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## **Control Systems Engineer PE Exam Review: Standards and References**

EN00W1 Version 1.4

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## Seminar Logistics

- Seminar materials
  - Downloadable presentation
  - Question and Answer session (audio and email)
  - Survey
  - Earn 1 Professional Development Hour (PDH)
- Seminar length
  - 60 minute presentation
  - Three 10-minute question and answer sessions



## Audio Instructions

- As a participant, you are in a “listen-only” mode.
- You may ask questions via the internet, using your keyboard, at any time during the presentation. However, the presenter may decide to wait to answer your question until the next Q&A Session.
- If you have audio difficulties, press \*0.



## Audio Instructions for Q&A Sessions

- Questions may be asked via your telephone line.
- Press the \*1 key on your telephone key-pad.
- If there are no other callers on the line, the operator will announce your name and affiliation to the audience and then ask for your question.
- If other participants are asking questions, you will be placed into a queue until you are first in line.
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## Introduction of Presenter



- **Gerald Wilbanks, P.E.** Vice President of Documentation and Engineering Services in Birmingham, Alabama has over 40 years of experience in engineering, management, consulting, and design in heavy industry. He is a registered professional engineer in 4 states, a member of NSPE and an International Former President (1995) of ISA. Gerald is a graduate of Mississippi State University with a Bachelors Degree in Electrical Engineering and was recognized as the Engineer of the Year in 1991 by the Engineering Council of Birmingham. He is a Distinguished Engineering Fellow of Mississippi State University and is a Life Fellow member of ISA. He was appointed to the Alabama Board of Licensure for Professional Engineer and Land Surveyors in 2009 and has served as an instructor in many courses, seminars, and other educational sessions for ISA and in his own business.



## Key Benefits of Seminar

- Provide general guidelines relating to the CS PE Exam
- Explore the development of the CS PE Exam
- List methods for being a successful test taker
- Review the standards and references that apply to CSE



## Section 1: CS PE Overview

- Professional Engineer Background
- CS PE Exam History
- Exam format
- CS Exam Specification





## Professional Engineer Background

- Professional Engineer licenses are granted by the individual state boards
- Wyoming passed the first engineering registration law in 1907
- The purpose of the PE license is to set a high standard for engineers to protect the safety and welfare of the public
- The engineer is to be tested and licensed in his/her field of practice
- A common exam is administered by the various states in the field of practice



## Professional Engineer Background (cont'd)

- The National Council of Examiners for Engineering and Surveying (NCEES) is composed of the state registration boards
- NCEES was formed in 1920 and has had several names
- The NCEES promotes uniformity and consistency among the state boards
- There are five Group I exams and 10 Group II exams
- Each exam must have a supporting society



## Professional Engineer Background (cont'd)

- Each state has specific requirements that are published
- Basic Requirements for Professional Engineer Registration
  - Graduation from an ABET accredited engineering program
  - Successfully pass the Fundamentals of Engineering Exam (FE)
  - Gain engineering experience in engineering – normally 4 years is required as a minimum
  - Pass the Principle and Practices Exam (PE) in the discipline of work



## CSE Exam History

- Prior to 1992, control systems engineers had to take an exam in electrical, chemical, mechanical or other field to register
- Exams are only developed for disciplines that are a recognized field of practice
- Control Systems Engineering (CSE) or instrument engineering was considered a subset of other areas of practice
- ISA began an activity through the Professional Development Department to champion the need for a CSE professional engineer registration



## CSE Exam History (cont'd)

- ISA worked with the NCEES and the Texas and California state boards to lay the groundwork for the exam
- Various requirements had to be met to establish the need for the exam.
- The first CSE PE exam was offered in 1992



## Exam Format

- All group II exams have moved to a common format
- The exam is one day in length
- The exam is designed to test the knowledge and skills of a person with a minimum of 4 years of experience
- The exam is open book and each candidate brings their own reference materials
- The exam is no choice, multiple choice format
- There are 40 problems in the morning
- There are 40 problems in the afternoon

## CSE Exam Specification

- The exam content is based on a knowledge, skills and ability survey of practicing control system engineers.
- A new PAKS survey was conducted in 2010 and these results were used to develop the new exam specification that will be in effect in October 2011.
- The exam problems are developed by control system engineers assisted by NCEES.



## CSE Exam Specification (cont'd)

The exam has six primary domains or areas:

- **Measurement** – 16 questions/20%
  - **Signals, Transmission, and Networking** – 12 questions/15%
  - **Final Control Elements** – 16 questions/20%
  - **Control Systems** – 18 questions/22%
  - **Safety Systems** – 12 questions/15%
  - **Standards, Codes & Regulations** – 6 questions/8%
- 40 problems in a.m. and 40 problems in p.m.



## Review of Key Points

- The Control Systems Engineer Professional Engineer Exam is an 8 hour test.
- There are 40 multiple choice problems in the morning session and 40 multiple choice problems in the afternoon.
- The exam is designed to test the competency of an engineer with a minimum of 4 years qualified experience.
- The Control Systems PE Exam is offered in October of each year by the various state licensure Boards.
- ISA is the sponsoring society for the exam through the NCEES.
- Only specific calculators are allowed in the test area.
- The exam is open book and only bound materials are allowed in the test area



## Live Question and Answer Session

- During Q&A, questions may be asked via your telephone line.
- Press the \*1 key on your telephone key-pad.
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## Section 2: Test Taking Tips

- Arrive early to the test site and listen to the instructions
- Select your reference material carefully and be very familiar with the content of each item.
- Read each question twice before answering it.
- If you are positive about the answer to a question, mark it on the answer sheet provided.
- If you are not sure, move on to the next question and follow the same process.
- Go through the entire test of 40 items and do not spend an abnormal amount of time on any solution.



## Test Taking Tips (cont'd)

- Go back to the start of the exam and follow the same process while eliminating the obvious incorrect multiple choice solutions.
- Always be aware of units of measure that are used in the problem item.
- Answer those questions with a selection of the most appropriate remaining solution.
- At this point, you have answered those items that are sure of and the ones that you had some degree of comfort with.



## Test Taking Tips (cont'd)

- Now, go through the exam and answer any remaining items by using logic and guessing. There is no additional penalty for wrong guesses.
- Do not change any first impression answers unless you identify an obvious error on your initial solution.



## Review of Key Points

- Take your time as you process the test items.
- Read the questions carefully two times.
- Do not spend excess time trying to beat a problem to death.
- Try to eliminate the obvious incorrect answers.
- Leave time to review the test and make changes.
- Do not override your first impression – it is usually correct.
- A small amount of useful references is better than a lot of confusing material.



## Live Question and Answer Session

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## Section 3: References, Resources, Standards

- There are numerous reference books, sources and standards that may be useful for the exam. This is dependent on the strengths and weaknesses of each individual. The following list contains those that seem to be common and of the most use.
- This is based on the feedback from past exam participants and is not an exhaustive compilation.
- Some may be useful for study and others may be needed in the exam room.
- Know any references very well that are carried into the exam. This will help avoid useless and fruitless thumbing through the documents.



## References, Resources and Standards (cont'd)

- National Electric Code Handbook – NFPA
- ISA5.1-2009 – Instrumentation Symbols & Identification
- ISA5.2-1992 – Binary Logic Diagrams for Process Operations
- ISA5.4-1991 – Instrument Loop Diagrams
- ISA5.5-1985 – Graphic Symbols for Process Displays



## References, Resources, and Standards (cont'd)

- ISATR84.00.02–2002 (Parts 1-5) - Safety Instrumented Functions (SIF) - Safety Integrity Level (SIL) Evaluation Techniques
- ISA75.01.01-2002 – Flow Equations for Sizing Control Valves
- *Instrument Engineers Handbook, 3<sup>rd</sup> Edition – Process Measurement & Analysis* (Bela Liptak)
- *Instrument Engineers Handbook, 3<sup>rd</sup> Edition – Process Control* (Bela Liptak)
- Flow of Fluids – Crane Technical Paper 410



## References, Resources, and Standards (cont'd)

- *Practical Thermocouple Thermometry* (T.W. Kerlin) – ISA Press
- *Fisher Control Valve Handbook, 2<sup>nd</sup> Edition*
- *Cameron Hydraulic Data, 3<sup>rd</sup> Edition*
- Consolidated Safety Relief Valves SRV-1
- *Good Tuning Pocket Guide* (Greg McMillan) – ISA Press
- *Fundamentals of Process Control Theory, 2<sup>nd</sup> Edition* (Paul Murrill) – ISA Press
- Summary of Equations (Gerald Wilbanks – Control Systems PE Review Course)



## References, Resources, and Standards (cont'd)

- *Controlling Multivariable Processes* (F.G. Shinskey) – ISA Independent Learning Module
- *ISA Handbook of Measurement Equations and Tables* (W.H. Cubberly) – ISA Press
- *Flow Measurement Engineering Handbook* (R.W. Miller) – McGraw Hill Publishing
- *Control Systems Engineering Study Guide, 5<sup>th</sup> Edition* – ISA Press
- *Condensed Handbook of Measurement and Control* (N. E. Battikha) – ISA
- *Control Systems Engineering Exam Reference Manual: A Practical Study Guide* (Bryon Lewis, CSE, P.E.)



## Domain VI – Standards and Regulations

- This domain represents 8.0% of the exam or approximately 6 questions.
- The primary requirement is the knowledge of why standards, codes and regulations are used and how they apply to safety in industrial operations.
- The questions can relate to specific information in a standard or in the application of the data.
- We will look at some of the basis for the documentation and a couple of example question items.



## P&IDs

- The primary road map to a process is the Process and Instrumentation Diagram.
- Standard symbology is used to depict the overall control schemes.
- 1990 Clean air act amendments section 304:
  - Required that OSHA develop and implement a chemical process safety standard to prevent accidental releases of chemicals that might threaten employees
  - OSHA issued the process safety management (PSM) standard in February 1992



## Some Reasons We Need P&IDs

- API Recommended Practice 750
  - Published in January 1990
  - Intended to help prevent the occurrence of, or to minimize the consequences of, catastrophic releases of toxic or explosive materials
  - From paragraph 2.3 “The mechanical design information should include ...piping and instrument diagrams...”
- AIChE Guidelines for Technical Management of Chemical Process Safety and Guidelines for Hazard Evacuation Procedures (1992)



## Government Numbering System

### OSHA PSM = 29 CFR 1910.119

OSHA	Occupational, Safety, and Health Administration
PSM	Process Safety Management
29	The number for all labor regs
CFR	Code of Federal Regulations
1910	Occupational, Safety, and Health Regulations
.119	Process Safety Management of highly hazardous chemicals



## Installation in Hazardous Areas

- Hazardous area classification
  - NEC class, division, group
- Explosion confinement
  - Explosion proofing (flame proofing)
- Isolation of energy source
  - Pressurization
  - Purging
- Energy release limitation
  - Intrinsic safety
  - Nonincendive equipment



## Hazardous Area Classification

- National Electrical Code (NEC) is sponsored by the National Fire Protection Association (NFPA)
  - Contains the most widely adopted set of electrical safety requirements
  - Includes a classification system consisting of three parts for hazardous areas where flammable materials might be a problem:
    - Class
    - Group
    - Division



## Class Designations

- **Class I**
  - Locations where flammable **gases or vapors** are or may be present in the air in quantities sufficient to produce an explosive or ignitable mixture (i.e., chemical plants and oil refineries)
- **Class II**
  - Locations where combustible **dusts** may be present in sufficient quantity to cause hazards (i.e., flour mills and coal pulverizing facilities)
- **Class III**
  - Locations where the hazardous material consists of easily ignitable **fibers or filings** that are not normally in suspension in the air in quantities to produce ignitable mixtures (i.e., sawmills and fiber manufacturing facilities)



## Class I Group Designations

- **Group A** – Acetylene
- **Group B**
  - Butadiene, ethylene oxide, propylene oxide, hydrogen (and gases or vapors of equivalent hazard)
- **Group C**
  - Cyclopropane, ethyl ether, ethylene, hydrogen sulfide (and gases or vapors of equivalent hazard)
- **Group D**
  - Acetone, alcohol, ammonia, benzene, butane, propylene, gasoline, methane, natural gas (and gases or vapors of equivalent hazard)



## Class II Group Designations

- **Group E**
  - Combustible metal dusts regardless of resistivity or other combustible dusts of similar hazard (magnesium, aluminum, bronze powder, etc.)
  
- **Group F**
  - Carbon black, charcoal, coal, or coke dusts that have more than 8 percent total volatile material
  
- **Group G**
  - Combustible dusts (flour, starch, pulverized sugar and cocoa, dairy powders, dried hay, etc.)



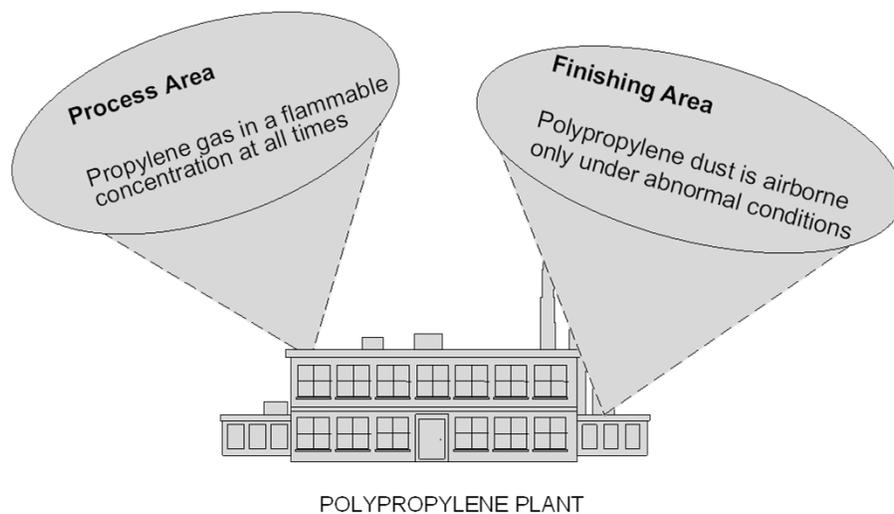
## Division Designations

- **Division 1**
  - The flammable or combustible mixture exists under normal conditions (during regular maintenance activities, chemical releases that happen regularly, etc.)
  
- **Division 2**
  - The flammable or combustible mixture exists under abnormal conditions (malfunctions, pipe rupture, equipment leaks, etc.)

## European Hazardous Area Classification

- **Zone 0** – An area where a flammable mixture exists much of the time during normal operation
- **Zone 1** – An area where a flammable mixture exists part of the time during normal operations
- **Zone 2** – An area where a flammable mixture exists only as the result of a fault

## Classification Example





## Code Application

- Safety Considerations
- Hazardous Areas
- Installation Practices



## Fire and Explosion Components

**For fire or explosion to occur,  
triangle must be complete**

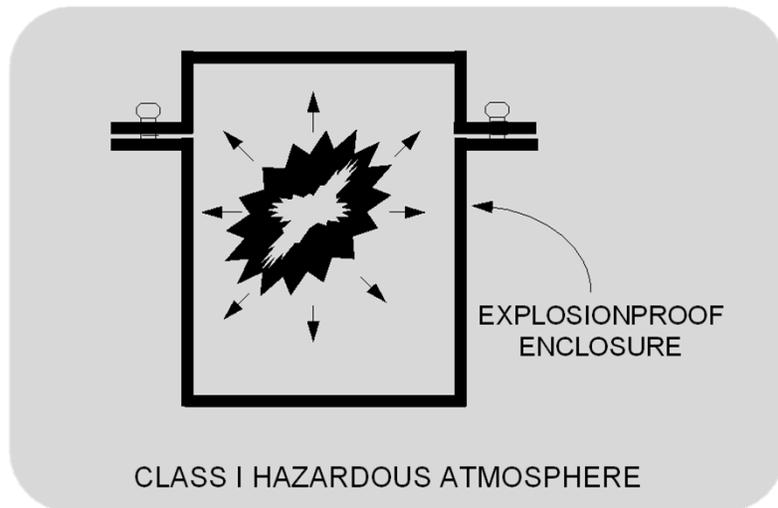
To reduce hazard, eliminate the fuel, the oxidizer,  
or the ignition source

## Protection Techniques

- Explosion confinement
  - Explosion proofing (flame proofing)
- Isolation of energy source
  - Pressurization
  - Purging
- Energy release limitation
  - Intrinsic safety
  - Nonincendive equipment

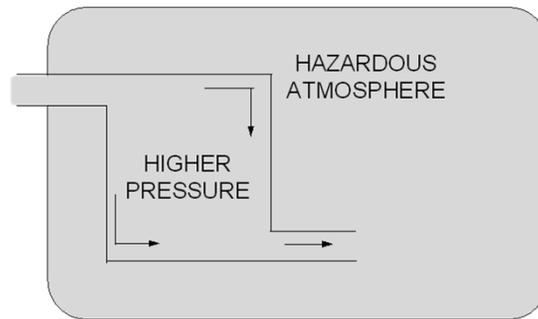
**Caution:**  
Decisions regarding  
the safe installation of any  
instrument is the responsibility  
of a qualified person..

## Explosion Confinement



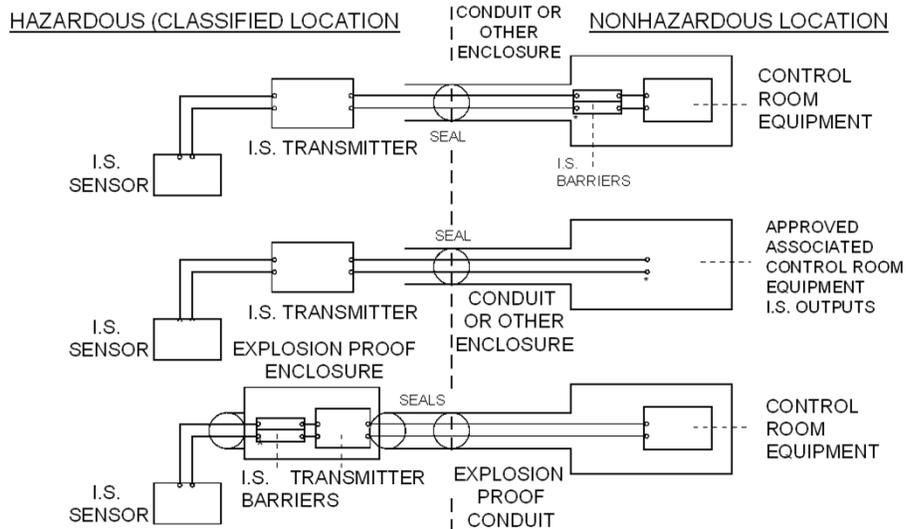
## Pressurized Enclosures

**Pressurization:** The technique of guarding against the ingress of the external atmosphere into an enclosure by maintaining a PROTECTIVE GAS therein at a pressure above that of the external atmosphere



**Purging:** In a pressurized enclosure, the operation of passing a quantity of PROTECTIVE GAS through the enclosure and ducts, so that the concentration of the explosive gas atmosphere is brought to a safe level.

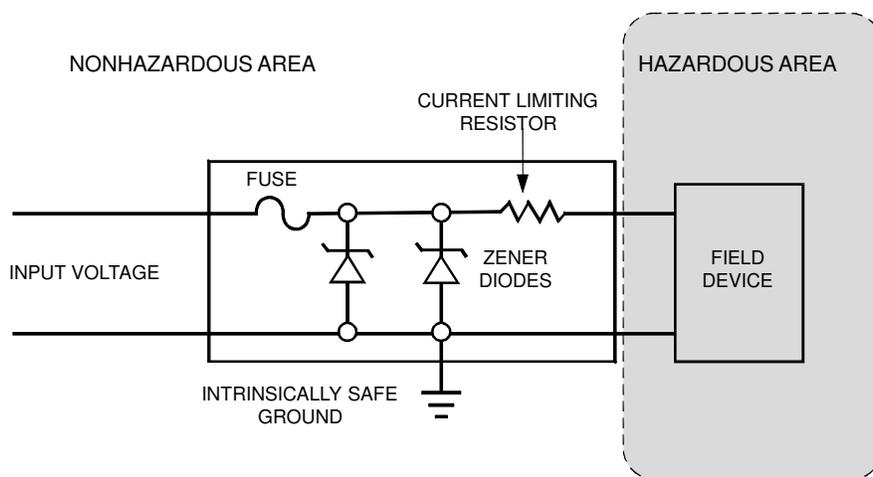
## Intrinsic Safety



## Device/Apparatus

- **Simple apparatus**
  - Devices in which will neither generate nor store 1.2 V; 0.1 A; 25 mW; 20  $\mu$ J
  - Passive sensors (thermocouples, RTDs, contacts LEDs, etc.)
  - Can be directly placed in hazardous locations
  - No requirements for certification when connected to a certified barrier
- **Intrinsically safe electrical apparatus**
  - Devices in which all circuits are intrinsically safe
  - Field instruments (transmitters, I/P, solenoid valves, etc.)
  - Certification based on maximum energy level (group of gas) and maximum surface temperature

## Intrinsically Safe Barrier





## Nonincendive Equipment

- Equipment having electrical/electronic circuitry and components that are incapable, **under normal conditions**, of causing ignition of a **specified flammable** gas or vapor-in-air mixture due to arcing or thermal effect



## Review of Key Points

- Based on the exam specification and content, determine your weak areas.
- Develop a study plan with resources to expand your knowledge in those areas.
- Obtain key references and resources that will be needed in the exam room.
- Organize and be familiar with the standards, codes, and reference materials.
- Set aside some specific study time each week and develop a discipline of concentration.



## Live Question and Answer Session

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## How Many People Are at Your Site?

- Poll Slide
- Click on the appropriate number indicating the number of people that are at your site.



### Sample Exam Question - #1

- The definition and classification of hazardous areas for the purpose of wiring and electrical equipment classification is found in codes published by:
  - A. National Fire Protection Association
  - B. ISA
  - C. Electric Power Research Institute
  - D. Occupational Safety and Health Administration



### Sample Exam Question - #2

- Coal grinding areas in a coal fired steam power plant would be classified under hazardous area provisions of the National Electric Code (NEC) as:
  - A. Class I, Group B
  - B. Class I, Group D
  - C. Class II, Group E
  - D. Class II, Group F



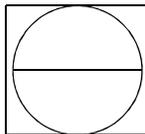
### Sample Exam Question - #3

- The OSHA Process Safety Management Directive, 29CFR, Part 1910, addresses all of the following EXCEPT:
  - A. Transportation of hazardous chemicals
  - B. Process operator training
  - C. Plant contractor safety
  - D. Process design considerations



### Practice Exam Question - # 4

- According to standard ISA5.1, the symbol below represents:



- A. A normally-inaccessible instrument
- B. A field mounted discrete instrument
- C. A shared display or shared control instrument
- D. A computer function
- E. A programmable logic control



## Sample Exam Question - #5

- Field mounted or outdoor instrumentation equipment in a wash-down area of an industrial facility would probably need a:
  - A. NEMA 1 enclosure
  - B. NEMA 2 enclosure
  - C. NEMA 3 enclosure
  - D. NEMA 4 enclosure



## Related Courses from ISA

- Sizing, Selecting, and Applying Process Control Valves (EI30)
- Understanding Industrial Processes, Measurement and Control (FG05)
- Tuning of Feedback Controllers (TC05C1)
- Industrial Flow Measurement Engineering (EI10)
- Ethernet and TCP/IP on the Plant Floor (FG21C)
- Control Systems Engineering (CSE) PE Exam Review Course (EN00)



## Other Related Resources from ISA

- *Instrument Engineers Handbook, 3<sup>rd</sup> Edition – Process Measurement & Analysis* (Bela Liptak)
- The ISA5.1-2009 Instrumentation Symbols & Identification standard
- ISA Membership is just \$100 per year, which includes free membership in two Technical Divisions (a \$20 value) - one from each Department: Automation and Technology and Industries and Sciences.
  - For more information: <http://www.isa.org/membership/meminfo> or (919) 549-8411



## ISA Certifications

- Certified Automation Professionals ® (CAP ®)
  - [www.isa.org/CAP](http://www.isa.org/CAP)
- Certified Control Systems Technician® (CCST®)
  - [www.isa.org/CCST](http://www.isa.org/CCST)
- Please visit us online for more information on any of these programs, or call (919) 549-8411.

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