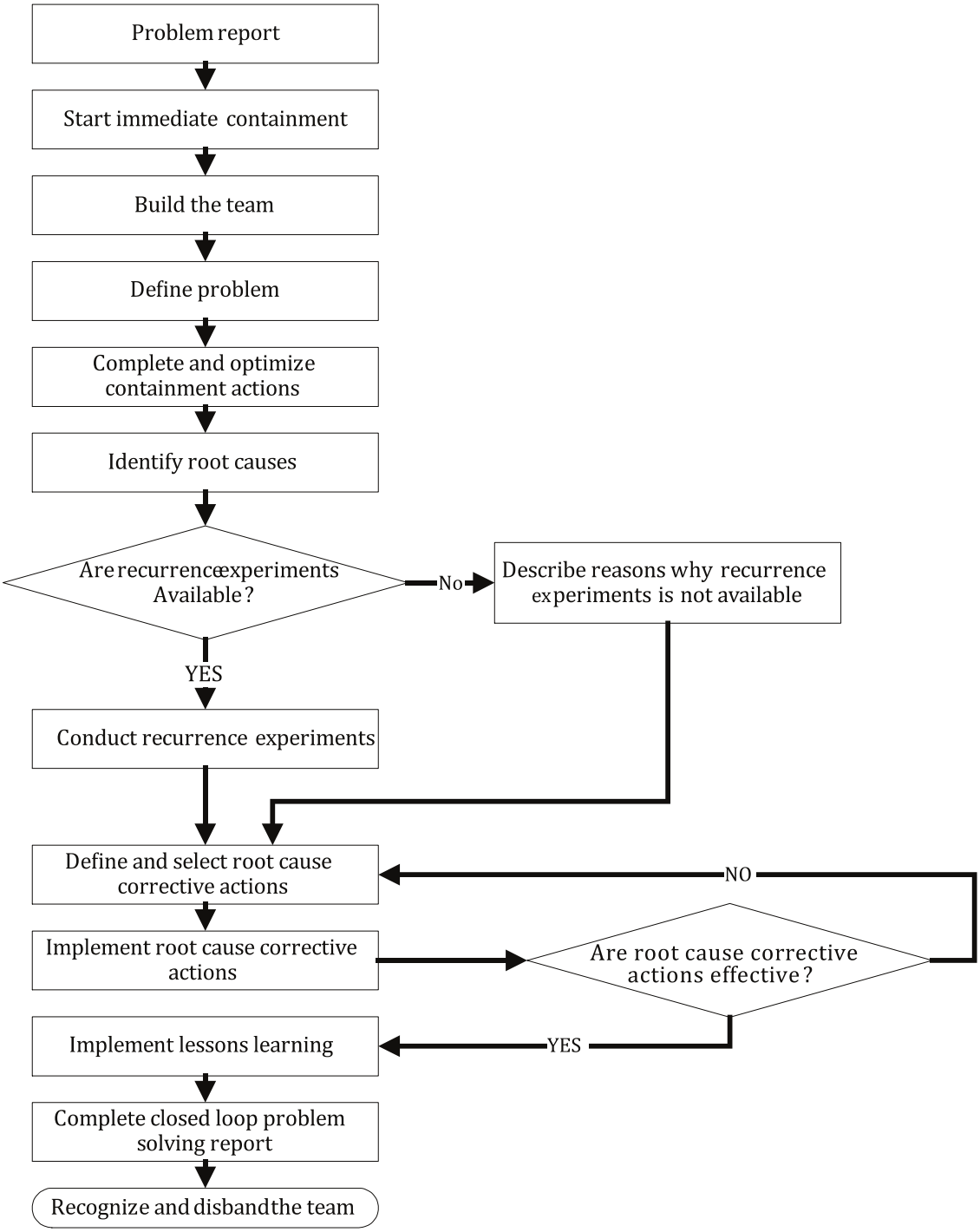

Figure 1 — Procedures of closed loop problem solving management

6 Implementation of closed loop problem solving

6.1 Problem report

a) The objective is to let related people informed about the problem timely.

b) When a problem is detected, the organization shall protect the scene, make records, and report timely without compromising safety and security.

c) Contents of the report include: product information; problem phenomena; test condition; working hours and environment; problem observer, etc.

Non-conformances of deliverable products and supplies shall be reported and disposed in accordance with ISO 23461. The relation between the problem report and the nonconforming report provided in ISO 23461 should be shown when it is done according to this International Standard.

6.2 Start immediate containment actions

a) The objective is to mitigate the impact of the problem, protect the customer operations and the organization, and ensure that problem does not deteriorate before identification of root causes.

b) The organization shall implement immediate containment actions when the problem detected is having an impact now on the customer or the organization, especially if no action is taken, the problem will deteriorate.

c) Immediate containment actions shall be implemented according to the following steps:

1) identify, isolate of defectives and perform immediate correction;

2) identify apparent cause and perform immediate corrective action to eliminate, prevent, or reduce the probability of any additional non-conformances from happening again in the short-term;

3) typical immediate containment actions include

— immediate stop of the working process, including deliveries, recall product if necessary,

— increase inspection, and

— conduct inventory checks and isolation of defectives.;

4) identify immediate potential risk for defectives not detected;

5) determine apparent criticality. Customers or the design department might be asked to assist in evaluating the criticality.

NOTE immediate containment actions terminate when corrective actions are in place or when a more effective containment action is found.

d) The organization shall communicate and implement actions across various entities and other organizations.

1) Identify the entities affected or impacted by the problem(internally and externally).

2) Inform all identified entities.

3) Immediate information to the customer is mandatory if product has been delivered which is known or suspected to be affected by the issue, potentially impacts safety and more generally have a significant impact on customer’s operations.

6.3 Build the team

a) The objective is to ensure that representatives from relative parties (suppliers and customers) and functions that might have an influence on the problem solving processes are in the team.

b) Gather a team in which members from different functions have an influence on the problem and get the team prepared to carrying out the problem solving activities. The team should be modified or completed if necessary all along the problem solving process.

c) Sufficient communication is required to ensure

1) team leader has a clear understanding of his responsibility, the team’s resources and constraints,

2) each team member has a clear understanding of his responsibility as far as possible,

3) managers of functions where team members come from are informed about the involvement (time, duration, role)of their staffs in the team, and

4) all stakeholders are informed about the team composition and objectives.

6.4 Define problem

a) The objective is to understand the significance, impact and extent of the problem and to ensure that the situation is fully described and understood.

b) After built, the team shall fully describe the situation, precisely analyse all its elements to gain a common understanding in order to define a corrective action plan.

c) The problem phenomena and location shall be confirmed. Accredited test institutions will provide their services if necessary. The problem statement shall be supported by objective evidence, based on facts and figures, rather than perception. The scope and extent of the problem and the symptoms which are being experienced by the customer shall be understood.

d) Continual communication between all team members is mandatory. Problem definition and extent shall be communicated to and agreed by appropriate customers and stakeholders.

e) Recommended tools to gather and analyse data for problem definition are the following:

1) brainstorming;

2) fishbone diagrams;

3) comparison sheets;

4) check sheets

5) tally charts;

6) histograms;

7) scatter diagrams;

8) control charts;

9) pareto analysis;

10) statistical process control;

11) is/is not analysis;

12) stratification.

6.5 Complete and optimize containment actions

a) The objective is to ensure that containment actions can suitably address the problem and to verify that immediate corrective actions are commensurate with the problem, implemented, and effective.

b) The organization shall check that all defective parts or data have been isolated and corrected to prevent their escape, and optimize immediate corrective actions to minimize impact on the customer, operation and the organization until the root cause of the problem is understood and permanent effective corrective actions are taken.

c) When problem is well defined, immediate containment actions need to be further developed, optimized and some might need to be removed.

d) Containment actions shall be completed and optimized according to the following steps:

   1) identify action owners and due dates;

   2) identify potential risk of defective parts or data not detected;

   3) assess criticality with all team members including suppliers and customers ;

   4) generally, additional containment actions include: over inspection upstream in the process; stock segregation in sub-tiers; product recall.

e) Continual information updating between all team members is required, for instance through regular reviews until containment actions are clearly identified, agreed by all, and implemented. The nature of containment actions shall be communicated to and agreed by all stakeholders, especially by the customer if defectives have been delivered and/or might soon be impacted (e.g. suspend deliveries).

6.6 Identify root causes

a) The objective is to identify, through structured root cause analysis, all causes that have generated or contributed to the undesirable condition, situation, nonconformity or failure.

b) After problem definition and containment implementation, a structured root-cause identification process shall be executed to identify all root causes for problem recurrence prevention.

c) Root causes shall be identified according to the following steps:

   1) understand and map the process;

   2) define what actions need to be taken in order to find the root causes;

   3) measure current performance;

   4) identification of root cause shall be supported by objective evidence based on proven tools;

   5) prioritize causes by performing a risk analysis based on impact on the product, operations and customer; probability to occur; detectability;

   6) select root causes that need to be addressed from those that do not require corrective and preventive actions due to their low criticality.

d) Communication between all team members is required, for instance through regular reviews until root causes are clearly identified and agreed by all. Root causes shall be communicated to all stakeholders, especially by the customer if defectives have been delivered and/or might soon be impacted.

e) Recommended tools for the problem definition, data collection, and analysing are:

   1) data collection: check list;

   2) data collection and analysis: histograms; scatter diagrams; run and control charts; process mapping(follow charts); design of experiment; Pareto analysis;

   3) analysis techniques: fishbone; 5 why's; cause and effect; Failure Mode and Effect Analysis (FMEA); Fault Tree Analysis (FTA); root cause chain, root analysis software, etc.

6.7 Conduct recurrence experiments

a) The objective is to verify the problem statement and identified root causes.

b) Recurrence experiments shall be conducted to make the problem reappear if available. When recurrence experiments are not to be conducted, the reason shall be described in the closed loop problem solving management report.

c) Recurrence experiments shall be conducted according to the following steps:

   1) prepare experiment documents;

   2) conduct experiments according to the experiment documents and make records;

   3) prepare experiments result analysis report.

d) Sufficient communication is required.

6.8 Define and select root cause corrective actions

a) The objective is to define, prioritize and select corrective actions that are to be implemented to address the root causes and prevent the problem from recurring.

b) The organization shall ensure corrective actions addressing the most likely or critical root causes are taken, considering operational and business constraints.

c) Root cause corrective actions shall be identified and selected according to the following steps:

   1) identify solutions for selected root causes based on results of root causes analysis;

   2) determine the probability of correcting the cause and the risk of creating a new or worse problem for each solution;

   3) select solutions that optimize value and effectiveness for all stakeholders.

d) Communication between all team members is required. Root cause corrective actions shall be communicated to and agreed by all stakeholders, especially by the customer when impacted.

6.9 Implement root cause corrective actions

a) The objective is to ensure all selected actions are implemented as defined and to assess their effectiveness to prevent the problem from recurring permanently.

b) The organization shall implement the solutions that have been selected, verify that all actions have been completed according to the schedule, and that they have prevented and will continue to prevent the problem from recurring.

c) Root cause corrective actions shall be implemented according to the following steps:

   1) identify action owners(individuals, not functions) and due dates;

   2) get commitment from action owners;

   3) plan detailed actions and make sure the corrective action plan is agreed by action owners;

   4) identify measures to verify effectiveness of actions;

   5) implement root cause corrective actions;

   6) measure and analyse new performance as planned and compare results with performance measured as described in 6.4 (define problem) and 6.6(identify root causes);

   7) establish a review process to verify effectiveness of the solutions. If the root cause corrective action is not effective, return to 6.6 and revisit the analysis process. If they are effective, evaluate the containment actions that can be eliminated (e.g. stop over inspection and over

production, return to normal transportation means, etc.) without adversely affecting the product and process output;

8) record evidence of actions completed and associated results.

Feedback of all information between each action owner, the team leader, and the customer shall be ensured. Content and frequency of reviews and status reports shall be defined between the team leader and stakeholders. The management and customer shall be informed in case of implementation difficulties or failures.

6.10 Implement lessons learning

a) The objective is to document analysis, results and changes, to capture and share learning with stakeholders to prevent similar undesirable condition, situation or failure occurring to other products, production lines, factories or suppliers.

b) The organization shall formalize and standardize decisions made and actions completed throughout the whole process and develop effective knowledge management to transfer ideas, lessons learned, best practices, etc. to stakeholders and other similar production lines, factories or suppliers that might require similar actions to be implemented. Guidelines for lessons learning in ISO 16192 are recommended.

c) The lessons learning shall be done according to the following steps:

1) update related documents including design documents, process documents, experiments documents, training packages, IT systems and tools, etc., and deploy training accordingly to ensure related personnel's understanding of updates;

2) identify products, production lines, factories or suppliers that might potentially be affected by similar types of undesirable condition, situation, nonconformity or failure (similar design, process, material source or supplier, location, function or use, environment, training, machines and tools), and ensure related process owners well informed about the problem information and lessons captured;

3) feedback the problem information and lessons captured to the superior quality management department who shall ensure owners of related products, production lines, factories or suppliers in other organizations that might potentially be affected by similar types of undesirable condition, situation or failure (similar design, process, material source or supplier, location, function or use, environment, training, machines and tools) be informed about the problem information and lessons captured;

4) record lessons captured: analyses, flow charts, databases, performance data, major actions and decisions, data sources, difficulties encountered, etc.

d) Communication is required. The organization shall

1) inform all main process owners (internally and externally) of experience gained (e.g. methods that worked, failed and the associated reasons), and

2) all functions and staff are required to be informed about the problem. Check whether similar failure modes exist and implement corrective actions if necessary.

6.11 Finish "Closed loop problem solving management report"

a) The objective is to summarize the closed loop problem solving management work and generate a systematic description about the solving procedures.

b) Before closing the closed loop problem solving management, the team leader shall organize the preparation of "closed loop problem solving management report" signed by related persons. Annex A provides a report format for reference.

c) The content of the closed loop problem solving management report shall include the following information.

1) Problem description:

— when and where the problem occurred;

— information of the product where the problem occurred (name, batch, phase of development, design organization, production organization);

— information of the problem, including the working status and environment situation when the failure occurred;

— immediate containment actions taken to stop problem deterioration.

2) Define problem:

— processes and methods used to analyse and locate the problem;

— basis of problem definition;

— problem statement;

— optimized containment actions;

— processes of completing and optimizing containment actions;

— effect of implementing containment actions;

— identified root causes;

— processes and methods of root cause identification, including theoretical analysis and experimental results.

3) Conduct reoccurrence experiments:

— the processes and results of reoccurrence experiments;

— whether problem definition and root cause identified are verified;

— reasons if reoccurrence experiments are unavailable.

4) Define and select root cause corrective actions:

— the processes of defining corrective actions;

— content of corrective actions.

5) Implement root cause corrective actions:

— implementation processes and results of corrective actions;

— verification processes of corrective actions.

6) Implement lessons learning:

— documents revised or to be revised, including technical and management documents;

— lessons captured and improvement in the product and whole business.

7) Conclusion:

— whether closed loop problem solving is completed;

— problems remained or suggestions.

8) Proof documents list, which includes but not limited:

   — name and code of problem report;

   — name and code of experiment report;

   — name and code of verification related documents;

   — name and code of revised or to be revised documents;

   — name and code of other proof documents.

d) For problems which cannot be solved thoroughly, the quality problem analysis report is required following Annex A with explanations why the problem solving cannot proceed. The quality problem analysis report shall be signed.

6.12 Recognize and close the team

When all actions have been successfully implemented with their effectiveness being verified, lessons captured have been transferred to relevant organizations or projects and customers are satisfied, the activity is complete. The organization shall inform all those been affected by the problem that the activity is complete, and recognize those who have been involved in the corrective action process and disband the team.

Annex A
(informative)

Format of "Closed Loop Problem Solving Management Report"

Annex A provides two formats, one is the format of the front cover of the closed loop problem solving management report, given in Figure A.1, and the other is the format of the text of the closed loop problem solving management report, given in Figure A.2.

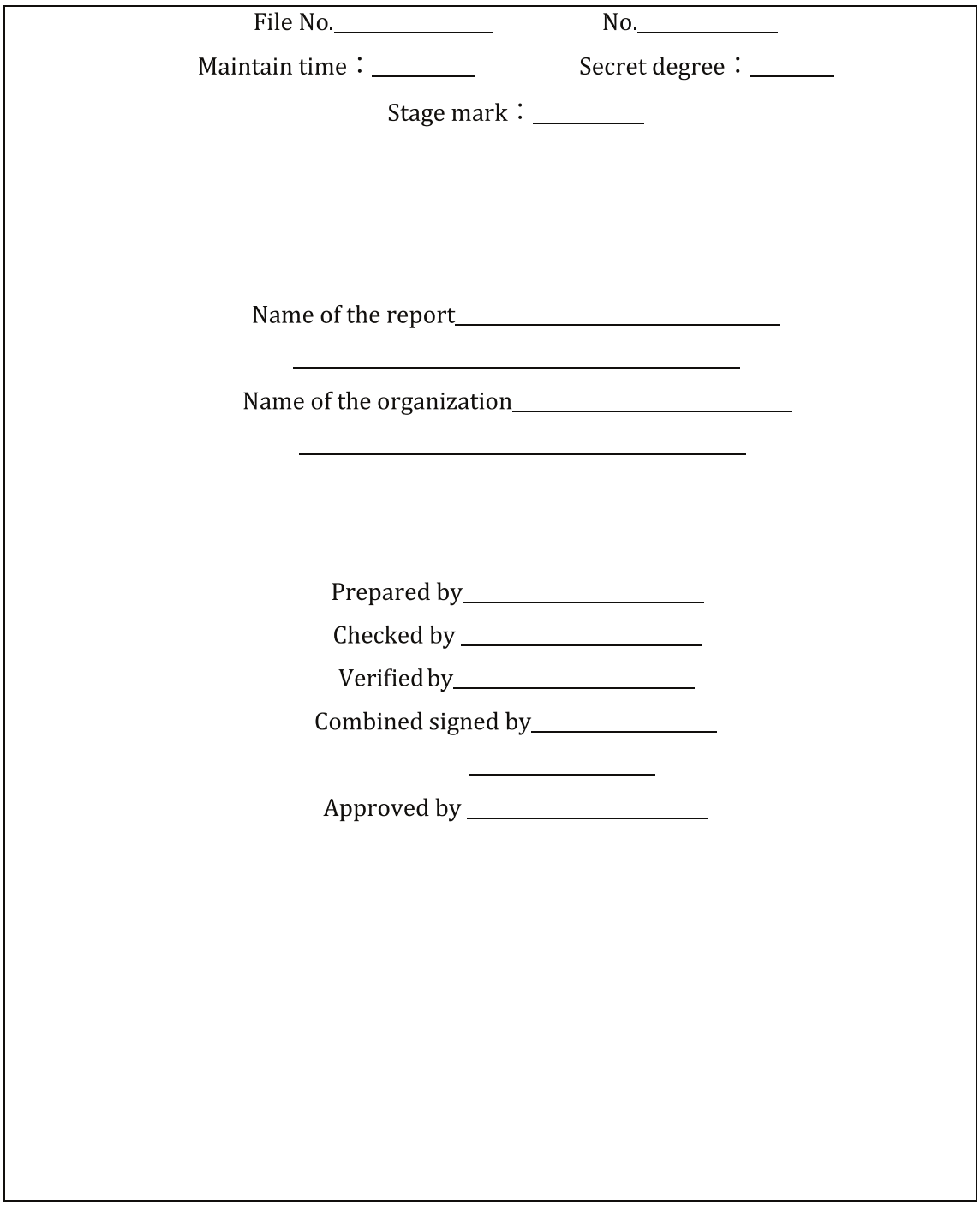

Figure A.1 — Format of the front cover of the report

Problem description

1 Define the problem

2 Complete and optimize containment actions

3 Identify root causes

4 Conduct recurrence experiments

5 Define and select root cause actions

6 Implement root cause corrective actions

7 Implement lessons learning

8 Conclusion

9 Proof documents list

Figure A.2 — Format of the text of the report

ICS 49.140

Price based on 13 pages