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Analyser systems – Guidance for maintenance management

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ANALYSER SYSTEMS – GUIDANCE FOR MAINTENANCE MANAGEMENT

FOREWORD

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IEC 62010, which is a technical report, has been prepared by subcommittee 65D: Analysing equipment, of IEC technical committee 65: Industrial-process measurement and control.

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The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
65D/109/DTR	65D/122/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

0 Introduction

In connection with the publication of EEMUA 187, the following text is related to the legal aspects of its publication in the U.K.

0.1 Legal aspects

In order to ensure that nothing in this publication can in any manner offend against, or be affected by, the provisions of the Restrictive Trade Practices Act 1976, the recommendations which it contains will not take effect until the day following that on which its particulars are furnished to the Office of Fair Trading.

As the subject dealt with seems likely to be of wide interest, this publication is also being made available for sale to non-members of the Association. Any person who encounters an inaccuracy or ambiguity when making use of this publication is asked to notify EEMUA without delay so that the matter may be investigated and appropriate action taken.

It has been assumed in the preparation of this publication that the user will ensure selection of those parts of its contents appropriate to the intended application and that such selection and application are correctly carried out by appropriately qualified and experienced people for whose guidance the publication has been prepared. EEMUA does not, and indeed cannot, make any representation or give any warranty or guarantee in connection with material contained in its publications, and expressly disclaims any liability or responsibility for damage or loss resulting from their use. Any recommendations contained herein are based on the most authoritative information available at the time of writing and on good engineering practice, but it is essential for the user to take account of pertinent subsequent developments or legislation.

0.2 Overview

This guidance defines the best practices in the maintenance of on-line analysers. Analysers are used in industry to measure variables which significantly contribute to safety, environmental, asset protection and profit maximization.

Maintenance organization, prioritizing of maintenance effort, maintenance methods, correct resourcing, performance monitoring and reporting all play an important role in successful application of on-line analysers.

The ultimate effectiveness of the contribution of on-line analysers is measured by the ability to perform their functional requirements upon demand. This technical report gives guidance on performance target-setting, strategies to improve reliability, methods to measure effective performance, and the organizations, resource and systems that need to be in place to allow this to occur.

The various subjects covered in this document are discrete items and can appear unrelated in the overall scheme of analyser maintenance procedures and strategies. The following flow path ties the sections together in a logical sequence of approach.

0.3 Flowpath detailing inter-relationships of document subject-matter

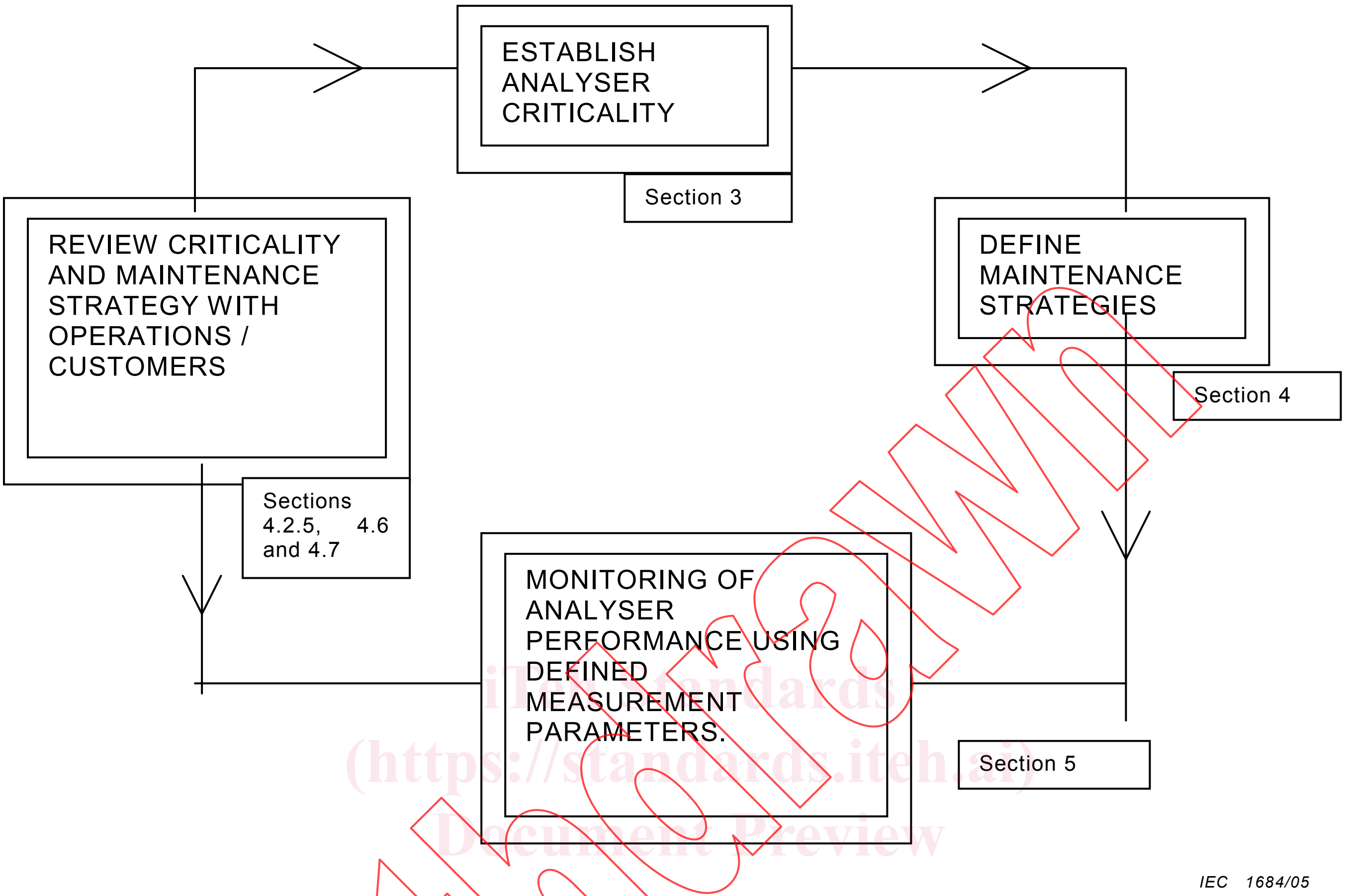

Figure 1 – Flowpath

This technical report provides a mechanism by which the critically of an analyser can be determined by means of a risk assessment, the risk assessment being based upon consideration of the consequence of the loss of the analysis to the operation of a process unit, or group of process units, personnel/plant safety and the environment.

Determination of a criticality rating for the analyser allows target values for reliability to be set for each criticality classification and prioritization for maintenance and support. Such approaches are covered in Clause 4.

A number of strategies designed to allow the target reliabilities calculated by the risk assessments to be met are defined in Clause 5.

Finally, mechanisms for tracking analyser performance and quantifying the performance as meaningful measures are presented in Clause 6.

ANALYSER SYSTEMS – GUIDANCE FOR MAINTENANCE MANAGEMENT

1 Scope and object

This technical report applies to analyser systems.

1.1 Purpose of this technical report

This technical report is written with the intention of providing an understanding of analyser maintenance to individuals from a non-engineering background. It is also designed as a reference source to individuals more closely involved with maintenance of analytical instrumentation, and provides guidance on performance target-setting, strategies to improve reliability, methods to measure effective performance, and the organizations, resources and systems that need to be in place to allow this to occur.

Effective management of on-line analysers is only possible when key criteria have been identified, and tools for measuring these criteria established.

On-line analysers are used in industry for one of the following reasons.

1.2 Safety and environment

One category of analysers are those used to control and monitor safety and environmental systems. The key measured parameter for this category of analyser is on-line time. This is essentially simpler to measure than an analyser's contribution to profits but, as with process analysers applied for profit maximization, the contribution will be dependent upon the ability to perform its functional requirements upon demand.

1.2.1 Asset protection and profit maximization

On-line analysers falling into this category are normally those impacting directly on process control. They may impact directly on protection of assets (for example, corrosion, catalyst contamination) or product quality, or may be used to optimize the operation of the process (for example, energy efficiency).

For this category of analysers, the key measured parameter is either the cost of damage to plant or the direct effect on overall profit of the process unit. Justification as to whether an analyser should be installed on the process may be sought by quantifying the payback time of the analyser, the pass/fail target typically being 18 months, although it should be noted that the contribution of the analyser to reduction in the extent of damage to, or the profit of, the process unit is difficult to measure. However, this contribution will be dependent upon the analyser's ability to perform its functional requirements upon demand.

This technical report focuses on the cost/benefits associated with traditional analyser maintenance organizations. In a modern set-up, the complexity of analysers demands on occasion data from chemotricians and scientists who may be owned by other parts of the organization, and, as such, care must be exercised to include their costs.

1.2.2 Questions that need to be addressed

When considering on-line analyser systems and their maintenance, the following list of key points is useful in helping decide where gaps exist in the maintenance strategy. Additionally, a structured mechanism by which the "health" of an analyser organization can be appraised is provided in Appendix 5.

1. What is the UPTIME of each critical analyser? (Do you measure UPTIME and maintain records? Do you know the value provided by each analyser and therefore which ones are critical? Do you meet regularly with operations ("the customer") to review priorities?)
2. What is the VALUE delivered by each analyser in terms of process performance improvement (i.e. improved yield figures, improved quality, improved manufacturing cycle time and/or process cycle time, process safety (for example, interlocks), environmental importance)? (Is this information readily available and agreed to in meetings with operations? Is the value updated periodically?)
3. What is the "utilization" of each critical analyser – that is, if the analyser is used in a control loop, what percentage of the time is the loop on manual due to questions about the analyser data? (Do you keep records on the amount of time that analyser loops are in automatic? Do you meet regularly with operations to review the operators feelings about the "believability" of the analyser data?)
4. Do you have a regular preventive maintenance programme set up for each analyser which includes regular calibrations? (Does the calibration/validation procedure include statistical process control concepts – upper/lower limits and measurement of analyser variability (or noise)? Is the procedure well documented? Do you conduct it regularly? Even when things are running well?)
5. Do you have trained personnel (capable of performing all required procedures and troubleshooting the majority of analyser problems) who are assigned responsibility for the analysers? (Do the trained personnel understand the process? Do they understand any laboratory measurements which relate to the analyser results?)
6. Do the trained maintenance personnel have access to higher level technical support as necessary for difficult analyser and/or process problems? (Do they have ready access to the individual who developed the application? Do they have ready access to the vendor? Can higher level support personnel connect remotely to the analyser to observe and troubleshoot?)
7. Do you have a maintenance record keeping systems which documents all activity involving the analysers, including all calibration/validation records, all repairs and/or adjustments? (Do you use the record-keeping system to identify repetitive failure modes and to determine the root cause of failures? Do you track the average time-to-repair analyser problems? Do you track average time-between-failures for each analyser?)
8. Do you periodically review the analysers with higher level technical resources to identify opportunities to significantly improve performance by upgrading the analyser system with improved technology or a simpler/more reliable approach?
9. Do you meet regularly with operations to review analyser performance, update priorities, and understand production goals?
10. Do you have management who understand the value of the analysers and are committed to, and supportive of, reliable analysers?
11. Do you know how much the maintenance programme costs each year and is there solid justification for it?

Consideration of the above questions will help to identify opportunities for continuously improving the reliability of installed process analysers. Once the opportunities are identified, the following sections are intended to give guidance in achieving the solutions with the aim of

- maximising performance and benefit of installed analysers;
- achieving full operator confidence in the use of on-line analysers;
- analyser output data becoming reliable enough to be used by operators, control systems, and other users to improve plant operation versus world-class manufacturing metrics and become best-of-the-best.

2 Normative references

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

IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

IEC 61508-5, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 5: Examples of methods for the determination of safety integrity levels*

IEC 61649, *Goodness-of-fit tests, confidence intervals and lower confidence limits for Weibull distributed data*

IEC 61710, *Power law model – Goodness-of-fit tests and estimation methods*

3 Terms and definitions

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

3.1
availability
ability of an item to be in a state to perform a required function under given conditions at a given instant of time or over a given time interval, assuming that the required external resources are provided

[IEV 191-02-05][1]

3.2
catastrophic failure
failure of a component, equipment or system in which its particular performance characteristic moves completely to one or the other of the extreme limits outside the normal specification range

3.3
consequence
measure of the expected effects of an incident outcome case

3.4
control system
system which responds to input signals from the process and/or from an operator and generates signals causing the EUC to operate in the desired manner

3.5
diversity
performance of the same overall function by a number of independent and different means

3.6
error/fault/failure/mistake

- fault: state of an item characterized by inability to perform a required function, excluding the inability during preventive maintenance or other planned actions, or due to lack of external resources [IEV 191-05-01]

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1 IEC 60050-191, *International Electrotechnical Vocabulary (IEV) – Chapter 191: Dependability and quality of service.*

- undetected fault: fault which is not detected by a diagnostic check
- design fault: fault in the design caused by a mistake in the design phase of a system. A design fault causes an error, remaining undetected in a part of the system until specific conditions affecting that part of the system are such that the produced result does not conform to the intended function. This results in a failure of that part of the system. If the conditions appear again, the same results will be produced
- error: discrepancy between a computed, observed or measured value or condition and the true, specified or theoretically correct value or condition [IEV 191-05-24]
- failure: termination of an item to perform a required function [IEV 191-04-01]
- mistake/human error: human action that produces an unintended result [IEV 191-05-25]
- failed state: condition of a component, equipment or system during the time when it is subject to a failure

3.7
fault tree analysis
analysis to determine which fault modes of the subitems or external events, or combinations thereof, may result in a stated fault mode of the item, presented in the form of a fault tree

[IEV 191-16-05]

3.8
functional safety
ability of a safety-related system to carry out the actions necessary to achieve a safe state for the EUC or to maintain the safe state for the EUC

3.9
hazard
physical situation with a potential for human injury

3.10
level of safety
level of how far safety is to be pursued in a given context, assessed with reference to an acceptable risk, based on the current values of society

3.11
maintainability
ability of an item, under given conditions of use, to be retained in, or restored to, a state in which it can perform a required function, when maintenance is performed under given conditions and using stated procedures and resources

[IEV 191-02-07]

3.12
mean time between failures
MTBF
expectation of the operating time between failures

[IEV 191-12-09]

3.13
mean time to failure
MTTF
expectation of the time to failure

[IEV 191-12-07]

3.14
mean time to repair
MTTR
expectation of the time to restoration

[IEV 191-13-08]

3.15
proof-testing
method of ensuring that a component, equipment or system possesses all the required performance characteristics and is capable of responding in the manner desired

3.16
random hardware failure
failure occurring at a random time, which results from one or more of the possible degradation mechanism in the hardware

NOTE 1 There are many degradation mechanisms occurring at different rates in different components, and, since manufacturing tolerances cause components to fail due to these mechanisms after different times in operation, failures of equipment comprising many components occur at predictable rates but unpredictable (i.e. random) times.

NOTE 2 A major distinguishing feature between random hardware failures and systematic failures is that system failure rates (or other appropriate measures) arising from random hardware failures can be predicted with reasonable accuracy but systematic failures, by their very nature, cannot be predicted. That is, system failure arising from random hardware failure rates can be quantified with reasonable accuracy, but those arising from systematic failure cannot be accurately quantified because events leading to them cannot easily be predicted.

3.17
redundancy
in an item, the existence of more than one means of performing a required function

[IEV 191-15-01]

3.18
reliability
probability that an item will perform a required function under given conditions for a given time interval (t_1,t_2)

[IEV 191-12-01]

3.19
risk
probable rate of occurrence of a hazard causing harm and the degree of severity of harm. The concept of risk always has two elements; the frequency or probability at which a hazard occurs and the consequences of the hazard event

3.20
safety
freedom from unacceptable risk of harm

3.21
safety integrity
SI
probability of a safety-related system satisfactorily performing the required safety functions under all the stated conditions within a stated period of time

3.22
safety integrity level
SIL
one of four possible discrete levels for specifying the safety-integrity requirements of the safety functions to be allocated to the safety-related systems, SIL4 having the highest level of safety integrity, SIL1 the lowest

3.23
safety-related system
SRL
system that

- implements the required safety functions to achieve a safe state for the EUC or to maintain a safe state for the EUC; and
- is intended to achieve, on its own, or with other safety-related systems, the necessary level of integrity for the implementation of the required safety functions

3.24
safety-related control system
SRCL
system which carries out active control of the EUC and which has the potential, if not in accordance with its design intent, to enter an unsafe state

3.25
safety-related protection systems
SRPS
designed to respond to conditions on the EUC, which may be hazardous in themselves, or if no action were taken, could give rise to hazardous events, and to generate the correct outputs to mitigate the hazardous consequences or prevent the hazardous events

3.26
safety requirements specification
specification that contains all the requirements of the safety functions that have to be performed by the safety-related systems divided into

- safety-functions requirement specification;
- safety-integrity requirement specification

3.27
software
intellectual creation comprising the programs, procedures, rules and any associated documentation pertaining to the operation of a data processing system

3.28
system
set of components which interact according to a design. A component may be another system (a subsystem). Such components (subsystems) may be, depending on the level:

- a controlling or controller system; and
- hard, software, human interaction

3.29
systematic failure
failure related in a deterministic way to a certain cause, which can only be eliminated by a modification of the design or of the manufacturing process, operational procedures, documentation or other relevant factors

[IEV 191-04-19]

3.30
system life cycle
activities occurring during a period of time that starts when a system is conceived and ends when the system is on longer available