API and ISO Standards for Artificial Lift

Anthony Allison – Occidental, API SC11
Greg Stephenson – Occidental, API 19G

Webinars

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Introductions

- Ben Nathan
  - Programming Chair, SPE AL&D Technical Section
- Anthony Allison – Occidental
  - Chair, API Subcommittee 11
- Greg Stephenson – Occidental
  - Chair, API Task Group 19G/11S

Objectives

- Educate members about similarities and differences between API and ISO standards
- Provide information about requirements and content of standards for SRP, ESP, GL, PL and PCP systems currently available
- Teach manufacturers and end users how to use these documents
- Inform members about upcoming revisions / new standards

Agenda

- API/ISO document creation, structure, approval process, use & enforcement
- Overview of documents available for:
  - Sucker Rod Pumps
  - Plunger Lift
  - Progressing Cavity Pumps
  - Gas Lift
  - Electric Submersible Pumps
- Q&A

API/ISO Document Creation, Structure, Approval Process, Use & Enforcement

HOW THE SAUSAGE GETS MADE

What responses to AL tenders seem like:

Why use standards?

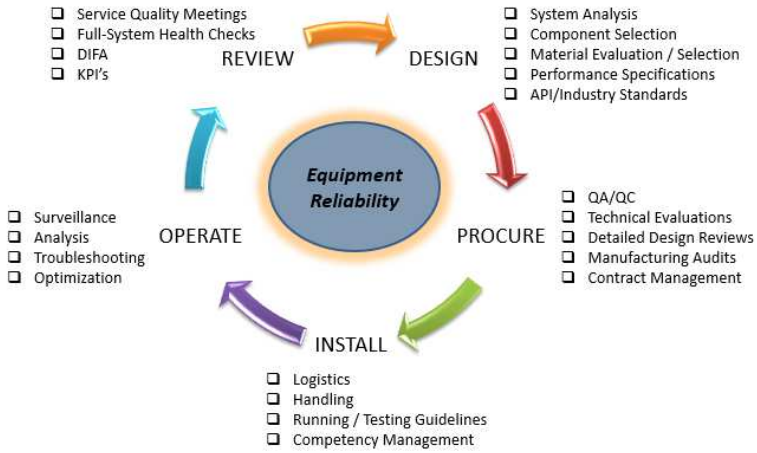
End users:

Be able to compare apples-to-apples for optimal equipment / vendor selection

Manufacturers:

Know their system is being compared fairly / correctly against others

Improving Artificial Lift Reliability



Why are artificial lift standards developed?

- Help optimize operations, therefore improve bottom line.
- Lack of standardized performance ratings and function tests makes comparisons across manufacturers difficult.
- Assurance that the equipment performs as advertised and supported with sound engineering practices.
- Establish common nomenclature and definitions so that everyone is speaking the same language.

» Further Reading:

1. http://www.api.org/publications-standards-and-statistics/standards/~/media/Files/Publications/FAQ/valueofstandards.ashx
2. http://www.iso.org/iso/home/standards/benefitsofstandards.htm

What a standard is NOT

- It is not a contract with the manufacturer.
- It does not guarantee or become an issue of equipment warranty.
- For ISO standards and API standards that adopted an ISO standard, manufacturers are not required to comply unless required by an end user (i.e., the end user must invoke use of the standard in contracts).

What Makes a Good Standard?

- Clear objective based on sound technical principles
- Reasonable and practical
- Not restrictive of technology development
- Proven engineering practices – not necessarily “good” or “best” practices (terms are subjective)
- Input from all stakeholders
- Addresses those issues that make a difference
- Risk-based when necessary
- Performance-based, rather than prescriptive

API vs ISO: Differences & Similarities

- One company, one vote
- Balance of user/purchasers and supplier/ manufacturers
- Approval process is a democratic vote by member company.
- API members are corporations, ranging from producers to service and supply companies.
- Process from new draft to published standard can take 18 months – several years.
- Documents include Standards/Specifications, Recommended Practices and Technical Reports.
- Monogram program.

- One country, one vote
- Balance of user/purchasers and supplier/ manufacturers
- Approval process is a democratic vote by member country – 2 rounds.
- ISO members are the national standards bodies of 165 countries
- Process from new draft to published standard can take 18 months – several years.
- Only publishes standards, no recommended practices or technical reports.
- No monogram program - enforcement through company purchasing requirements.

API Document Designations

- Specifications — **Mandatory 5-year Review Cycle**
- Standards (combine elements of specifications & RP's)
- Recommended Practices

- Bulletins — **"One and done"**
- Technical Reports

Co-branding

- Certain standards drafted by one organization and "adopted back" by other.
  - Example: API SPEC 19G2, First Edition = ISO 17078-2:2007
- Practice largely ended over past decade due to export compliance and IP concerns.
  - Example: API SPEC 19G2, Second Edition has no ISO equivalent

How a Standard is Structured

- Clauses 1-9: Requirements
- Normative Annexes: Additional details for requirements in Clauses
- Informative Annexes: Related Guidelines

API/ISO Document Structure

1. Scope
2. Normative References
3. Terms and Definitions
4. Symbols and Abbreviated Terms
5. Functional Specification
6. Technical Specification
7. Supplier/Manufacturer Requirements

Normative Annexes

Informative Annexes

ISO Only:

8. Repair
9. Shipping, handling and storage

Document Structure – 3 Main Components

Clause 5

Functional Specifications

- Operation conditions
  - Well
  - Fluids
  - Operational parameters
- Q/C & documentation requirements
- Other requirements

What the user needs

Clause 6

Technical Specifications

- Equipment characteristics
- Design criteria
- Validation procedures

Manufacturers response to user's request

Clause 7

Supplier Requirements

- Documentation and data control
- Product identification
- Q/C procedures
- Design verification

How we ensure this happens

Usage and Enforcement

- End-users reference in purchasing requirements & contracts.
- End-users select applicable grades for design validation, functional testing, quality assurance and environmental service.
- End-users perform audits.
- Manufacturers ***may*** participate in voluntary monogram program.
- API auditors enforce compliance with monogram program through audits.
- API can withdraw monogram license.

- End-users reference in purchasing requirements & contracts.
- End-users select applicable grades for design validation, functional testing, quality assurance and environmental service.
- End-users perform audits.
- No monogram program.

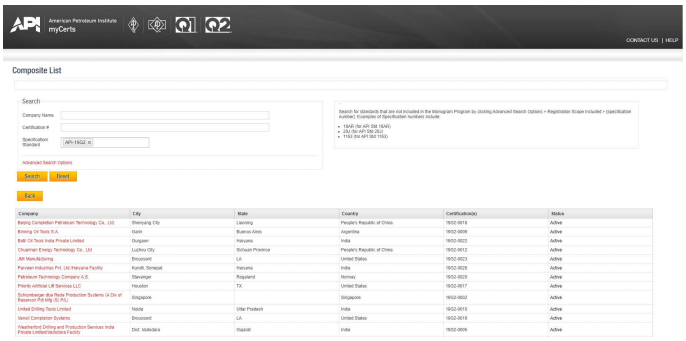
How do you purchase standards?

- API Publications Store
  https://www.apiwebstore.org/
- ANSI WEBSTORE*
  https://webstore.ansi.org/
- IHS Markit Standards Store*
  https://global.ihs.com/

*Your company may have a subscription.

How can you tell which vendors are licensed to produce monogrammed equipment?

- Search the API Composite List: https://mycerts.api.org/Search/CompositeSearch



*Note: Monogram licenses are ***per facility*** and non-transferrable.

SUCKER ROD PUMPS

What's available for Rod Pump Systems?

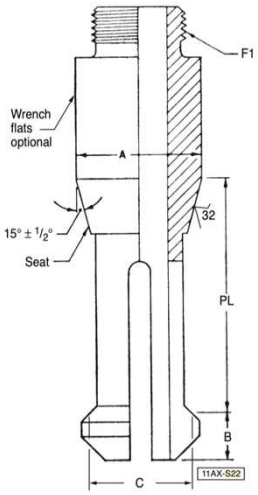
- API SPEC 11AX: Specification for Subsurface Sucker Rod Pump Assemblies, Components, and Fittings; *Thirteenth Edition, 2015; Addendum 1, 2019*
  - API RP 11AR: Recommended Practice for Care and Use of Subsurface Pumps; *Fourth Edition, 2000; Errata, 2013; Reaffirmed, 2020*
- API SPEC 11B: Specification for Sucker Rods, Polished Rods and Liners, Couplings, Sinker Bars, Polished Rod Clamps, Stuffing Boxes, and Pumping Tees; *Twenty-Seventh Edition, 2010; Errata 1, 2010; Errata 2 2011*
  - API RP 11BR: Recommended Practice for the Care and Handling of Sucker Rods; *Ninth Edition, 2008; Reaffirmed, 2020*

What's available for Rod Pump Systems?

- API SPEC 11E: Specification for Pumping Units; Nineteenth Edition, 2014; Errata, 2015; Addendum 1, 2018
  - API RP 11ER: Recommended Practice for Guarding of Pumping Units; Third Edition, 2009; Reaffirmed, 2020
  - API RP 11G: Recommended Practice for Installation, Maintenance, and Lubrication of Pumping Units; Fifth Edition, 2013; Reaffirmed: 2019
- API TR 11L: Design Calculations For Sucker Rod Pumping Systems (Conventional Units); Fifth Edition, 2008
  - API BUL 11L2: Catalog of Analog Computer Dynamometer Cards; First Edition, 1969; Reaffirmed, September 1999
  - API TR 11L6: Technical Report on Electric Motor Prime Mover for Beam Pumping Unit Service; Second Edition, 2008

API SPEC 11AX: Rod Pumps

- Updates for the 14th edition are in progress.
- Will include additional materials and pump assemblies to clarify what assemblies can be monogrammed.
- Compatibility of mechanical holddowns and seating nipples across different manufacturers



API RP 11AR: Care and Use of Subsurface Pumps

- Major revisions underway for the fifth edition, including:
  - Maximum pull force for stuck pumps.
  - Dynamometer card examples for troubleshooting.
  - Safety concerns for removing stuck plunger from barrel during teardown.
  - Addition of RX barrels to tables for maximum pump depths.

API SPEC 11B: Sucker Rods and Rod Related Products

- The 28th edition was approved by the committee; currently awaiting correction to some figures before publication.
- Document title shortened to "Sucker Rods and Rod-Related Products"
- High-strength rods are now included in the specification.
  - This will allow for high-strength rods to be included in the API Monogram program and API RP 11BR.
- Reference master gauge requirements updated.

API SPEC 11E/RP 11ER: Pumping Units

- Addendum 1 for 11E was published in 2018; added welding workmanship requirements for walking beams.
  - Welding requirements reference AWS D1.1/D1.1M, *Structural Welding Code—Steel.*
- Twentieth edition of 11E will expand AWS D1.1 requirements to the entire structure.
  - Will also remove chain reducers from the specification.
- Updates to 11ER will include new ladder requirements that comply with recent OSHA changes.

PLUNGER LIFT

What's available for plunger lift systems?

- SPEC 11PL, 1st Edition (2019): Plunger Lift Lubricators and Related Equipment
  - Provides consistent guidance on
    - Kinetic Energy Testing*
    - Interface connection requirements
    - Pressure Ratings
    - Validation Testing

*First time in industry

SPEC 11PL – Summary of Grades

- 3 Grades for Design Validation, 3 Grades for QA/QC, 1 Functional Verification Grade.

Table 1 - Design Validation Grade Summary

Grade	Synopsis
V1	Gas testing per V1 as in Annex B after V2 testing
V2	Perform testing as defined in Annex B
V3	Supplier/manufacturer defined validation criteria and testing procedure results that when compiled into a comprehensive report and approved by a qualified person support the product's design ratings.

Table 2 - Quality Grade Summary

Grade	Synopsis
QL1	Most stringent level of requirements
QL2	Intermediate level of requirements
QL3	Supplier/manufacturer defined criteria.

Validation Grades requirements V2 and V1 have new kinetic energy absorption and catcher testing validation requirements. V3 is a legacy grade.

Quality Grade requirements describe material specifications, sampling plans, traceability and weld requirements. QL1-3

PROGRESSING CAVITY PUMPS

What's available for PCPs?

- ISO 15136-1 (2009): **Progressing Cavity Pump Systems for Artificial Lift—Pumps**
  - API SPEC 11D2 (withdrawn)
- ISO 15136-2 (2006) : **Progressing Cavity Pump Systems for Artificial Lift-Surface-drive Systems**
  - API SPEC 11D3 (withdrawn)

ISO 15136-1: Highlights

- Defines validation testing (details in Annex B)
  - V3 (legacy grade) is a grandfather clause that accommodates validation through documentation of historical performance
  - V2 (basic grade) requires hydraulic validation and elastomer and bond validation
  - V1 (highest grade) V2 plus durability validation
- Hydraulic validation is test to confirm volume capability, pressure capability and performance characteristics
- Elastomer/bond validation includes suite of fluid compatibility, mechanical property and elastomer bond retention tests
- Durability validation involves extended duration full-scale testing
  - typically specified for new models and elastomers
  - tests at 100% of rated speed, 125% of rated pressure, rated temperature
  - must run minimum of 25M revolutions (~30 days@ 500 RPM)

ISO 15136-2 Highlights

- No grades for design validation or functional testing
- 2 grades for quality control documentation
  - Q2 is just delivery documentation.
  - Q1 is Q2 plus material certifications, inspection reports, additional processes and the operating manual.
- Informative annexes on brake system selection, installation and operation; sucker rod selection and use.

Is there a PCP drive string standard?

- Short answer: No
- However … both 15136-1 and -2 contain informative annexes on the drive string.
  - 15136-1 annex is the more recent and comprehensive version.

GAS LIFT

What's available for gas lift?

- Active:
  - SPEC 19G1, 2nd Edition – **Side-pocket Mandrels (2019)**
  - SPEC 19G2, 2nd Edition – **Flow-control Devices for Side-pocket Mandrels (2020)**
  - SPEC 19G3, 1st Edition – **Kick-over Tools and Latches for Side-pocket Mandrels (Reaffirmed June 2019)**
  - RP 19G4, 1st Edition – **Practices for Side-pocket Mandrels and Related Equipment (Reaffirmed January 2019)**
  - RP 19GLHB, 1st Edition – **Gas Lift Handbook (2020)**
- Under Development:
  - SPEC 19G15, 1st Edition – **Conventional Gas Lift Equipment**
  - 19GLHB Addendum – **Gas Lift Automation**

SPEC 19G1: Side-pocket Mandrels

Table B.1—Design Validation Grades

Criterion	Grade			
	V3	V2	V1	V1H
Documentation	B.1.2.2	B.1.3.2	B.1.4.2	B.1.5.2
Design review (burst, collapse, tolerance)	B.1.2.3	B.1.3.3	B.1.4.3	B.1.5.3
Burst and collapse validation pressure test to destruction at ambient temperature	Not required	B.1.3.4 or B.1.4.6	Not required	Not required
Pressure testing at rated temperature	B.1.2.4	B.1.3.5	B.1.4.4	B.1.5.4
Internal pressure cycles	Not required	B.1.3.6	B.1.4.5	B.1.5.5
Finite element analysis/strain gauge	Not required	Not required	B.1.4.6	B.1.5.6
Failure mode and effect analysis	Not required	Not required	Not required	B.1.5.7
Flow control—install/pull with KOT	B.1.2.5	B.1.3.7	B.1.4.7	B.1.5.8
Slick line operational test with KOT	Not required	Not required	B.1.4.8	B.1.5.9
Product validation internal drift test	C.1.3.3	C.1.3.3	C.1.3.3	C.1.3.3
Product validation external drift test	C.1.3.4	C.1.3.4	C.1.3.4	C.1.3.4

KOT = kick-over tool

Table C.1—Product Functional Testing Grades

Criterion	Grade			
	F3	F2	F1	F1H
Internal pressure test	C.1.3.2	C.1.4.2	C.1.5.2	C.1.6.2
External pressure test	Not required	C.1.4.3	C.1.5.3	C.1.6.3
ID drift test	C.1.3.3	C.1.4.4	C.1.5.4	C.1.6.4
OD drift test	C.1.3.4	C.1.4.5	C.1.5.5	C.1.6.5
Installation/removal method—KOT	Not required	C.1.4.6	C.1.5.6	C.1.6.6

ID = inside diameter; KOT = kick-over tool; OD = outside diameter

SPEC 19G2: Flow-control Devices for Side-pocket Mandrels

Table B.1—Purpose of Normative and Informative Annexes

Annex	Annex Title	Purpose of Annex [a]
A	API Monogram	Provide guidance to API Licensee on the application of the API Monogram.
B	Design validation and device functional testing requirements	List purpose of each annex List all required design validation and device functional test requirements
C	Validation and device functional testing overview	Table summarizing the design validation and device functional testing requirements
D	Interface testing requirements	Design validation testing of all interfaces between flow-control devices and other related devices such as SPMs
E	Insertion testing requirements	Design validation testing of insertion and retrieval of flow-control devices into and from SPMs
F	Probe and travel testing and load rate determination	Design validation testing of maximum travel and load rate Device functional testing of maximum travel and load rate
G	Dynamic flow testing and flow coefficient, C_v, calculation	Design validation testing of flow and flow coefficient, C_v Device functional testing of flow and flow coefficient, C_v
H	Back-check testing	Design validation testing of back-check devices Device functional testing of back-check devices
I	Opening and closing pressure testing	Design validation testing of opening and closing Device functional testing of opening and closing
J	Bellows actuation life cycle testing	Design validation testing of bellows life cycles
K	Erosion testing requirements	Design validation testing of effects of erosion
L	Shelf (bellows integrity) testing requirements for nitrogen-pressure-charged flow-control devices	Design validation shelf (bellows integrity) testing Device functional shelf (bellows integrity) testing
M	Conducting port/seat leakage rate testing	Design validation testing of port/seat leakage rates Device functional testing of port/seat leakage rates

[a] The purpose of the normative Annexes B to M is to define design validation and device functional test requirements for flow-control devices.

Table C.1—Testing Requirements

Flow-control Device Group and Type (See 6.1.2)		Design Validation Test and/or Device Functional Test	Annex	Design Validation and Device Functional Test Requirements for Each Flow-control Device Grade							
				V3 Basic Grade	V2 Intermediate Grade	V1 Highest Grade	V0 Severe Service	F3 Basic Grade	F2 Intermediate Grade	F1 Highest Grade	F0 Severe Service
I	IPO	Interface	D	D.2.1	D.2.1	D.2.2	D.2.2	—	—	—	—
		Insertion	E	E.2	E.2	E.2	E.2	—	—	—	—
		Probe or travel	F	F.2	F.2	F.2	F.2	—	F.6.2	F.6.3	F.6.3
		Load rate	F	F.3	F.3	F.3	F.3	—	F.7.2	F.7.3	F.7.3
	Balanced IPO	Flow	G	—	G.2.2	G.2.3	G.2.3	—	—	—	—
	IPO w/ choke	Back-check	H	H.2.2	H.2.3	H.2.4	H.2.5	H.3.1	H.3.1	H.3.2	H.3.3
		Open and close	I	I.1.2	I.1.2	I.1.2	I.1.2	I.2	I.2, I.3.1	I.2, I.3.1	I.2, I.3.1
		Actuation life cycle	J	—	—	J.2.2	J.2.2	—	—	—	—
		Erosion	K	—	K.2.3	K.2.3	K.2.4	—	—	—	—
		Shelf	L	L.2.1	L.2.1	L.2.1	L.2.1	L.3.2	L.3.2	L.3.2	L.3.2
		Port/seat leakage rate	M	M.2	M.2	M.2	M.2	M.3	M.3	M.3	M.3
II	PPO	Interface	D	D.2.1	D.2.1	D.2.2	—	—	—	—	—
		Insertion	E	E.2	E.2	E.2	—	—	—	—	—
		Probe or travel	F	F.2	F.2	F.2	—	—	F.6.2	F.6.3	—
		Load rate	F	F.3	F.3	F.3	—	—	F.5.2	F.5.3	—
		Flow	G	—	G.2.2	G.2.3	—	—	—	—	—
		Back-check	H	H.2.2	H.2.3	H.2.4	—	H.3.1	H.3.1	H.3.2	—
		Open and close	I	I.1.2	I.1.2	I.1.2	—	I.2	I.2, I.3.2	I.2, I.3.3	—
		Actuation life cycle	J	—	—	J.2.2	—	—	—	—	—
		Erosion	K	—	K.2.2	K.2.2	—	—	—	—	—
		Shelf	L	L.2.1	L.2.1	L.2.1	—	L.3.2	L.3.2	L.3.2	—
		Port/seat leakage rate	M	M.2	M.2	M.2	—	M.3	M.3	M.3	—

SPEC 19G3: Kick-over Tools and Latches for Side-pocket Mandrels

- Annex A (normative): **Requirements for running and pulling tools**
- Annex B (normative): **Requirements for kick-over tools**
- Annex C (normative): **Requirements for latches**
- Annex D (normative): **Side-pocket mandrel tool interface evaluations**
- Annex E (informative): **Figures**
- Annex F (informative): **API Monogram Program**

Withdrawn but available for purchase

- RP 19G5 (2019): **Operation, Maintenance, Surveillance, and Troubleshooting of Gas-lift Installations**
- RP 19G6 (1999): **Recommended Practice for Design of Continuous Flow Gas Lift Installations Using Injection Pressure Operated Valves**
- RP 11V7 (1999): **Recommended Practice for Repair, Testing, and Setting Gas Lift Valves**
- RP 11V8 (2003): **Recommended Practice for Gas Lift System Design and Performance Prediction**
- RP 19G9 (2015):**Design, Operation, and Troubleshooting of Dual Gas-lift Wells**
- RP 19G10 (2018): **Design and Operation of Intermittent Gas-lift Systems**
- RP 19G11 (2018): **Dynamic Simulation of Gas-lift Wells and Systems**
- API Vocational Book 6: **Gas Lift, Book 6 of Vocational Training Series** (2007)

* The above were superseded by RP 19GLHB, The API Gas Lift Handbook

ELECTRIC SUBMERSIBLE PUMPS

What's available for ESP's?

- Reaffirmed in 2021:
  - ISO 15551-1, 1st Edition **- Electric submersible pump systems for artificial lift**
- Under Development:
  - ISO 15551-1, 2nd Edition **- Electric submersible pump systems for artificial lift**

- Reaffirmed in 2020:
  - RP 11S1, 3rd Edition **– ESP Teardown Sheet**
- Under Development:
  - RP 11S1 4th Edition **– Dismantle, Inspection and Failure Analysis of ESP Systems**
  - RP 11S9, 1st Edition **– Recommended Practice on Permanent Magnet Motor Safety**

ISO 15551-1: Electric submersible pump systems for artificial lift

Product	Selected Grades							
	Design Validation (Annex A)		Functional Evaluation (Annex D)			Quality Control		
	V-1	V-2	F-1	F-2	F-3	Q-1	Q-2	Q-3
Bolt on discharge								
Pump and gas handlers								
Bolt on intake								
Mechanical gas separators								
Seal chamber sections								
Induction motor								
Cable and MLE								
Assembled ESP system	Annex C*		Annex E**					

Withdrawn but available for purchase

- RP 11S (2000): **Operation, Maintenance & Troubleshooting of ESP Installations**
- RP 11S2 (1997): **ESP Testing (Pumps)**
- RP 11S3 (1999): **ESP Installations**
- RP 11S4 (2002): **Sizing & Selection of ESP Installations**
- RP 11S5 (2008):**Application & ESP Cable Systems**
- RP 11S6 (1995): **Testing of ESP Cable Systems**
- RP 11S7 (1999): **Application & Testing of ESP Seal Chamber Sections**
- RP 11S8 (2012): **ESP System Vibrations**

* Most content created in 1980s / 1990s and reaffirmed without industry input.

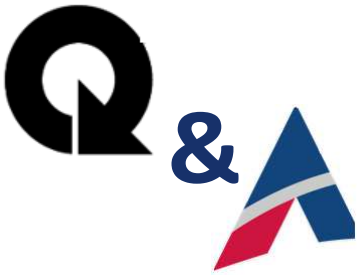
15551-1 Highlights: Performance Ratings

- Shaft power rating
- Shaft coupling rating
- Bolt on discharge – pressure rating
- Bolt on discharge and bolt on intake – flow capacity rating
- Design performance curve
- GVF rating
- Pump stage thrust rating
- Housing pressure rating

CLOSING REMARKS

Value of Participation

- Gives your company a voice in the development of a standard
- Networking with experts from other companies to learn from their experiences
- Sharing lessons learned to prevent problems before they occur
- Early access to information
- Use knowledge to help demonstrate compliance with industry standards to customers and regulators
- Opportunity for company personnel to gain expertise through consistent participation

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