THE QUEEN OF POWER

The use of **SURGE PROTECTIVE DEVICES** at reducing the effects of lightning strikes in **OFFSHORE OIL APPLICATIONS**

Surge
Protection
Device

EUROPEAN UNION
European Regional Development Fund
Operational Programme Enterprise and Innovations for Competitiveness

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

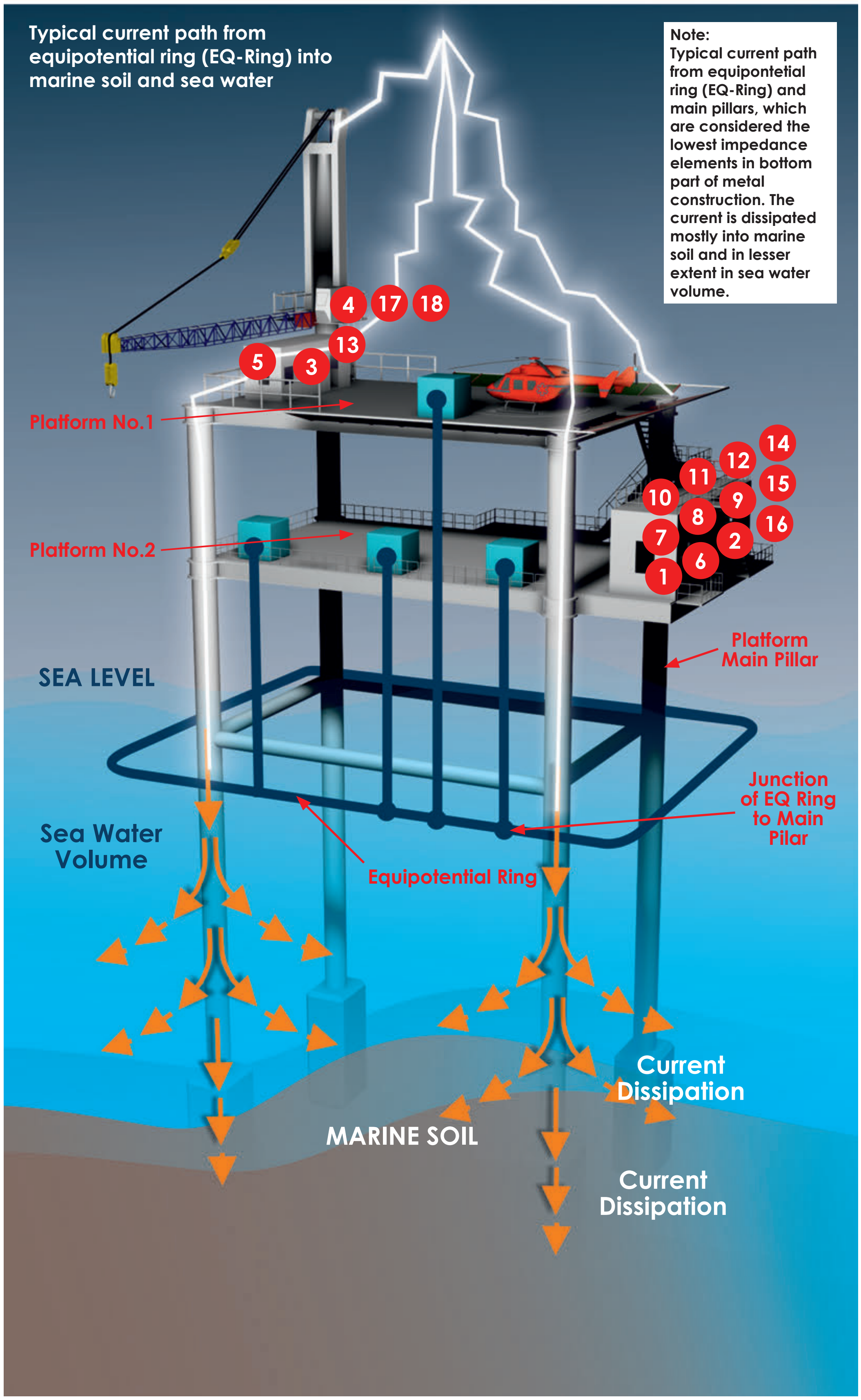
International standard bodies and industry trade groups have written specifications that deal with the mitigation of effects of primary lightning strikes. More than 100 lightning protection codes and standards are in use by various countries and agencies around the world. Although none of these specifications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

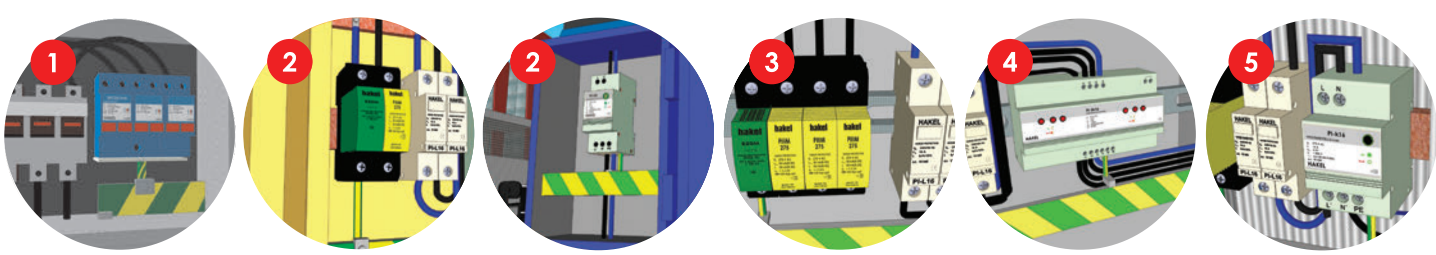
IEC 62305 and EN 62305 standards. The Technical Committee TC81, (Lightning Protection) of the International Electrotechnical Commission (IEC) has released a series of five documents under the general heading "Protection against Lightning." The five parts (Part 1, Protections of Structures against Lightning: General Principles; Part 2, Risk Management; Part 3, Physical Damage and Life Hazard; Part 4, Electrical and Electronic Systems within Structures; and Part 5, Services) provide a comprehensive standard.

ANSI/NFPA – 780-2008. Among the best-known sources of information for the protection of external lightning protection systems, the U.S. National Electric Code covers grounding, bonding, and shielding issues related to conducting primary strike currents to ground.

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 the primary conduction paths and the focus of the primary current strike to the earth ground.This figure also illustrates the critical importance of maintaining low-impedance grounding and bonding of all metal cunstruction parts.





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Subject: ***Industrial building***

Power supply

incoming powerline to the building

1

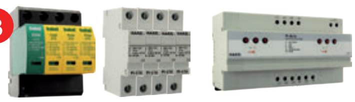
SPC25/3+0

subsidiary switchboards (power supply for offices)

2

PIIIM275/1+1 PI-L16 PI-k16

subsidiary switchboards (power supply for industrial equipment)

3

PIIIM275/3+1 4xPI-L16 PI-3k16

power supply of control section

4

PI-k8 PI-3k16

power supply of sensitive section units

5

PI-k16

socket circuits power supply of electronic appliances

6

ZS-1P

Telecommunication system - *select type of connection*

Analog connection *ISDN connection* *DSL connection*

7

HT-TEL

8

HT-ISDN

9

DTB*/ART

TV, CCTV (video) and SAT - select application

digital over land transmitting

10

KO-10P

satellite transmitting

11

KO-9P

security system

12

HT-CCTV

fire-stopping system

13

HT-DATA

Data technology - select type of technology and connection

LAN category 6

14

HAKELNET 4/250M 6cat

LAN category 5 for server

15

HAKELNET 8.2 RJ/RJ

LAN category 5 for unit

16

HAKELNET 1.2 RJ/RJ


PSK24

Measurment and control systems

Power supply of control section

17

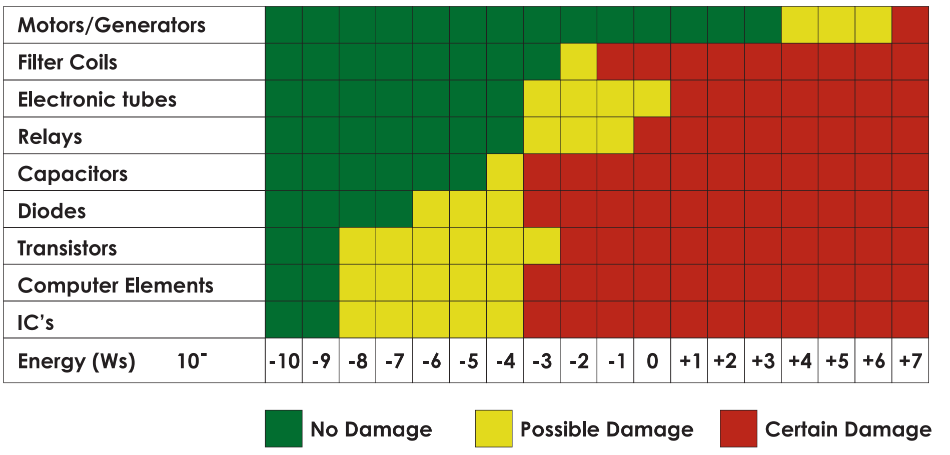
PI-k8

Communication data transmission

18

DTE 1/6/L

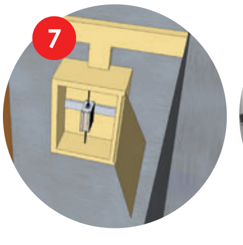
Component energy level damage chart

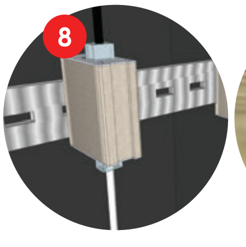


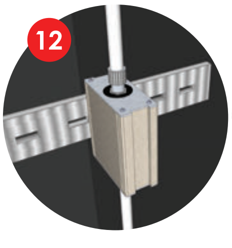
A lightning strike on an offshore oil platform causes many secondary transient effects. Inductive and capacitive coupling mechanisms expose secondary power and control lines to radiated and conducted electromagnetic interference (EMI). Inductively coupled conducted interference is possible energetically 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.

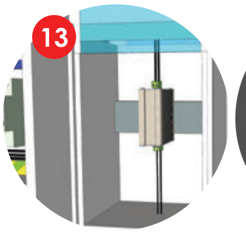
Inductively coupled conducted interference is a primary cause of failures for power and control circuits during a lightning strike. This conducted interference is present at all levels of circuitry on the platform.

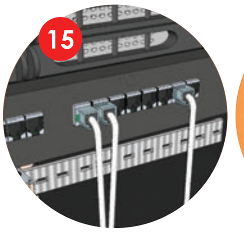
The sensitivity of the components being used plays a key role in the amount of protection required at the system and subsystem level. The energy required to damage typical components found in an offshore oil platform is shown in upward figure. As expected, the sensitivity, and therefore, the amount of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

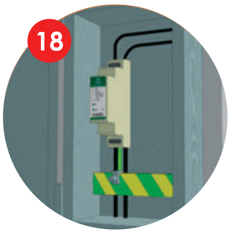










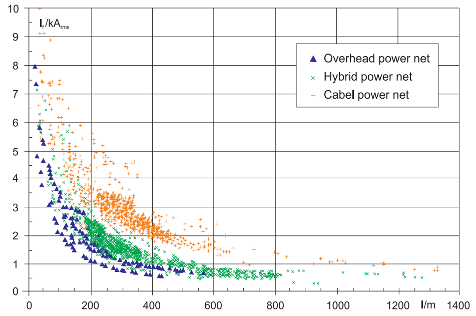


Possible usage of 1st stage surge protection

Varistor arresters of lightning current offer quality protection for their application in 1st stage of surge protection cascade with amplitude up to I_{imp} = 20 kA(10/350). In most applications it suits 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 gap type. It is necessary to pay attention to the parameter level of self-extinguishing follow current I_{fi} at U_C while a spark gap is choosed, because during the activation of a spark gap there is short-circuit in the place of its installation. Varistor arresters don´t have this property.

The follow currents at the spark gaps application in a protective overvoltage cascades

The follow short circuit currents occure in the spark gap-based surge arresters (HS 45, HS 55, HS 50-50) after their activation by an impulse discharge current, whereas their magnitude is restricted by an arised short circuit overall impedance of the energetic power network. These follow currents are spontaneously extinguished by an overpressure acting in an individual operative spark-gap chambers during the first net's half-period transit through a zero. The amplitude 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, 1215 on a combine lines and 715 on a cabel network. This graf shows that the value of prospective short circuit current never exeeds the value of 3kA_{rms} applicable for any power net type (overhead, combine or cabel network) for example while using an application distance of 600 m from a distribution transformer. The above mentioned diagram is a favourably applicable in a project practice for a qualified estimation of a suitable spark-gap selection for a defined application and first of all for I_{fi} parameter determination (self-extinguish follow current at U_c). The eventual doubts, caused by a defined application specification, depends totaly 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_{rms} then it is suitable to choose the surge arrester with an approximately twice higher parameter of I_{fi}.



Usage of surge separating inductors between particular stages of surge protection

Surge separating inductors with impedance 2÷15μH ensure 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 missing 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 than the 2nd stage (with the min. distance of 10m between them). If this 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 in 1st and 2nd stages of overvoltage protection cascades. The protection is secured by backup safety fuses. Generally, every manufacturer of overvoltage protection devices declares dimensioning of these backup fuses in the accompanying documentation.

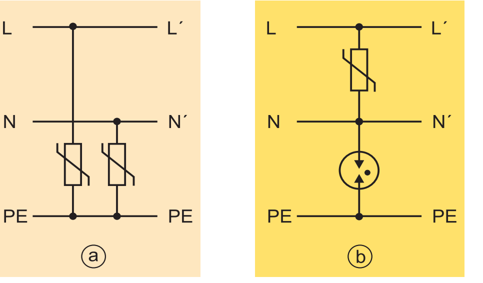
Recommendation for the installation of 3rd stage surge protection with the high frequency filter

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 protections-range PI-k* and PI-3k*. The products reduce overvoltage (thanks to their inside connection-high protection, filter, low protection) to the level U_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 15m. When there is a longer distance it is necessary to use other class III overvoltage protection devices (for example protection sockets or overvoltage protection on DIN rail) cca 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 cascades in two ways:

Common mode **Differential mode**



Connection ***a*** prefers protection against lenghtwise overvoltage. Connection ***b*** prefers protection against transverse overvoltage. Because statistical results of long-term made measurements affirm generally higher danger of transverse overvoltage (on clamps of appliances L/N) than lengthwise overvoltage (on clamps of appliances L/PE, L/PE), are all the connections and applications of SPD manufacturing range of the Hakel company oriented on preferential protection of appliances against transverse overvoltage.

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

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