# Examination syllabuses for Manual stack emissions monitoring

**Environment Agency**
**Version 13**
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THE ENVIRONMENT AGENCY'S
MONITORING CERTIFICATION SCHEME

## Record of amendments

| Version number | Date | Section | Amendment |
|---|---|---|---|
| 11 | May 2017 | 11 | Replaced old versions of EN 14791, EN 14789, EN 14792 and EN 15058 with versions published in 2017 |
| | | 11 | Deleted reference to MID for EN 14792 |
| 12 | Sept 2017 | 11 | Replaced old version of EN 14790 with version published in 2017 |
| 13 | Jan 2018 | 11 | Replaced old version of EN 13284 with version published in 2017 |

### Status of this document

These MCERTS examination syllabuses may be subject to review and amendment following publication of this document. The latest version of the standard, together with guidance on the scheme, is available at www.mcerts.net.

Questions on EN 13284-1:2017 will be introduced into the MCERTS personnel competency scheme examinations from 1 January 2019

### Feedback

If you have any comments on this document, please contact our National Customer Contact Centre at:

Email: enquiries@environment-agency.gov.uk

## Content

# MCERTS examination syllabuses for manual stack emission monitoring

## 1. Introduction

1.1 Manual stack-emission monitoring for regulatory purposes includes measurements for:

- determining compliance with numerical limits in authorisations and permits
- the calibration of continuous emission monitoring systems (CEMs)
- acceptance trials on new pollution-abatement plant or alternative fuel applications

Note – stack-emission monitoring is a general term used to describe the preparation work before a measurement campaign, undertaking the site work, calculating the monitoring results and producing the final report for the client.

1.2 MCERTS for manual stack-emission monitoring is built on proven international standards to ensure good quality monitoring data. The scheme is split into two components – the certification of personnel to the MCERTS personnel competency standard and the accreditation of stack-emission monitoring organisations to the MCERTS performance standard for organisations.

1.3 The MCERTS personnel standard specifies three levels of competency: an entry level (trainee), Level 1 (technician) and Level 2 (team leader). Level 2 is the most senior level. Level 2 personnel must achieve at least one technical endorsement (covering monitoring of specific groups of substances) in addition to the general Level 2 requirements. Level 2 personnel with technical endorsements relevant to the substances being measured are required to supervise measurement planning, sampling and reporting.

1.4 This document defines the examination syllabuses for Level 1, Level 2 and the four technical endorsements. Examinations are by multiple choice and structured written papers, plus an oral examination for Level 2.

1.5 This document should be used in conjunction with the MCERTS personnel competency standard and the MCERTS performance standard for organisations. These are available at:

www.mcerts.net

# 2. Level 1 syllabus

## 2.1 Examination structure

The candidate has to take two papers at Level 1: a multiple-choice and a structured written paper.

For recertification the candidate sits a single paper consisting of multiple choice and structured written questions.

## 2.2 Level 1 syllabus content

L1.1 Introduction to pollutants

The candidate must know the pollutants that are routinely measured during stack emissions monitoring. These include CO, $CO_2$, $O_2$, $SO_2$, $NO_X$, HCl, TOC, particulate matter, dioxins, furans, PCBs and PAHs.

For these pollutants the following knowledge is required:

- common sources of the pollutant
- typical emission concentrations
- typical measurement techniques
- the environmental and health effects

The candidate must know the reasons why stack emission monitoring is carried out.

L1.2 Overview of legislation and monitoring guidance

The candidate must demonstrate an understanding of the:

- purpose of monitoring
- MCERTS scheme for manual stack emission monitoring
- use of emissions limit values
- use of
  - standard reference methods
  - MCERTS method implementation documents (MIDs)
- role of Environment Agency guidance notes M1 and M2
- role of UKAS

L1.3 Health and safety requirements

The candidate must demonstrate knowledge of the risk management principles outlined in Environment Agency Technical Guidance Note M1 and the STA's *Risk assessment guide: Industrial emission monitoring.*

The candidate must know the difference between hazard and risk when discussing health and safety issues.

The candidate must know typical safety hazards involved with stack emission monitoring and their associated risks.

The candidate must understand the application of suitable control measures.

L1.4 Units and reference conditions

The candidate must demonstrate understanding of:

- temperature, pressure, velocity, mass and volume
- concentration and mass-based units
- ppm and $mg/m^3$
- reference conditions and normalisation
    - wet gas and dry gas
    - standard temperature and pressure
    - reference levels of $O_2$

L1.5 Equipment

The candidate must demonstrate awareness of:

- pitots, gas meters, rotameters and orifice plates
- thermocouples
- barometers
- arrangement of manual extractive sample trains
- calibration of instrumental equipment
- the most commonly used arrangements for gas sample handling and conditioning systems, which are used with extractive gas analysis systems (for example hot/wet and cool/dry systems)
- an ability to demonstrate understanding of the advantages and disadvantages of each approach hot/wet and cool/dry systems
- the typical measurement techniques for temperature, pressure, moisture and oxygen

L1.6 Principles of stack-emission monitoring

The candidate is required to demonstrate knowledge of:

- the importance of representative sampling for particulates and gases
- the principle of isokinetic sampling
- sampling planes and sampling points
- measurement of stack gas velocity and pressure
- an awareness of the principles of measurement uncertainty
- the causes of unrepresentative sampling
- an ability to demonstrate what is meant by the term ‘calibration’ and to describe a typical calibration procedure
- the calculation of mass emissions rates

L1.7 Process conditions

The candidate is required to demonstrate an awareness of how process conditions, sampling conditions or location may affect the approach to planning and carry out a stack emission monitoring campaign.

# 3. Level 2 syllabus

## 3.1 Examination structure

The candidate has to sit an oral examination at Level 2.

Recertification is maintained through relevant work experience and an up to date health and safety course certificate.

## 3.2 Level 2 syllabus content

L2.1 Monitoring standards and methods

The candidate must demonstrate knowledge of the use of applicable standards relevant to monitoring. This includes:

- hierarchy of methods
  - CEN
  - ISO
  - National methods such as USEPA and VDI
- knowledge of appropriate methods for stack emission monitoring
- what to do if no standard method is available
- the effects of deviation/modification of methods

L2.2 Reference conditions

The candidate must demonstrate knowledge of the following:

- reference conditions and normalisation
  - conversion of wet gas to dry gas
  - conversion to standard temperature and pressure
  - conversion to reference levels of $O_2$

L2.3 Analytical techniques and limits of detection

The candidate is required to demonstrate awareness of analytical techniques used to support pollutant measurements in the field. This includes:

- implications of analytical sensitivity for sample amounts and sampling times;
- limits of detection
- sample handling
- liaison with analysis laboratories

L2.4 Abatement systems and their effects on monitoring

The candidate is required to demonstrate general knowledge of abatement systems used for the control of the principal pollutants from industrial processes and their impact on emission levels.

L2.5 Choice of sampling location

The candidate must demonstrate knowledge of typical plant configurations, their impact on monitoring results, and where to carry out sampling. This includes:

- achieving representative sampling
- positional requirements for particulate matter and gaseous species
- criteria for locating a sample plane
- surveying the sample plane
- number of sampling points

L2.6 Undertaking a measurement campaign

The candidate must demonstrate knowledge of the factors to be addressed when undertaking a measurement campaign. These include:

- determining the objectives of the sampling exercise
- assessing the parameters to be measured
- reviewing process conditions
- liaison with plant operators

L2.7 Health and safety requirements

The candidate must demonstrate a detailed knowledge of the risk-management approach to minimising hazards at work.

L2.8 Choice of sampling method, technique and equipment

The candidate is required to understand the different monitoring approaches, techniques, equipment and the factors that influence their applicability.

L2.9 Types of process operation and process details

The candidate must demonstrate knowledge of the types of process operation and relevant process details. These include:

- types of operation
- continuous (steady state, variable or cyclic)
- batch process
- process details
- timescale of operation
- awareness of inputs, outputs and mass flows
- fuel composition
- stack gas conditions

L2.10 Developing site-specific protocols

The candidate must demonstrate knowledge of the requirements to be considered when undertaking a measurement campaign at a specific site.

L2.11 Principles of calculating uncertainty

The candidate is required to demonstrate knowledge of the principles of calculating uncertainty. This includes:

- basic terminology including accuracy, precision, repeatability, reproducibility, systematic and random errors
- rules for combining uncertainties
- confidence limits and statistically defined uncertainties
- tests using certified reference materials
- repeat measurements using paired instruments and comparison with certified reference method
- building an uncertainty budget from estimates of component uncertainties
- assessing deviations from a standard reference method
- effect of number and duration of samples on accuracy

L2.12 Quality assurance

The candidate must demonstrate knowledge of the systems for quality assurance and quality control in stack-emission monitoring. These include:

- role of ISO/IEC 17025 "General requirements for the competence of testing and calibration laboratories"
- MCERTS performance standard for organisations
- role of auditing
- MCERTS personnel competency standard and use of appropriate personnel
- use of appropriate methods
- equipment certification
- measurement traceability
- site review and site-specific protocol
- work file and monitoring record sheets
- use of blanks
- handling of test items
- assuring the quality of test results
- reporting results

# 4. Technical endorsement 1 - Particulate monitoring by isokinetic sampling techniques

## 4.1 Examination structure

The candidate has to sit a multiple-choice and a written paper.

For recertification the candidate sits a single paper consisting of multiple-choice and structured written questions.

## 4.2 TE1 syllabus content

TE1.1 Sample train components

The candidate must be able to:

- sketch/annotate the sample train configurations used for particulate sampling under the range of conditions typically encountered in industrial processes
- understand when in and out of stack filter configurations are required

TE1.2 Sample location

The candidate must be able to:

- discuss the issues associated with selecting the most appropriate sample location
- describe the practical steps to be taken on site in order to identify a suitable location
- describe the approach taken to modify the sampling procedure in cases where a fully-compliant sample location does not exist

TE1.3 Preliminary work and quality control

The candidate must be able to:

- calculate sample times based on expected particulate concentrations and uncertainty of the balance requirements
- describe a sample plane survey, including the swirl test procedure
- describe specific preliminary requirements for sampling at low particulate levels
- describe appropriate quality control checks such as:
    - leak checks
    - blanks
    - filter specifications and conditioning
    - filter capture efficiencies
    - isokinetic ratios
    - temperature requirements for key components of the sample train

TE1.4 Calculating stack gas volumetric flow rates

The candidate must be able to:

- calculate volumetric flow, velocities and cross sectional areas using the following equation: Volumetric flow = velocity * cross sectional area
- use this equation to calculate volumetric flow, or velocities in stacks where the volumetric flow and cross sectional area are known

TE1.5 Calculating flow rates in a sample train

The candidate must be able to:

- calculate flow rate through a sample train based on stack gas velocity and nozzle size
- calculate a theoretical nozzle size for isokinetic sampling
- calculate an area from a diameter and be able to calculate a diameter from an area

TE1.6 Units and reference conditions

The candidate must be able to:

- convert the following parameters into compatible units for calculations:
  - volumes in litres or $m^3$
  - velocities in m/s
  - nozzle diameters in mm and/or m
  - time expressed as seconds and/or minutes
- correct volumes from a wet/dry gas to a dry/wet gas

TE1.7 Detailed knowledge of standards and MIDs

- The candidate must be able to demonstrate detailed knowledge of the standards and MIDs specified in the relevant section of the table of monitoring standards (see section 10).

# 5. Technical endorsement 2 - Multi-phase sampling techniques

## 5.1 Examination structure

The candidate has to sit a multiple-choice paper and a written paper.

For recertification the candidate sits a single paper consisting of multiple-choice and structured written questions.

## 5.2 TE2 syllabus content

TE2.1 <u>Multiphase sampling of metals</u>

The candidate must be able to describe:

- the content, arrangement and role of the different impinger trains that can be used for measuring metals and mercury
- the information required to determine sample duration
- the solutions used on site for recovering a sample
- temperature requirements for key components of the sample train
- normative sampling requirements, such as nozzle size and isokinetic rates
- the quality control checks, such as leak checks, blanks, impinger capture efficiencies
- calculation of results at standard reference conditions
- calculation of a blank value and assessment of its compliance with quality assurance requirements

TE2.2 <u>Sampling dioxins and furans</u>

The exam questions are on the filter/condenser method described in BS EN 1948. The candidate must be able to describe:

- the materials of construction and arrangement of the sample train
- the solutions used on site for cleaning a sample train
- all appropriate quality control checks, such as leak checks, blanks, resin trap capture efficiencies and temperature requirements for the sample train
- the temperature data that must be recorded during the sample run
- normative sampling requirements, such as nozzle size and isokinetic rates
- conversion of a dioxin result in picograms into nanograms ITEQ, using I-TEF
- calculation of results at standard reference conditions
- calculation of a blank value and assessment of its compliance with quality assurance requirements

TE2.3 <u>Detailed knowledge of standard and MIDs</u>

The candidate must be able to demonstrate **detailed** knowledge of the standards specified in the relevant section of the table of monitoring standards (see section 10).

# 6. Technical endorsement 3 – Gases/vapours by manual techniques

## 6.1 Examination structure

The candidate has to sit a multiple-choice paper and a written paper.

For recertification the candidate sits a single paper consisting of multiple-choice and structured written questions.

## 6.2 TE3 syllabus content

TE3.1 Wet chemistry (impinger) techniques

The candidate must be able to:

- describe the contents and arrangement of “wet chemistry” sample trains
- describe all appropriate quality control checks, such as leak checks, blanks, capture efficiency, temperature requirements for key components of the sample train
- calculate the concentration of a gaseous species in flue gas when supplied with the gas sample volume, impinger solution volume and concentration of target species in solution
- calculate the percentage moisture in a stack gas using sample volumes and impinger/silica gel weight gain data
- correct data to standard reference conditions
- select a sample position to ensure representative samples are taken

TE3.2 Adsorbent tube technique

The candidate must be able to:

- describe the arrangement of the sampling train, including any additional requirements to take account of different stack sample conditions, such as high moisture content or high temperatures
- calculate the concentration of a gaseous species in stack gas when supplied with the appropriate information, such as gas sample volume and mass of target species on a sample tube
- calculate the mass emission rate of a gaseous species in stack gas when supplied with the appropriate information, such as duct area and stack gas velocity
- describe the appropriate quality control checks, such as detection limits and capture efficiency

TE3.3 Describing a real example

The candidate must be able to demonstrate knowledge and understanding of the measurement of a pollutant using a wet chemistry or adsorbent tube monitoring technique at a site they are familiar with. They must be able to describe the:

- process, including how the pollutant was formed
- typical gas concentration
- stack gas conditions
- method used
- arrangement of the sampling system used
- monitoring principles on which the measurements were based
- sampling procedure
- principles on which the laboratory analysis was based

TE3.4 Detailed knowledge of standards and MIDs

The candidate must be able to demonstrate detailed knowledge of the standards specified in the relevant section of the table of monitoring standards (see section 10).

## 7. Limited technical endorsement 3 – Gases/vapours by manual techniques

### 7.1 Examination structure

The candidate has to sit a structured written paper.

For recertification the candidate sits a structured written paper.

### 7.2 LTE3 syllabus content

LTE3.1 Wet chemistry (impinger) techniques

The candidate must be able to:

- describe the contents and arrangement of "wet chemistry" sample trains
- describe all appropriate quality control checks, such as leak checks, blanks, capture efficiency, temperature requirements for key components of the sample train
- calculate the concentration of a gaseous species in flue gas when supplied with the gas sample volume, impinger solution volume and concentration of target species in solution
- calculate the percentage moisture in a stack gas using sample volumes and impinger/silica gel weight gain data
- correct data to standard reference conditions
- select a sample position to ensure representative samples are taken

LTE3.2 Adsorbent tube technique

The candidate must be able to:

- describe the arrangement of the sampling train, including any additional requirements to take account of different stack sample conditions, such as high moisture content or high temperatures
- calculate the concentration of a gaseous species in stack gas when supplied with the appropriate information, such as gas sample volume and mass of target species on sample tube
- calculate the mass emission rate of a gaseous species in stack gas when supplied with the appropriate information, such as duct area and stack gas velocity
- describe the appropriate quality control checks, such as detection limits and capture efficiency

LTE3.3 Describing a real example

The candidate must be able to demonstrate knowledge and understanding of the measurement of a pollutant using the wet chemistry or adsorbent tube monitoring technique that they use at their site. They must be able to describe the:

- process, including how the pollutant was formed
- typical gas concentration
- stack gas conditions
- method used
- arrangement of the sampling system used
- monitoring principles on which the measurements were based
- sampling procedure
- principles on which the laboratory analysis was based

LTE3.4 Detailed knowledge of standards and MIDs

The candidate must be able to demonstrate detailed knowledge of the relevant standard specified in the table of monitoring standards (see section 10).

# 8. Technical endorsement 4 – Gases/vapours by instrumental techniques

## 8.1 Examination structure

The candidate has to sit a multiple-choice and a written paper.

For recertification the candidate sits a single paper consisting of multiple-choice and structured written questions.

## 8.2 TE4 Examination syllabus

TE4.1 Instrumental sampling systems

The candidate must be able to describe:

- the main advantages/disadvantages of instrumental gas analysis systems
- the arrangement of gas analysis systems used to measure combustion gases and TOC in chimney stacks

TE4.2 Converting results to standard conditions

The candidate must be able to:

- convert emissions data from an 'as measured' basis to the basis required for reporting purposes
- this includes converting data collected on a 'wet' basis to a 'dry' basis

TE4.3 Converting ppm results to $mg/m^3$ and calculating mass emission rates

The candidate must be able to:

- convert ppm results to $mg/m^3$ using molecular weight and standard volumes
- convert TOC from propane to carbon equivalent
- calculate the emission rate of a gaseous species in stack gas when supplied with the appropriate information, such as stack area and velocity

TE4.4 Uncertainty budgets

The candidate must be able to:

- Demonstrate understanding of the basic principles of generating an uncertainty budget for an instrumental gas analysis system.
- State a number component uncertainties which would be included.
- Calculate an expanded uncertainty from a range of type A, type B and expanded uncertainties associated with some components of a typical gas sampling and analysis system.

TE4.5 Describing a real example

The candidate must be able to demonstrate knowledge and understanding of the measurement of a pollutant using an instrumental monitoring technique at a site they are familiar with. They must be able to describe the:

- process including how the pollutant is generated
- typical gas concentration
- stack gas conditions
- instrumental method used including the principles of operation
- arrangement of the gas sample handling and conditioning system that was used
- calibration procedure for site work

TE4.6 Sampling strategy

The candidate must be able to demonstrate knowledge of appropriate strategies for representative gas sampling (i.e. determination of homogeneity).

TE4.7 Detailed knowledge of standards and MIDs

The candidate must be able to demonstrate **detailed** knowledge of the standards specified in the relevant section of the table of monitoring standards (see section 10).

# 9. Limited technical endorsement 4 – Gases/vapours by instrumental techniques

## 9.1 Examination structure

The candidate has to sit a structured written paper.

For recertification the candidate sits a structured written paper.

## 9.2 Limited technical endorsement 4 (LTE4) syllabus content

LTE4.1 Instrumental sampling systems

The candidate must be able to describe:

- the main advantages/disadvantages of instrumental gas analysis systems
- the arrangement of gas analysis systems used to measure combustion gases and TOC in chimney stacks

LTE4.2 Converting results to standard conditions

The candidate must be able to:

- convert emissions data from an ‘as measured’ basis to the basis required for reporting purposes
- this includes converting data collected on a ‘wet’ basis to a ‘dry’ basis

LTE4.3 Converting ppm result to mg/m$^3$ and calculating mass emission rates

The candidate must be able to:

- convert ppm results to mg/m$^3$ using molecular weight and standard volumes
- convert TOCs from propane to carbon equivalent
- calculate the emission rate of a gaseous species in stack gas when supplied with the appropriate information, such as stack area and velocity

LTE4.4 Uncertainty budgets

The candidate must be able to:

- demonstrate understanding of the basic principles of generating an uncertainty budget for an instrumental gas analysis system
- state a number component uncertainties which would be included
- calculate an expanded uncertainty from a range of type A, type B and expanded uncertainties associated with some components of a typical gas sampling and analysis system

LTE4.5 Describing a real example

The candidate must be able to demonstrate knowledge and understanding of the measurement of a pollutant using the instrumental monitoring technique at their site. They must be able to describe the:

- process including how the pollutant is generated
- typical gas concentration
- stack gas conditions
- instrumental method used including the principles of operation
- arrangement of the gas sample handling and conditioning system that was used
- calibration procedure for the site work

LTE4.6 Detailed knowledge of standards and MIDs

The candidate must be able to demonstrate detailed knowledge of the relevant standard specified in the table of monitoring standards (see section 10).

# 10. Table of monitoring standards

| Technical Endorsement | Applicable standards | Method Implementation Documents | Substance |
|---|---|---|---|
| TE1 | EN 13284-1:2017 | MID 13284-1 | Particulates |
| | EN ISO 16911-1:2013[1] | MID 16911-1 | Velocity |
| | EN 14790:2017 | | Water vapour |
| | EN 14789:2017 | | Oxygen |
| | | | |
| TE2 | EN 1948-1:2006[2] | MID 1948 | Dioxins and furans |
| | EN 14385:2004 | MID 14385 | Metals |
| | EN 13211:2001 | | Mercury |
| | ISO 11338-1:2003[3] | | Polycyclic aromatic hydrocarbons |
| | | | |
| TE3 | EN 1911:2010 | | Hydrogen chloride |
| | CEN/TS 13649:2014 | | Gaseous organic carbon (individual compounds) |
| | EN 14790:2017 | | Water vapour |
| | EN 14791:2017 | | Sulphur dioxide |
| | ISO 15713:2006 | MID 15713 | Hydrogen fluoride |
| | | | |
| TE4 | EN 12619:2013 | | Gaseous organic carbon (total) |
| | EN 14789:2017 | | Oxygen |
| | EN 14792:2017 | | Oxides of nitrogen |
| | EN 15058:2017 | | Carbon monoxide |
| | EN 15259:2007 | MID 15259 | Homogeneity survey - (Section 8.3) |

[1]A detailed knowledge of measuring velocity using Pitot tubes is required. Knowledge of the other techniques described in the standard is not required.

[2]A broad overview of Parts 2 and 3 of this standard is also required

[3]A broad overview of Part 2 of this standard is also required

# 11. Guide for MCERTS exam success

## 11.1 Introduction

A large number of people have sat MCERTS exams. Many have succeeded, others have struggled. Feedback has been received from many candidates after their exams. This has provided information on what went well and what did not. The following guidance is based on this information.

## 11.2 How to prepare for multiple choice and narrative papers

The exams are an assessment of your knowledge of your job. However, it is essential to prepare for the exams. Even candidates coming up for re-certification, who have many years of experience in the job, do better if they study and revise for the exams.

Site experience alone is not going to be enough. Detailed knowledge of the methods is required. Therefore, you should:

- Study each of the relevant standards (or their organisation's accredited procedure for each of the standards the exam will cover). The list of methods relevant to each exam is provided in Section 10). Don't just scan the methods, read them completely. You may be surprised at what you find, have forgotten or did not know, especially if you have not used the method for a while.
- Read the associated Method Implementation Documents. They are important supplements to the standards.
- Practise common calculations (formulas for commonly carried out calculations are provided in Environment Agency Technical Guidance Notes M2). In particular, example calculations from the narrative papers are provided on the CSA website:

http://www.csagroupuk.org/services/mcerts/mcerts-personnel-certification/

## 11.3 The oral exam

The oral exam is carried out to gain a clear understanding of your knowledge and experience. The questions are designed to give you an opportunity to talk about how you do your job. There are no trick questions.

You should prepare for the exam by studying:

- Environment Agency Technical Guidance Note M1
- Environment Agency Technical Guidance Note M2
- Source Testing Association: Industrial risk assessment guide

However, it is equally important for you to be able to show a good all round level of first hand stack emissions monitoring experience and understanding. This must be gained through carrying out site work and being involved in the planning and reporting of site work.

The interview lasts for approximately one hour. It is carried out by two people.

The interview is split into two parts. The first part (carried out by one of the interview panel) will ask you about planning a sampling campaign. This includes completion of a risk assessment, site review and site specific protocol.

The second part of the interview (carried out by the other examiner) covers on-site sampling work and quality assurance.

Wherever possible, you should use examples of your own on-site experience.

## 12. References


1. *MCERTS competency standard for personnel*, Environment Agency.

2. *MCERTS performance standard for organisations*, Environment Agency

3. Technical Guidance Note M1 *Sampling requirements for stack emissions monitoring,* Environment Agency.

4. Technical Guidance Note M2, *Monitoring of stack emissions to air*, Environment Agency.

5. *Risk assessment guide: industrial emission monitoring*, Source Testing Association document HS1069-00.


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