rotork®

Enclosures Explained

Understanding

Hazardous and Non-Hazardous

Actuator Enclosures

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Enclosures Explained

The enclosure is a vital component in the safe use and reliability of electric actuators.

Putting aside the requirement to provide structural strength in accommodating torque and thrust forces, the enclosure must protect control equipment located inside and, for actuators located in hazardous areas, ensure safe use.

"Hazardous" and "Non-Hazardous"

These are terms used to broadly describe the area in which the actuator is located. The "hazard" referred to is the possibility of the surrounding atmosphere being an explosive gas or dust mixture. Locations are assessed to quantify the risk of there being an explosive mixture present and, if so, how often and of what composition.

A simple example of a non-hazardous location would be an actuator operating a river gate while a hazardous location would be gasoline storage tank-side valve actuator. Many locations are less obvious to assess however and require specific knowledge of the process, media and physical environment. Only the responsible Engineer with access to all the details can carry out the risk assessment and specify the protection level required for equipment in a given location.

Enclosures for Non-Hazardous Areas

Where there is no possibility of the surrounding atmosphere being an explosive gas mixture the location is described as "non-hazardous". Actuators for such locations are often specified to be "waterproof " or "watertight". Sometimes specific reference is made to an "IP" or NEMA rating. However expressed, users know water and electricity do not mix!

The degree of protection from the environment varies with the type of location and the type of machine. For example, a pump motor ventilated to optimise its duty rating and located in a building may require a very different level of protection to that of an actuator located outside on a sluice gate or in a wet well. This is where the "IP" and NEMA Standards enclosure rating systems come in.

The IP - Ingress Protection System

The IP rating is set out in standard IEC EN 60529 and rates electrical enclosures by the level of ingress protection against solids (1st digit) and against liquids (2nd digit). The higher number for each digit, the better the protection – refer to table 1.

Although the table uses simplified definitions such as "splashed water", IEC 60529 details exactly the test conditions and the requirements each level must meet. For IPX8 the machine manufacturer defines the immersion depth and time, in the case of Rotork IQ "IP68 depth 7 metres, 72 hours duration"

The IEC IP system is internationally recognised, however within the Americas NEMA will usually be specified.

Protection against solids	IP		Protection against water
No protection	0	0	No Protection
Solids > 50 mm	1	1	Vertically falling water
Solids > 12 mm	2	2	Vertically water – enclosure tilted 15°
Solids > 2.5 mm	3	3	Sprayed water 60° from vertical
Solids > 1.0 mm	4	4	Splashed water from all directions
Dust protected	5	5	Hosing jets from all directions
Dust tight	6	6	Strong hosing jets from all directions
		7	Temporary Immersion: 1m for 30 minutes
		8	Immersion: manufacturer defined depth and time

Table 1 – IEC60529 Ingress protection codes

For example an IP rating of IP55 indicates the device is dust protected and protected against water jets.

NEMA Protection System

The NEMA – National Electrical Manufactures Association system of rating uses a scale between 1 (low protection) and 13, mixed for indoor and outdoor locations, different liquid and dust types, and corrosive agents and is therefore a more complex matrix. NEMA is recognised across North and South America including Canada and may also be specified in other parts of the word if a US based contractor or end user has specified the actuators. Table 2 shows a simplified version with the nearest equivalent IEC standard IP code.

The NEMA code also includes ratings for hazardous locations but these are rarely referred to, with other hazardous area classification systems being favoured.

NEMA Rating	Abbreviated Protection Description	IP Equivalent
1	Indoor: Accidental contact and falling dirt.	IP30
2	Indoor: Accidental contact, falling dirt and falling liquid/light splashing	IP31
3	Outdoor: Rain tight, dust tight & ice resistant (enclosure undamaged after ice has melted)	IP64
3S	Outdoor: Rain tight, dust tight & ice proof (operable during icing)	IP64
4	Indoor/outdoor: Water tight (hose down), dust tight & ice resistant	IP66
4X	Indoor/outdoor: Water tight (hose down), dust tight, ice resistant & corrosion resistant	IP66
6	Indoor/outdoor: Occasional submersion (6 ft/30min), dust tight, ice resistant & corrosion resistant	IP67
7,8,9 & 10	Hazardous locations	N/A
12	Indoor: Dust tight, dripping water, oil and non corrosive liquids	IP64
13	Indoor: Dust tight, spraying water, oil and non corrosive liquids	IP65

Table 2 – NEMA codes

Protection Beyond Standards

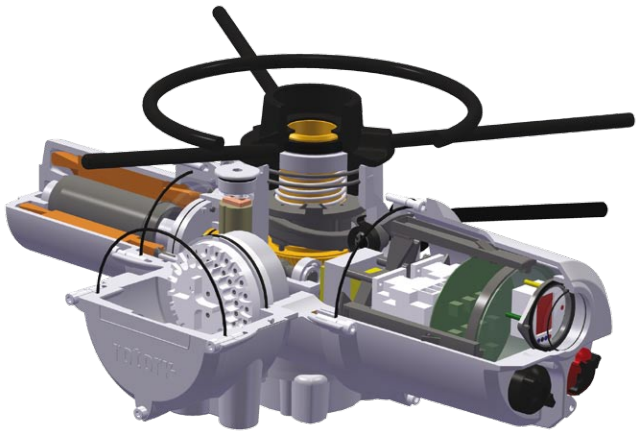
Rotork have long understood the relationship between enclosure rating and reliability – simply, the better the enclosure rating the greater the reliability. Rotork first developed a watertight IP67 "non-breathing" enclosure design in the 1960's (since upgraded to IP68 - 7m & 72 hours) based on the simple spigot and "O" ring joint.

Over the years it has been clearly demonstrated that when electro-mechanical control equipment is protected, actuator life is extended to that consistent with operational wear and tear alone. With a completely sealed enclosure and high specification control equipment, actuator life can be measured in decades.

Rotork Service recently took a call from a water utility engineer enquiring about upgrading water supply valve actuators with analogue indication which was required by a new control scheme. It turned out the actuators were commissioned 31 years ago! When asked about their condition the customer informed us "they operate regularly and never give a problem". Needless to say they were upgraded.

Double sealing

This level of reliability is due to Rotork looking beyond the basic requirements in meeting watertight enclosure standards by applying sealing not only to the complete enclosure but also protecting the actuator during vulnerable installation processes where the enclosure must not be compromised. The biggest factor in this requirement is maintaining the seal during the cabling process. Beyond the direct control of Rotork and usually of the end-user, cabling up the actuator requires access to the terminal compartment. During this stage, which could be a significant time or repeated many times, the enclosure is exposed to the elements. Rotork identified and solved the problem by providing a "double sealed" terminal enclosure in the late 1960's. By making the terminal compartment IP68 sealed in its own right, internal control equipment within the actuator remains fully protected even if the terminal cover is removed. No longer could actuators be damaged or compromised before they were even commissioned. So successful was this system that many users of actuators now often specify "double sealing" as a basic requirement.



Non–Intrusive

Taking the concept of double sealing one stage further, Rotork identified the actuators vulnerability during commissioning. All actuators require at least limits and torque overload switches to be set to suit the valve and process. With traditional electro-mechanical actuator systems this required access to the "switch-mechanism". Once again, covers need to be removed to gain access to the mechanism and therefore internal equipment is compromised.

In the early 1990's Rotork pioneered the development of "non-intrusive set up. This resulted in the IQ range actuator and made available set up via infra-red control from a supplied setting tool. Much like modern entertainment equipment, set up is remote, reliable and simple and most importantly, no covers need be removed. While providing full protection of internal equipment and further protecting the actuator, the non-intrusive spin-off for users is that no time is wasted removing covers, intimate knowledge of a manufacturers specific switch mechanism design is not required and status and alarm/fault finding information is available at the touch of a button. Anyone can set-up, adjust and interrogate the actuator with no special training or knowledge of actuator systems. As with double sealing, the benefits of non-intrusive setup are seen to be so great that users often specify it.

Enclosures Explained

Enclosures for Hazardous Areas – "Ex"

Where there is a possibility of the surrounding atmosphere being "potentially explosive", the location is described as "hazardous" and requires special protection measures in the construction and testing of the installed apparatus, in our case the actuator. The basic principal employed is that the actuator ***"will not cause an explosion of the surrounding atmosphere"***.

The special measures applicable to actuator enclosures are known as "Explosionproof" or "Flameproof" and "Flameproof - Increased Safety" protection types.

There is often confusion in understanding the differences between these protection concepts which could lead to incorrect specification, supply, installation or maintenance rendering the protection useless and risking an explosion of the surrounding atmosphere.

This article will explain "Explosionproof", "Flameproof" and "Increased Safety" concepts of protection and provide guidance on safe use.

Standards & Codes

Electrical actuators include components such as motors, contactors, switches and other devices capable of producing a spark or getting hot and therefore must be designed in such a way as to "protect" the potentially explosive atmosphere surrounding the actuator from these sources of ignition.

National, regional and international agencies produce "apparatus" or product standards and codes prescribing the construction and testing necessary to meet the required level of protection determined by:

- How often an explosive atmosphere is present
- The composition of the explosive atmosphere – type of gas, dust or fibre
- The composition of apparatus

Once designed, independent test houses must test apparatus to ensure it meets the applicable standards and is safe to use. Once "certified" or "approved" a certificate is issued detailing conformance to the standards and sets out its type of protection, where it can be used and for what gases or dusts. Any changes in design that effect its protection level may require the apparatus to be re-tested.

Protection Types

The equipment product construction standards make provision for different methods or "types" of protection. Some types prevent an internal explosion occurring in the first place, including eradicating "atmosphere" from within the enclosure by filling it with inert gas, powder, oil or potting compound. Another is "intrinsic safety", a method of electrical design where circuits are segregated and restricted to very low power levels and therefore the energy available is so low that it cannot produce a spark to cause ignition of the gas.

None of these protection methods are practical for electric actuators due to the necessary control components, maintenance and power requirements and therefore this article concentrates on the protection type that can be employed, known as "Flameproof" or "Explosionproof" and "Flameproof - Increased Safety".

Protection Types: "Explosionproof" & "Flameproof" – "Exd"

"Explosionproof" is the US/Canadian reference for the same concept as the IEC/CENELEC "Flameproof Exd" protection type, however there are differences in construction which mean they are *not* interchangeable.

"Explosionproof" equipment will be marked in accordance with NEC (National Electrical Code) Article 500, for example **Explosionproof, Class I, Division 1, Group C, T4**.

"Flameproof Exd" equipment will be marked in accordance with IEC (EN) 60079-1, for example **Exd IIB T4**.

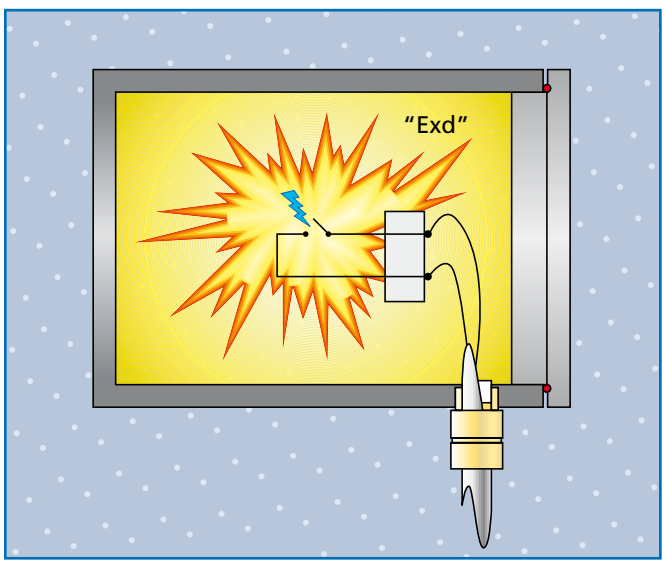


Figure 1 – "Exd" concept - enclosure can withstand pressure and includes flamepaths.

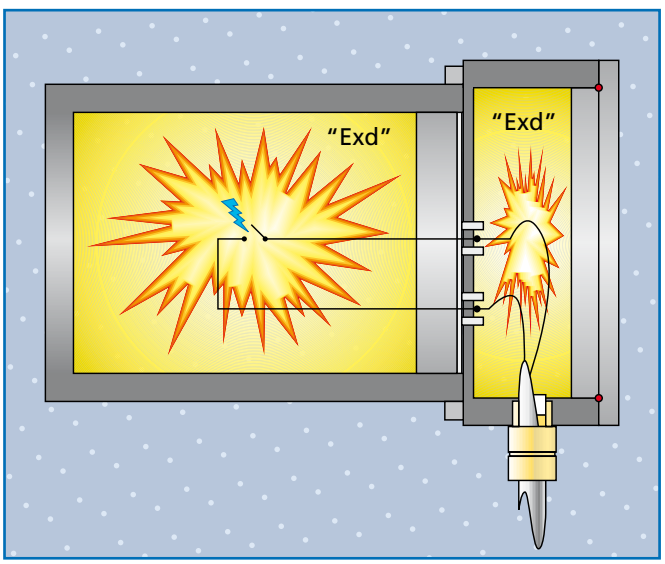


Figure 2 – "Exd" enclosure with flameproof terminal barrier – Rotork concept.

For the purposes of all explosionproof and flameproof construction standards, it is assumed that the atmosphere inside the actuator enclosure will have the same composition as that surrounding the enclosure - regardless of the sealing capability of the enclosure. So, with an explosive atmosphere inside the actuator which also contains spark producing components, an internal explosion *will occur*. To gain certification the "flameproof" or "explosionproof" actuator enclosure must therefore provide:

> ***"a type of protection in which components capable of igniting an explosive atmosphere are placed in an enclosure which can withstand the pressure developed during an internal explosion and which prevents the transmission of the explosion to the explosive atmosphere surrounding the enclosure."***

Electric actuators must therefore enclose spark-producing components within an enclosure capable of withstanding pressure created when the explosion takes place. The pressure achieved will be related to the type of gas, the internal free volume and the internal geometry of the enclosure and it is for this reason that the type of gas present will affect the type of certification the actuator must have.

As actuator enclosures must include joints, cable entries and covers, all construction standards prescribe methods by which they can be safely achieved. Interfaces must be of a minimum length. Be it a flange, spigot or thread design and with the gap between components closely controlled. The principle applied here is that the hot expanding gas resulting from the explosion must be "squeezed" through the small gap or "flamepath" between components to get to the outside. The flamepath joint absorbs heat from the gas to the point where on reaching the outside it is cooled and cannot ignite the surrounding explosive atmosphere.

Rotork pioneered the use of the spigot joint for explosion proof actuator covers and joints in the 1960's allowing the use of an "O" rings to create a watertight seal. Up to this time manufacturers producing explosion proof actuators used a flange joint that could not be effectively sealed causing all the associated problems of water ingress and subsequent poor reliability described in "non hazardous enclosures". It is true that some manufacturers still retain the flange interface today!

The Rotork Exd enclosure has a flameproof terminal barrier between the main enclosure and the terminal box enclosure. This provides a "double sealed" terminal area for protection from water ingress during the installation cabling /connection processes when the terminal cover is removed. The barrier also divides the enclosure so that the both sides are segregated within the "d" enclosure, figure 2. An explosion on either side of the terminal barrier will not be transmitted to the other side or to the outside.

Protection Type: "Flameproof - Increased Safety – "Exde"

Flameproof - Increased safety Exde type protection is in fact an actuator made up of an "Flameproof Exd" enclosure type plus a separate, segregated "Increased Safety Exe" enclosure and therefore an understanding of the "e" concept alone is required.

"Increased Safety - "Exe"

Increased safety "e" protection is based on the premise that an explosion cannot occur if a spark cannot occur, a definition for "e" protection being:

> ***"a type of protection in which increased safety measures are applied so as to give increased security against the possibility of excessive temperatures and the occurrence of arcs or sparks for electrical apparatus which does not normally produce arcs or sparks in normal service"***

Exe can only be used for equipment that does not include spark or heat producing components in normal service and where "increased safety" measures have been implemented to further

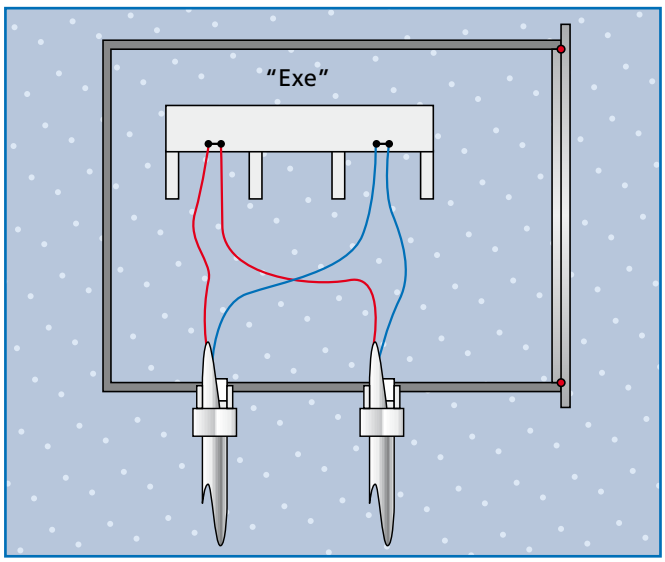


Figure 3 – Typical "Exe" enclosure concept.

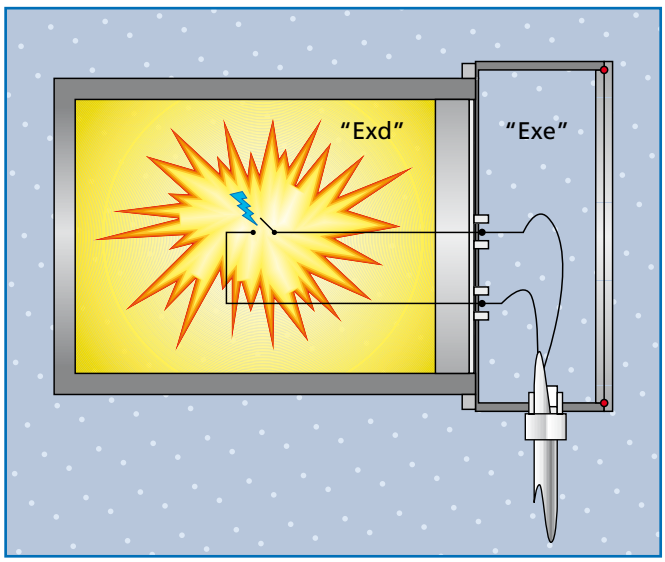


Figure 4 – Typical "Exde" enclosure.

reduce these risks. An Exe enclosure need only meet a rating of IP54 to prevent water ingress leading to electrical fault and sparking. It does not have to withstand pressure nor include "flamepaths" to safely release hot gasses associated with an internal explosion.

A simple example of apparatus suitable for increased safety protection would be a cable junction box, figure 3. As a single method of protection it cannot be used for electric actuators.

Increased safety as a concept of protection is not recognised in the US and Canada where the "class" and "division" approach requires "explosionproof" design (same concept as Exd). Originally a German DIN standard, Exe was adopted into harmonised European standards and later with the IEC standards. With this history, type "e" is usually only specified where there is German influence and the concept remains familiar.

"Flameproof - Increased safety - Exde"

By definition, increased safety type of protection cannot be used to enclose switches, contactors, heaters etc that may produce arcs or sparks in normal service and therefore it cannot be applied to the complete actuator enclosure.

However, it can be applied to the terminal compartment where there are no such components, providing this compartment is segregated from the explosionproof enclosure which must still meet the full requirements of the construction standards relating to flameproof as described above.

Actuators therefore can only use increased safety type of protection *in addition* to flameproof type protection. So, for actuators, the only possibility is for the part of the enclosure containing switches, contactors etc to comply with the flameproof "d" type protection requirements with the segregated terminal part complying with the increased safety "e" type protection requirements - ending up with a combined -"Exde" arrangement. The "d" comes before the "e" because the flameproof part of the enclosure is the major part.

To meet the increased safety construction standard the termination of power, control and indication cabling within the segregated terminal compartment must be arranged in such a way as to provide increased safety from producing hot spots or sparks. Terminals must be fixed and of such a design to prevent "the possibility of self-loosening", a set minimum distance apart and insulation material used must resist electrical tracking, aspects all designed to prevent sparks. The terminal compartment only has to meet a rating of IP54 to stop water ingress leading to corrosion, which may cause electrical fault and subsequent sparking. It does not have to withstand pressure nor include "flamepaths" to safely release hot gasses associated with an internal explosion.

Exe type of protection for the terminal compartment relies on preventing sparks or hot spots occurring. If a spark or excessive heat were to occur, due to fault or loose connection for instance, this could cause ignition of an explosive gas within the enclosure. As the enclosure does not have to withstand pressure or include flamepaths the explosion would be transmitted to the surrounding atmosphere. It is therefore vital that that the "increased safety" measures applied by the manufacturer to minimise the risks of sparks or excessive heat are followed.

"Safe Use"

For the purposes of this article "safe use" refers to the requirements of hazardous area protection in terms of the responsibility of those installing, commissioning and maintaining the actuator:

The principal remains that in use the actuator ***"will not cause an explosion of the surrounding atmosphere"***.

Providing standards for installation, cabling and maintenance are rigorously followed with the necessary controls put in place, there is no inherent difference in the ability of Exd or Exde enclosures ensuring "safe use".

Exde type of protection demands additional control during the installation and maintenance processes and is therefore regarded by some as higher risk as it places more responsibility on third parties to achieve "safe use" through life.

Installation & maintenance

Actuators certified Exd and Exde are not interchangeable nor can they be adapted from one to the other and therefore it is important that the enclosure type and site requirements match.

It is usually the case that actuators are ordered as part of the valve/pipe procurement, often a long time before electrical installation and therefore the electrical contractor must ensure that the cabling/glanding certification matches the installed actuator enclosure: *Exde actuators must have Exde glands and stopping plugs fitted, likewise for Exd*.

For both Exd and Exde enclosures safe use also requires correct earth bonding of the actuator. All covers must be fitted correctly with all fasteners in place and any unused cable entries blanked off to the same protection level as the actuator enclosure.

The exact safety requirements will be stated in installation and maintenance documentation supplied with the actuator (and available in advance from Rotork) and these should be referred to prior to installation.

Additional measures for Exde

As the Exde terminal compartment is outside the flameproof enclosure and must not produce or be subjected to sparks or excessive heating, cable selection and electrical protection must ensure that the electrical loading by the actuator does not cause terminal overheating. In addition and most importantly, correct cable termination must be carried out to ensure sparks cannot occur and safe use is assured.

The installer must follow exactly the termination method prescribed by the manufacturer in gaining certification, i.e. the use of clamping and locking devices, even down to the exact type of ring tag that must be used.

It is clear that a loose terminal connecting the 3-phase power or 24V DC control to the actuator could cause sparking and therefore control measures must ensure this does not happen.

In an attempt to overcome these complications some manufacturers employ a simplified clamp type terminal arrangement. This method requires that each individual conductor is bared from its insulation and inserted into the clamp and

tightened – not the easiest method to control and seen as less reliable than ring-tag termination by many users, especially where the actuator is subjected to plant induced vibration.

To ensure continuing safe use, the maintenance of Exde actuators should include checking of termination integrity.

Non–Intrusive commissioning and adjustment

This article has already introduced the "non-intrusive" concept as part of the explanation of Non-Hazardous enclosures and explained the additional environmental protection brought to the actuator and ease of commissioning and adjustment to the engineer.

Additionally for hazardous areas, non-intrusive setup can save a lot of time in commissioning while increasing accuracy and quality without compromising site safety at all. With traditional actuators, covers need removing to set cams and switches or access terminals and potentiometers for calibration which in turn means electrical isolation is necessary or a "hot work" permit required.

With the advent of IQ actuators, all settings and adjustments can be made with power on and covers in place over an infra-red IrDA interface. The IQ is supplied with an Infra-red Setting Tool certified intrinsically safe (Exia IIC T4) which can be used or carried in all hazardous area zones.

Local Variations

Outside of the US and Canada national standards bodies such as TIIS in Japan and Inmetro in Brazil use the IEC 60079 series of standards as the basis for their own national standard variants. It is important to note that equipment supplied usually has to comply with the certification requirements for the country or territory in which it will be located.

In Europe, it is a legal requirement that equipment supplied must fully comply with the ATEX 94/9/EC products directive, which uses the IEC EN 60079 group of standards as the basis of compliance.

Rotork can help...

Getting the correct actuator enclosure for the environment and location can sometimes be confusing.

Rotork actuators are available with enclosures for both hazardous and non-hazardous locations, meeting the certification requirements of all countries and territories.

Rotork are available to advise on actuator product specification and enclosure requirements.

Please contact your local representative for information.
Product information and contact details can be found at www.rotork.com

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