Possible usage of 1st stage surge protection

Varistor arresters of lightning current offer quality protection for their application in 1st stage of surge protection cascade with amplitude up to \( I_{\text{imp}} = 20 \text{kA}(10/350) \). In most applications, such as in case of so-called low voltage overhead grid input to a building, if endurance against all higher amplitudes of lightning current is demanded, it is recommended to use arresters of spark gap type. It is necessary to pay attention to the parameter of \( If_{\text{i}} \) (the arresters which end the stage of surge protection with the high frequency filter.

Usage of surge separating inductors between particular stages of surge protection

Surge separating induction with impedance 2:1(Up) ensures energetic coordination of particular stages of overvoltage protection cascade in most cases. They are inserted in conduct in case that the distance between 1st and 2nd stage or between 2nd and 3rd stage is smaller than 10m. When there is a longer distance it is necessary to use separating impulse arresters (HS 45, HS 50-50) after their activation by an impulse discharge current, whereas their magnitude is restricted by a arised short circuit overall impedance of the energic power network. These follow currents are spontaneously extinguished by an overpressure acting in an individual operational spark-gap chamber during the extinguishing period. The current magnitude of a prospective short circuit current in case of a defined application partly depends on the type of power system and partly on a lead distance of given application from a distribution transformer. The following diagram describes the results of measurement evaluation of these prospective follow currents performed in 2325 three-phase network of 29 distribution plants, from that 135 were made on overhead lines, 1213 on a combine lines and 713 on a cable network. This graph shows that the value of prospective short circuit current never exceeds the value of \( \text{Im}_{\text{a}} \) applicable for any power net type (overhead, combine or cable network) for example while using on application distance of 400 m from a distribution transformer. The above mentioned diagram is favorably applicable in a project practice for a qualified estimation of a suitable spark-gap selection for a defined application. A parameter determination (self-extinguish follow current) of following cascade stages

Recommendation for the installation of 3rd stage surge protection with the high frequency filter

3rd protection stage is an essential part of 3-stage overvoltage protection cascade. The typical representatives of this protection type are for example transient overvoltage protection, filter, low protection) to the level \( U_{\text{p}}<0,8 \) up to 1kV, which is safe for the final appliances. They are usually constructively fitted on DIN rail 35mm. It is important to place these products as near to the protected appliance (for example flat switchboards) as possible. The distance between switchboard and appliance must not overreach 10m. When there is a longer distance it is necessary to use separating impulse arresters or overvoltage protection on DIN rail 10m far away from each other along the protected socket line. On the other hand protected sockets are in no way equivalent substitution for 3rd stage protection with high-frequency filter.

Standardized implementation of the particular surge cascade stages

It is possible to connect the particular stages of overvoltage protection cascade in two ways:

- **Common mode**
- **Differential mode**
THE USE OF SURGE PROTECTIVE DEVICES AT REDUCING THE EFFECTS OF LIGHTNING STRIKES IN OFFSHORE OIL APPLICATIONS

A lightning strike on an offshore oil platform causes many secondary transient effects. Inductive and capacitive coupling mechanisms expose secondary power and control lines to radiated and conducted electromagnetic interference (EMI). Inductively coupled conducted interference is possible to mitigate by the use of shielding of power and control lines. The shield on all shielded lines must be connected to the primary ground conduction path. Inductively coupled conducted interference is a primary cause of failures for power and control circuits during a lightning strike. This conducted interference is present at all levels of circuitry on the platform.

The sensitivity of the components being used plays a key role in the amount of protection required at the system and subsystem level. The energy required to damage typical components found in an offshore oil platform is shown in the following figure. As expected, the sensitivity, and therefore, the amount of protection required varies as a function of the power handling capability of the component.

Component energy level damage chart

- **Motors/Generators**
- **Filter Cables**
- **Electronic tubes**
- **Relays**
- **Capacitors**
- **Diodes**
- **Transistors**
- **Computer Elements**
- **IC’s**

**Pair of Energy (Ws)**
- 10^1
- 9 - 7
- 6 - 4
- 3 - 1
- 0
- 1 - 3
- 4 - 6
- 7

**No Damage**
**Possible Damage**
**Certain Damage**

**THE USE OF SURGE PROTECTIVE DEVICES AT REDUCING THE EFFECTS OF LIGHTNING STRIKES IN OFFSHORE OIL APPLICATIONS**

International standard bodies and industry trade groups have written specifications that deal with the mitigation of effects of primary lightning strikes. More than 100 lightning protection codes and standards are in use by various countries and agencies around the world. Although none of these specifications deal directly with offshore oil lighting strikes, some that have been used in offshore oil applications are shown below:

IEC 62305 and EN 62305 standards. The Technical Committee TC81, (Lightning Protection) of the International Electrotechnical Commission (IEC) has released a series of five documents under the general heading “Protection against Lightning.” The five parts (Part 1: Protections of Structures against Lightning; General Principles; Part 2: Risk Management; Part 3: Physical Damage and Electronic Systems within Structures; and Part 4: Services) provide a comprehensive standard.


API RP 14C – Seventh 2001 Edition, American Petroleum Institute Recommended Practice for Analysis, Design, Installation, and Testing of Basic Surface Safety Systems for Offshore Production Platforms. All of these specifications and procedures focus on mitigating primary lightning strikes and address the problems of grounding, bonding, and shielding of primary conduction paths. Beside figure shows a typical example as applied to an offshore oil platform

Note: typical current path from equipotential ring (EQ-Ring) info marine soil and sea water

Typical current path from equipotential ring (EQ-Ring) into marine soil and sea water

The queen of power

Dissipation

Current
THE USE OF SURGE PROTECTIVE DEVICES AT REDUCING THE EFFECTS OF LIGHTNING STRIKES IN OFFSHORE OIL APPLICATIONS

International standard bodies and industry trade groups have written specifications that deal with the mitigation of effects of primary lightning strikes. More than 100 lightning protection codes and standards are in use by various countries and agencies around the world. Although none of these specifications deal directly with offshore oil lightning strikes, some that have been used in the offshore oil applications are shown below:

IEC 62035 and EN 62305 standards. The Technical Committee TCBJ, (Lightning Protection) of the International Electrotechnical Commission (IEC) has released a series of five documents under the general heading “Protection against Lightning.” The five parts (Part 1: Protection of Structures against Lightning: General Principles; Part 2: Risk Management; Part 3: Physical Damage and Life Hazard; Part 4: Electrical and Electronic Systems within Structures; and Part 5: Services) provide a comprehensive standard.


API RP 14C – Seventh 2001 Edition, American Petroleum Institute Recommended Practice for Analysis, Design, Installation, and Testing of Basic Surface Safety Systems for Offshore Production Platforms. All of these specifications and procedures focus on mitigating primary lightning strikes and address the problems of grounding, bonding, and shielding of primary conduction paths.

Component energy level damage chart

A lightning strike on an offshore oil platform causes many secondary transient effects. Inductive and capacitive coupling mechanisms expose secondary power and control lines to radiated and conducted electromagnetic interference (EMI). Inductively coupled conducted interference is possible energetically mitigate by rigorous applications of the surge protective devices (SPDs) and will be the main focus of this paper. Capacitively coupled secondary radiated interference is possible to liquidate by the use of shielding of power and control lines. The shield on all shielded lines must be connected to the primary ground conduction path.

Inductively coupled conducted interference is a primary cause of failures for power and control circuits during a lightning strike. This conducted interference is present at all levels of circuitry on the platform.

The sensitivity of the components being used plays a key role in the amount of protection required at the system and subsystem level. The energy required to damage typical components found in an offshore oil platform is shown in upward figure. As expected, the sensitivity, and therefore, the amount of required protection varies as a function of the power handling capability of the component.

Typical current path from equipotential ring (EQ-Ring) into marine soil and sea water

Note: Typical current path from equipotential ring (EQ-Ring) and main pillar, which are considered the lowest impedance elements in bottom part of metal construction. The current is dissipated mostly into marine soil and in lesser extent in sea water volume.
Possible usage of 1st stage surge protection

Variety arresters of lightning current offer quality protection for their application in 1st stage of surge protection cascade with amplitude up to \( I_{\text{imp}} = 20 \text{ kA}(10/350) \). In most applications, it suffices as well in case of so-called low voltage overground input into a building, if endurance against all higher amplitudes of lightning current is demanded. It is recommended to use arresters of spark-gaps type. The follow current at the spark gap application in a protective overvoltage cascades the follow short circuit currents occur in the spark gap-based surge arrester HS 45, HS 50, HS 50-50 after their activation by an impulse discharge current, whereas their magnitude is restricted by an arced short circuit overvoltage of the energized power network, these follow currents are spontaneously extinguished by an overpressure acting in an individual spark-gap chamber during the final stage of the switch-off current process. A high recovery parameter of a prospective short circuit current, in place of a defined application, partly depends on the type of power system and partly on a lead distance of given application from a distribution transformer. The following diagram describes the results of measurement evaluation of these prospective follow currents performed in 2325 three-phase network of 29 distribution plants, from that 315 were made on an overhead lines, 1213 on a combine lines and 715 on a cabal network. This graph shows that the value of prospective short circuit current never exceeds the value of \( 3kA \) applicable for any power net type (overhead, combine or cabal network) for example while using an application distance of 400 m from a distribution transformer. The abovementioned diagram is favorably applicable in a project practice for a qualified estimation of a safe spark-gap selection for a defined application. This parameter determination (building up follow current with defined application specification), depends totally on a designer to cover them by a reasonable safety coefficient (the exact measurement is from the financial and technical point of view rather demanding). For example, if the value of a prospective follow current according to the qualified estimation is \( 3kA \), then it is suitable to choose the surge arrester with an approximately twice higher parameter of \( I_{\text{imp}} \).

Usage of surge separating inductors between particular stages of surge protection

Surge separating induction with impedance 2÷15μH ensures energetic coordination of particular stages of overvoltage protection cascade in few cases. They are inserted in conduct in case that the distance between 1st and 2nd stage or between 2nd and 3rd stage is smaller than 10m. Short distance or merging surge separating inductor creates a certain possibility of damage of some arrester in overvoltage protection cascade by progressing lightning current impulse. It is important to pay a special attention to the coordination between 1st and 2nd stage of surge protection cascade in all cases where the 1st stage is fitted by spark-gap based lightning arresters. The most economical way is to secure that the 1st protection cascade is placed in other switchboard from the 2nd stage (with the min. distance of 10m between them). If the min. distance is impossible to fulfil either from the constructive or structural reasons, it is recommended to use separating inductors of 15μH.

Surge protection backup

It is necessary to use additional protection of particular SPDs for protection against short circuit 1st and 2nd stages of overvoltage protection cascade. The protection is needed for damage limitation of the drift of overvoltage protection devices during the testing of these backup fuses in the accompanying documentation. To be protected in the case of a defined application of surge arrester, there is a certain possibility of damage of some arrester in overvoltage protection cascade and their complete inactivity with the rest of the surge arrester.

Recommendation for the installation of 3rd stage surge protection with the high frequency filter

3rd protection stage is on essential part of 3-stage overvoltage protection cascade. The typical representatives of this protection type are for example transient overvoltage protection range 95μm and 25μm. The products reduce overvoltage (thanks to their inside connection/high protection, filter, line protection) to the level 5μV up to 1kV, which is safe for the final appliances. They are usually constructively fitted on DIN rail 35mm. It is important to place these products as near to the protected appliances (for example flat switchboards) as possible. The distance between switchboard and appliance must not overreach 15m. When there is a longer distance it is necessary to use separating inductors with impedance 2÷15μH, where the distance between 1st and 2nd stage of surge protection cascade or overvoltage protection on DIN rail is still 15m far away from each other along the protected socket line. On the other hand protected sockets are in no way equivalent substitution for 3rd stage protection with high-frequency filter.

The use of surge protective devices at reducing the effects of lightning strikes in offshore oil applications

H-HGS-HL-21-01-2016-EN-sales