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	BK	GCS	PEDCO	120	EL	CN	0006	D01

طرح نگهداشت و افزایش تولید ۲۷ مخزن

CALCULATION NOTE FOR EARTHING & LIGHTNING SYSTEM

نگهداشت و افزایش تولید میدان نفتی بینک

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- **IDC: Inter-Discipline Check**
- **IFC: Issued For Comment**
- **IFA: Issued For Approval**
- **AFD: Approved For Design**
- **AFC: Approved For Construction**
- **AFP: Approved For Purchase**
- **AFQ: Approved For Quotation**
- **IFI: Issued For Information**
- **AB-R: As-Built for CLIENT Review**
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REVISION RECORD SHEET

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1.0 INTRODUCTION

Binak oilfield in Bushehr province is a part of the southern oilfields of Iran, is located 20 km northwest of Genaveh city.

With the aim of increasing production of oil from Binak oilfield, an EPC/EPD Project has been defined by NIOC/NISOC and awarded to Petro Iran Development Company (PEDCO). Also PEDCO (as General Contractor) has assigned the EPC-packages of the Project to "Hirgan Energy - Design and Inspection" JV.

As a part of the Project, a New Gas Compressor Station (adjacent to existing Binak GCS) shall be constructed to gather of 15 MMSCFD (approx.) associated gases and compress & transfer them to Siahmakan GIS.

<u>GENERAL DEFINITION</u>

The following terms shall be used in this document.

CLIENT:	National Iranian South Oilfields CLIENT (NISOC)
PROJECT:	Binak Oilfield Development – Surface Facilities; New Gas Compressor Station
EPD/EPC CONTRACTOR (GC):	Petro Iran Development Company (PEDCO)
EPC CONTRACTOR:	Joint Venture of : Hirgan Energy – Design & Inspection (D&I) Companies
VENDOR:	The firm or person who will fabricate the equipment or material.
EXECUTOR:	Executor is the party which carries out all or part of construction and/or commissioning for the project.
THIRD PARTY INSPECTOR (TPI):	The firm appointed by EPD/EPC CONTRACTOR (GC) and approved by CLIENT (in writing) for the inspection of goods.
SHALL:	Is used where a provision is mandatory.

SHOULD: Is used where a provision is advisory only.

WILL: Is normally used in connection with the action by CLIENT rather than by an EPC/EPD CONTRACTOR, supplier or VENDOR.

MAY: Is used where a provision is completely discretionary.

2.0 SCOPE

The main purpose of this document is calculate earthing and lightning system relating to “Binak gas compressor station plant”.

3.0 NORMATIVE REFERENCES

3.1 Codes & Standards

- BS 7430:2011+A1:2015 Code of practice for protective earthing of electrical installations
- IEC 60364 Electrical installation of buildings
- IEC 60621 Electrical installation for outdoor sites under heavy conditions
- IEC 60724 Short circuit temperature limits of electric cables
- BS 6651 Protection of structures against lightning
- IPS E-EL-100(1) Engineering standard for electrical system design D01
- NFPA 780 Standard for installation of lightning protection system

3.2 The Project Documents

- BK-GCS-PEDCO-120-GT-RT-0001 Geotechnical Investigation Report for Compressor Station
- BK-GNRAL-PEDCO-000-EL-SP-0006 Specification For Earthing & Lightning System
- BK-GNRAL-PEDCO-000-EL-DC-0006 Electrical System Design Criteria
- BK-GNRAL-PEDCO-000-EL-DW-0002 Typical Installation Details & Notes For Earthing & Lightning Protection System

3.3 Environmental Data

- BK-GNRAL-PEDCO-000-PR-DB-0001 Process Basis of Design

3.4 Order of Precedence

In case of conflict between requirements specified herein & the requirements of any other referenced document, the most approved stringent requirements of below listed items shall be considered based on the approval given by the owner’s representative:

- Purchase order
- Material Requisition
- MTO & Data Sheet
- This Specification
- Drawings
- Reference Project Specification
- Iranian Petroleum Standard (IPS)
- International Code & Standards

When the term “Authorized”, Authorization”, “Approval”, or “Approved” are used in this specification, it shall mean authorization or Approval from Client.

In case of any conflict between the project documents, the most stringent one shall be considered.

4.0 DEFINITION

4.1 Earth Plate

Earth plate shall be consist of a 0.7*0.7 square meter copper plate with thickness 3mm which should be set vertically underground to depth where receive wet organics soil.

4.2 Earth Rod

Copper or galvanized steel rod embedded in ground and electrically connects to it. The length and diameter is obtained regarding to the location are used.

4.3 Protective Conductor

A conductor that connects parts of the installation to main earth conductor and the main earth conductor to the earth well.

4.4 Main earth conductor

A conductor which makes a ring loop in a room or electrical substations or process plants to which several earth conductors are connected.

4.5 Earthing System

Arrangement of connections and devices necessary to earth equipment or a system separately or jointly.

4.6 Exposed Conductive part

A conductive part of equipment which can be touched and which is not a live part but may become live under faulty condition.

4.7 Extraneous conductive part

A conductive part liable to introduce a potential, generally earth potential, and not forming part of the electrical installation.

4.8 Equipotential bonding

Electrical connection maintaining various exposed conductive parts and extraneous conductive parts at substantially the same potential.

4.9 Neutral conductor

A conductor connected to the neutral point of a system and capable of contributing to the transmission of electrical energy.

4.10 Earthing voltage

E_u Is the voltage which occurs between an earthing installation and a reference earth.

4.11 Earth Fault Current

If is the current passing to earth or earthed parts when an earth fault exists at only one point at the site of the fault (earth fault location). This is:

I) The capacitive earth fault current IC with networks with isolated neutral.

II) The earth fault residual current IRest in networks with earth fault compensation.

III) The Earth fault current I”k1 in networks with low resistance neutral earthing. Also includes networks with isolated neutral point or earth fault compensators in which the neutral point is briefly earthed at the start of the fault.

4.12 Reference Earth

Reference earth or neutral earth, is that part of the earth, particularly surface outside the area of influence of an earth electrode or an earthing system, in which there are no detectable voltages resulting from the earthing current between any two random points.

5.0 GENERAL CONCEPTION EARTHING

5.1 Main Earth conductor

Stranded copper conductors to be embedded in the soil. This earth conductor will make the main earthing system layout to carry the main earth fault current to earth wells and provide the major safety for operators. This conductor will run among the whole site and will interconnect all earthing wells and sub-systems via a loop.

For achieving more reliability the connection of main earthing conductor to the earthing of a building will be via a ring the buildings. The ring should be installed in a cable gallery.

5.2 Earth Bar

A min. 6-way copper earth bar can be installed wherever various earthing conductors should be connected to each other (e.g. Earth well to the main earthing conductor or neutral conductor).

5.3 Equipment to be earthed

- All crane runways shall be earthed on both ends.
- All MV- and LV switchgear should be earthed.
- Steel structures (welded or screwed) should be interconnected to each other (e.g. staircases with railings) and common earth. The minimum size of earth bridges is 50mm2 stranded copper conductors.
- Conveyors will be earthed at their entering points to the buildings (inside of building).
- Any mobile electrical equipment (conveyor,…) shall be connected to the earth by earthing tong before operation.
- All LV equipment like MCC panels or distribution boards with metallic covers, doors or walls shall be connected to earth.

- The fixing bolts of the apparatus and structures may not be used for the fixing of earthing wire. If there are no earthing screws, the connection of earthing wire have to be done by means of a hexagonal screw of minimum size M10 welded or screwed to a metallic body of equipment.
- To avoid spark discharges due to either electrostatic charge inside the system or lightning stroke, steel structures and equipment's piping are to be earthed.
- All motor frames and their local control box with metallic covers shall be earthed by earthing conductors separately.
- Vertical beams around structures with height up to 20m shall be earthed at maximum intervals of 20m. For higher structures, maximum interval is 10m.
- The steel structure of all cable trays and ladders installed in the plant should be earthed. The cable ladders shall form a continuous electrically conductive part. Where necessary, the cable ladders must be electrically bridged.
- All cable ladder runs should be earthed with interval connection 20 m.
- All the tanks shall be earthed and bonded earth.

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6.0 SOIL RESISTIVITY

Soil resistivity measurement has been done by Baran Geotechnics Company for several points of the site as below:

TABLE A.ELECTRICAL TEST RESISTIVITY RESULT

(DOC NO. BK-GCS-PEDCO-120-GT-RT-0001)

STATION NO.	P_A (ΩM)	
	A=1M	A=3M
BH-1	5.98	114.89
BH-2	4.56	19.74
BH-3	7.49	74.10
BH-4	3.97	77.90
BH-5	1.24	9.32
BH-6	16.96	66.04
AVERAGE	6.7	60.33

According to Table A data the average resistance in 3 meters for these 6 boreholes is 60.33 ohm.m. So in this
calculation the equal soil resistivity will be considered as 60 ohm.m

7.0 CONDUCTOR SIZING

7.1 Selection of an earthing conductor for Transformer neutral point

The minimum cross-section of earthing conductor for earthing neutral point of transformer and main earthing of around substation is calculated with below formula according to BS 7430:2015.

$$S = I\frac{\sqrt{t}}{K}(mm^2)$$

Where:

- I: is the average fault current, in A r.m.s.;
- t: is the fault current duration, in s.;
- K: is the current density in amperes per square millimeter r.m.s;(Table 4:BS 7430)

For other initial and final temperatures the current density K for a 1 s duration may be obtained from the following equation:

$$K = K'\left[\ln\left(\frac{T_2+\beta}{T_1+\beta}\right)\right]^{1/2} (A/mm^2)$$

Where:

- T2: Final temperature in °C
- T1: Initial temperature in °C (max. ambient temp.)
- K´ & ß: Coefficients as Table 7 of BS 7430

Table 2 – K′ Coefficient for different materials (according to BS 7430-Table 7)

Metal	K′ A/mm² (rms)	β
Copper	226	234.5
Aluminum	148	228
Steel	78	202

- T2 = 160 ˚C for PVC insulation cables (Table 1: IEC 60724)

So, the r.m.s current density (K) for PVC insulation cables will be:

$$K = K'\left[\ln\left(\frac{T_2+\beta}{T_1+\beta}\right)\right]^{1/2} = 226[\ln\left(\frac{160+234.5}{30+234.5}\right)]^{\frac{1}{2}} \cong 142.3(A/mm^2)$$

So the used values are as below:

Isc= 50 kA (According to ETAP study)

t = 0.5 s

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K= 142.3

$$S_{min} = 50kA \times \frac{\sqrt{0.5}}{142.3} = 248.4 \approx 300\ mm2$$

300 mm2 PVC insulated copper conductor will be applied for neutral point of transformers earthing.

7.2 Selection of an Earthing Conductor Around Substation

According to table 4 of BS 7430, the coefficient of bare conductor is 159.

Table 4 **Earth fault current densities for 1 s duration for earthing conductors with initial conductor temperature of 30 °C**

✓	✓	✓		200	E)	159	105	58
✓	✓	✓	✓	150	F)	138	91	50
✓	✓	✓	✓	100		—	—	—

A) A tick (✓)indicates that the type of joint is suitable for use at temperatures up to and including the value indicated.
B) It should be verified that a material likely to be in the same location as the conductor will not be damaged or present a fire risk at the temperature selected.
C) At temperatures in excess of 200 °C the conductor should be visible throughout its length, have ceramic or metallic supports (or an equivalent) and there should be no risk of organic materials being in contact with or adjacent to the conductor. Temperatures higher than 500 °C are not recommended.
D) The mechanical strength of conducting quality aluminium is seriously reduced at higher temperatures.
E) For normal conditions where the conductor is not visible throughout its length.
F) Certain building materials likely to be adjacent to the conductor may present a fire risk if 150 °C is exceeded.

NOTE Please refer to A1 BS 7671:2008+A3 A1 for maximum temperatures.

Therefore main earthing around of substation with bare copper cable is

$$S_{min} = 50kA \times \frac{\sqrt{0.5}}{159} = 222.36 \approx 240\ mm2$$

240 mm^2 bare copper conductor will be applied for main ring around substation.

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7.3 Selection of an earthing conductor for main earthing loop at site:

The minimum cross-section of earthing conductor for main earthing loop is calculated with below formula according to BS 7430:2015.

$$S = I\frac{\sqrt{t}}{K}(mm^2)$$

Where:

- I: is the average fault current, in A r.m.s.;
- t: is the fault current duration, in s.;
- K: is the current density in amperes per square millimeter r.m.s;(Table 4:BS 7430)

- So the used values are as below:
- Isc= 16 kA (According ETAP result)
- t= 0.5 s
- K= 159

$$S_{min} = 16kA \times \frac{\sqrt{0.5}}{159} = 71 \approx 70\ mm2$$

Therefore, 70 mm^2 **bare copper conductor** will be applied for earthing system around site.

8.0 EARTHING SYSTEM CALCULATION

8.1 Earthing System Calculation for process plants

According to site plan there are two area which are:

Process Area: 210x65 meter

Utility Area: 75x67 meter

Refer to section 9.5.5 of BS 7430, the approximate resistance to earth of a round conductor can be calculated from the following:

$$Rt = \frac{\rho}{2\pi L} Ln\left(\frac{L^2}{khd}\right)$$

Where:

- ρ: is the resistivity of the soil in in Ω.m
- L: is the length of the strip or conductor, in metres (m
- h: is the depth of the buried, in metres (m)
- d: is the width of the strip or the diameter of the round conductor, in metres (m);

- k: has the value 1.36 for strip or 1.83 for round conductor.
- Rt is the resistance of a single strip of length L, calculated from the preceding Rt equation, in ohms (Ω).

When two or more straight lengths, each of length L in metres (m) and a separation distance s metres (m) are laid parallel to each other and connected together at one end only the combined resistance may be calculated from the following equation:

$$R_n = \mathrm{F}R_t$$

Where:

- R_n is the resistance of n conductors in parallel, in ohms (Ω)

F has the following value:

$$\mathrm{F} = 0.5 + 0.078 \times (\frac{S}{L})^{-0.307}$$

The Resistance for Process & Utility Area

Item	Process Area	Utility Area
ρ	60 Ω.m	60 Ω.m
L	210 m	75 m
W	65	67
h	0.6 m	0.6 m
d	$\sqrt{\frac{70 \times 4}{\pi}} = 9.44\ mm$	$\sqrt{\frac{70 \times 4}{\pi}} = 9.44\ mm$
K	1.83	1.83
Rt	$\frac{60}{2 * 3.14 * 210} Ln\left(\frac{210^2}{1.83 * 0.6 * 0.00944}\right) = 0.69\ \Omega$	$\frac{60}{2 * 3.14 * 75} Ln\left(\frac{75^2}{1.83 * 0.6 * 0.00944}\right) = 1.68\ \Omega$
F	$0.5 + 0.078 \times (\frac{65}{210})^{-0.307} = 0.61$	$0.5 + 0.078 \times (\frac{67}{75})^{-0.307} = 0.58$
Rt = FRn	$0.69 \times 0.61 = 0.42$	$1.68 \times 0.58 = 0.97$

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8.2 Clean Earth

In this project, clean earth is also required for instrument system, the earthing resistance shall be below 0.5 Ω. Regarding to achieve this resistance using rod electrode with 1 meter length and 19 mm2 diameter based on BS 7430 section 9.5.8.5 around control room is done as below:

The average of soil resistance in depth of one meter is almost 6.7, so it should be considered for calculating clean earth system as well.

$R_{rod} = \frac{\rho}{2\pi L} \times \left[Ln\left(\frac{8.L}{d}\right) - 1\right]$

Where:

L: is the length of electrode in (m)

d: is the diameter of the electrode in (m)

ρ: The resistivity of the soil (Ω.m)

$R_{rod} = \frac{6{\cdot}7}{2x\pi x1} \times \left[Ln\left(\frac{8x1}{0{\cdot}019}\right) - 1\right] = 5{\cdot}37\ \Omega$

The combine resistance of 'N' rod electrodes in parallel can be obtained from the following equation (BS 7430-2011-table2):

Table 2 Factors for vertical electrodes arranged in a hollow square

Number of electrodes (*n*) along the side of the square	Factor λ	Number of electrodes (*n*) along the side of the square	Factor λ
2	2.71	9	7.65
3	4.51	10	7.90
4	5.46	12	8.22
5	6.14	14	8.67
6	6.63	16	8.95
7	7.03	18	9.22
8	7.30	20	9.40

NOTE The number of electrodes around the square is 4(n – 1).

$R_n = R\left[\frac{1+\lambda a}{N}\right]$

In Which

$a = \frac{\rho}{2\pi Rs} = \frac{6.7}{2\times\pi\times5.37\times10} = 0.02$

Rn: is the resistance of 'n' rods in Hollow Square in 'Ω'

R: is the resistance of one rod in 'Ω'

s : is the spacing of rods, in meters (m);=10

λ: is a factor given in above table

N: is the number of rods used as electrodes

Therefore:

$R_2 = 5{\cdot}37 \times \left(\frac{1+2.71\times0..02}{4\times(2-1)}\right) = 1.41\ \Omega$

$R_3 = 5{\cdot}37 \times \left(\frac{1+4.51\times0..02}{4\times(3-1)}\right) = 0.73\ \Omega$

$R_4 = 5{\cdot}37 \times \left(\frac{1+5.46\times0..02}{4\times(4-1)}\right) = 0.496\ \Omega$

According to above calculation the number of electrodes are 4x(4-1)=12

So all instrument facilities should be connected to clean earth system

8.3 Equipment Earthing Conductor Sizing

According to IPS-D-EL-417, all steel structures in site shall be earthed with Green-Yellow PVC insulated stranded copper wire. Earthing conductor which is applied to the exposed conductive part shall be selected from following table:

Number of Metallic Earthing Connection

Equipment	Remark	No. of Grounding Points	Grounding Conductor Size (sq.mm.)
Tank or Storage	≤ 10 m in diameter	2	35
	>10 m in diameter	One connection at maximum 30 m interval along the perimeter of the tank	35
Tower	<20 m in height	1	35
	≥20 m in height	2	35
Drum		1	35
Heat Exchanger		1	16
Steel Structure		2	70 or 35
Pipe Rack		Every 30 m (Min. 2)	70
Pipe		In Accordance with Layout	16
Ladder & Stairways		In Accordance with Layout	35

Number of Electrical Earthing Connection

Electrical Equipment	Remark	No. of Grounding Points	Grounding Conductor Size (sq.mm.)
Transformer	Body	1	70 (min.)
Medium Voltage & High Voltage Switchgear	Switchgear	2	120 (min.)
	Lightning Arrestor	1	70
Low Voltage Switchgear, MCC or Panels	-	In Accordance with Layout	185 (min.)
Local Control Station	-	1	16
Local lighting/Small Power Distribution Boards	-	1	35
Motor	Up to 22kW	1	16
	23kW to 55kW	1	35
	More than 56kW	1	70
Welding Outlet	-	1	35
Main Loop	-	In Accordance with Layout	70
Substation Loop	-	In Accordance with Layout	300

9.0 LIGHTNING PROTECTION SYSTEM

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9.1 Calculation number of rods for lightning system

Rod electrode are used for lightning system, the min. resistance should be 5 ohm. Regarding to achieve this resistance using rod electrode with 3 meter length and 19 mm2 diameter based on BS 7430 section 9.5.8.5 around buildings is done as below:

The average of soil resistance in depth of three meter is almost 60, so it should be considered for calculating clean earth system as well.

$$R_{rod} = \frac{\rho}{2\pi L} \times \left[Ln\left(\frac{8L}{d}\right) - 1\right]$$

Where:

L: is the length of electrode in (m)

d: is the diameter of the electrode in (m)

ρ: The resistivity of the soil (Ω.m)

$$R_{rod} = \frac{60}{2x\pi x3} \times \left[Ln\left(\frac{8x3}{0.019}\right) - 1\right] = 19.5\ \Omega$$

The combine resistance of 'N' rod electrodes in parallel can be obtained from the following equation (BS 7430-2015-table2):

Table 2 Factors for vertical electrodes arranged in a hollow square

Number of electrodes (n) along the side of the square	Factor λ	Number of electrodes (n) along the side of the square	Factor λ
2	2.71	9	7.65
3	4.51	10	7.90
4	5.46	12	8.22
5	6.14	14	8.67
6	6.63	16	8.95
7	7.03	18	9.22
8	7.30	20	9.40

NOTE The number of electrodes around the square is 4(n – 1).

$$R_n = R\left[\frac{1+\lambda a}{N}\right]$$

In Which

$$a = \frac{\rho}{2\pi Rs}$$

Rn: is the resistance of 'n' rods in Hollow Square in 'Ω'

R: is the resistance of one rod in 'Ω'

s : is the spacing of rods, in meters (m);=7

λ: is a factor given in above table

N: is the number of rods used as electrodes (N=4*(n-1)) n=4 and N=12

$a=\frac{60}{2x\pi x19.5x7}=0\cdot07$

Therefore:

$R_2=19\cdot5\left[\frac{1+(2.71x0\cdot07)}{4(2-1)}\right]=5.8\ \Omega$

$R_3=19\cdot5\left[\frac{1+(4\cdot51x0\cdot07)}{4(3-1)}\right]=3.2\ \Omega$

9.2 Calculation Method (Simplified Risk Assessment)

Regarding to BS 661 standard, at first we have to calculate the risk assessment of lightning which may be occur. If the risk is high according to NFPA780 standard, lightning protection system shall be considered.

9.2.1 Average Lightning Flash Density

According to below map, approximately 15 thunderstorm days per year is expected for site location.

Average lightning flash density (Ng) will be estimated from following equation according to BS EN 62305-2-2012

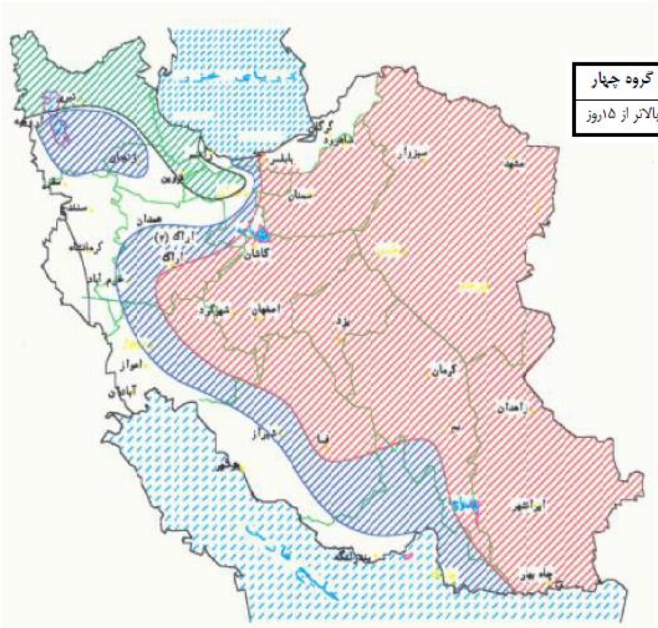
$$N_g = 0.1(T_d)$$

Where:

T_d : Thunderstorm days per year

So:

$$N_g = 0.1 \times (15) = 1.5$$



گروه چهار	گروه سه	گروه دو	گروه یک	عنوان گروه
بالاتر از ۱۵روز	۱۰ تا ۱۵ روز	۵ تا ۱۰ روز	کمتراز ۵ روز	میانگین تعداد روزهای رعدوبرقی در سال

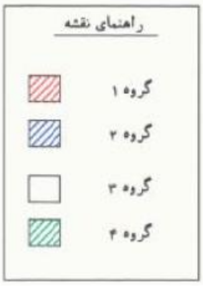


Figure A: Lightning isochrones map of Iran

9.2.2 Annual Threat of Occurrence

The yearly annual threat of occurrence (lightning strike frequency) (N_d) to a structure is determined by the following equation:

$$N_d = N_g \times A_e \times C_1 \times 10^{-6}$$

Where:

N_d = yearly lightning strike frequency to the structure or object

N_g = lightning ground flash density in flashes/km2/year

A_e = the equivalent collection area of the structure (m2)

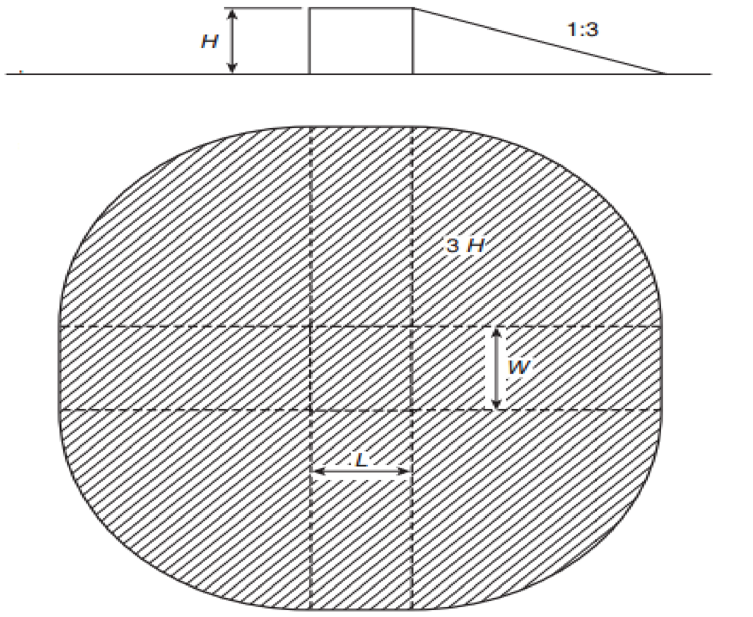
C_1 = environmental coefficient

9.2.3 Equivalent Collection Area

It is an area adjusted for the structure that includes the effect of the height and location of the structure.

The equivalent collection area of a rectangular structure with length L, width W, and height H is as follows:

$$A_e = (L \times W) + 6 \times H \times (L + W) + \pi \times 9 \times H^2$$



Where:

A_e= equivalent collection area of the building in m2

L= length of the building in meter

W=Width of the building in meter

H=Height of the building in meter.

9.2.4 Environmental Coefficient (C1)

The location factor accounts for the topography of the site of the structure and any objects located within the distance 3H from the structure that can affect the collection area.

Location factors are given in below Table:

Relative Structure Location	C_1
Structure surrounded by taller structures or trees within a distance of 3*H*	0.25
Structure surrounded by structures of equal or lesser height within a distance of 3*H*	0.5
Isolated structure, with no other structures located within a distance of 3*H*	1
Isolated structure on hilltop	2

NFPA 780 - Table L.4.2- Location Factor, C_1

9.2.5 Simplified Risk Assessment

Simplified risk assessment calculates the tolerable lightning frequency (Nc) and compares it to the annual threat of occurrence (Nd). The tolerable lightning frequency (Nc) is a measure of the risk of damage to the structure, including factors affecting risks to the structure, to the contents, and of environmental loss. It is calculated by dividing the acceptable frequency of property losses by various coefficients relating to the structure, the contents, and the consequence of damage. The tolerable lightning frequency is expressed by the following formula:

$$N_c = \frac{1.5 \times 10^{-3}}{C}$$

Where:

$$C = C_2 \times C_3 \times C_4 \times C_5$$

9.2.6 Construction Coefficient (C2)

Structure	Construction Coefficient—C_2 Metal Roof	Nonmetallic Roof	Combustible Roof
Metal	0.5	1.0	2.0
Nonmetallic	1.0	1.0	2.5
Combustible	2.0	2.5	3.0

NFPA 780 - Table L.5.1.2 (a) - Determination of Construction Coefficient, C_2

9.2.7 Structure Contents Coefficient (C3)

Structure Contents	C_3
Low value and noncombustible	0.5
Standard value and noncombustible	1.0
High value, moderate combustibility	2.0
Exceptional value, flammable liquids, computer or electronics	3.0
Exceptional value, irreplaceable cultural items	4.0

NFPA 780 - Table L.5.1.2 (b) - Determination of Structure Contents Coefficient, C_3

9.2.8 Structure Occupancy Coefficient (C4)

Structure Occupancy	C_4
Unoccupied	0.5
Normally occupied	1.0
Difficult to evacuate or risk of panic	3.0

NFPA 780 - Table L.5.1.2(c) - Determination of Structure occupancy Coefficient, C_4

9.2.9 Lightning Consequence Coefficient (C5)

Lightning Consequence	C_5
Continuity of facility services not required, no environmental impact	1.0
Continuity of facility services required, no environmental impact	5.0
Consequences to the environment	10.0

NFPA 780 - Table L.5.1.2 (d) - Determination of Lightning Consequence Coefficient, C_5

9.2.10 Conclusion

f:

$N_c < N_d$	Lightning protection is required
$N_c => N_d$	Lightning protection is not required.

9.3 Lightning Protection Risk Calculation

No.	Structure Name	Structure Dimension			A_e	C_1	N_d (Ng=1.5)	C_2	C_3	C_4	C_5	C	N_c	LPS Requied
		L(m)	W(m)	H(m)										
Receiving Area														
1	Control Building	25	23	6.5	3641	1	$5.46x10^{-3}$	1	3	1	5	15	$0.1x10^{-3}$	Yes
2	Gas Compressor Shelter	72	12	6	4905	0.5	$3.6x10^{-3}$	0.5	3	1	5	7.5	$02x10^{-3}$	Yes
3	Fire Fighting Shelter	18	10	6	2205	0.25	$0.8x10^{-3}$	0.5	0.5	0.5	5	0.625	$2.4x10^{-3}$	Not
4	Chemical Shelter	10	5	6	1812	0.5	$1.2x10^{-3}$	0.5	3	0.5	10	7.5	$0.2x10^{-3}$	Yes
5	Utility Shelter	18	14	6	2421	0.25	$0.9x10^{-3}$	0.5	2	0.5	5	2.5	$.6x10^{-3}$	Yes

The installation of lightning system for required structures will be done according BS 6651.