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Hazardous Area Classification in Simultaneous Production and Drilling at Oil and Gas Platform

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Abstract: *Hazardous area, three-dimensional space, in which a flammable/explosive atmosphere is or may be expected to be present in quantity, requiring ignition source controls to manage safety risks, such as fires and explosions. Fire and explosion can result in catastrophic consequences for people and property, causing loss of life or severe injury and possible loss of business. Hazardous Area Classification is a method of analyzing and classifying the environment where explosive gas atmospheres may occur. The primary purpose of this classification is to facilitate the proper selection and installation of the apparatus to be used safely in that environment, considering the properties of the flammable materials that will be present. The method used is the point source approach, where equipment with variabilities of temperature, pressure, equipment, and the degree and type of ventilation that would take place on release may vary significantly, making individual assessment necessary. This study discusses the extent of the hazardous area due to an explosive atmosphere in Simultaneous Production and Drilling mode. It classifies the identified hazardous area based on frequency and likelihood of flammable release or ignitable cloud expected to be present. Using this information, ignition of flammable release or explosive gas cloud suspension in the air, which inevitably occurs in a Simultaneous Production and Drilling area handling flammable components, can be avoided.*

Keywords: Hazardous Area Classification; Area Classification; Zone Classification; Hazard Radii; Simultaneous Production and D

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1. Introduction

Simultaneous Production and Drilling units are very compact and complex structures with significant inherent safety risks, including potentially explosive atmospheres. Identifying and managing hazardous areas is essential to the safety of these vessels [5,7]. Drilling rigs on the Simultaneous Production and Drilling platform are movable structures and rarely stay at the exact location for long periods [3,10,13]. Consequently, the classification had to consider variable environmental conditions (such as temperature and solar radiation) and differing regulations in the anticipated geographical locations where the drilling rig may operate [1,8]. In oilfields or industrial worksites, various areas may exist where an explosive mixture of air and gas (or other materials) is possible [9,14]. Standards organizations in the world's industrial nations have defined various classifications to be applied to equipment to characterize the equipment's suitability for use in hazardous conditions [16,23]. Hazardous area design criteria consider the probability of an explosive mixture being present, the type of combustible material, and the spark energy or temperature required to ignite the combustible material likely to be present [20,25].

Area classification is the assessed division of a facility into hazardous and non-hazardous areas and the subdivision of hazardous areas into zones [12]. A hazardous area is defined as a three-dimensional space in which a flammable atmosphere may be expected to be present at such frequencies as to require special precautions for the design and construction of equipment and the control of other potential ignition sources [11]. All other areas are non-hazardous in this context, though they may, in part or whole, form part of a wider restricted area within the facility in which all work is carried out under unique controls classification should constantly be reviewed, and drawings modified if necessary, on completion of the design and before any change is made to existing plants handling flammable fluids [17]. In classifying a new facility or modifying an existing facility, the area classification should be carried out before the design and layout of equipment are finalized. It may be possible to make considerable improvements at this stage at a small cost [24]. Therefore, hazardous area classification can help optimize facilities and equipment design by identifying areas that require special protection measures. This can help to reduce costs associated with over-design or unnecessary safety measures.

For specific operating modes, such as Simultaneous Production and Drilling, the area classification will be addressed from case to case [6]. The decision to classify a location is based on the probability that flammable gases or vapors may be present. Possible release sources include vents, flanges, control valves, drains, pump and compressor seals, fittings, and floating roof seals. Having decided that a location should be classified and having designated the gas or vapor as Group IIA, IIB, or IIC, the next step is to designate the location as either Zone O, Zone 1, or Zone 2. This latter step must consider the probability of whether a flammable gas or vapor release is likely to occur in sufficient quantities to be ignitible during normal operations or only as a result of an unusual occurrence or abnormal condition [2]. The likelihood of the presence of an explosive gas atmosphere, and hence the zone designation, depends mainly on the grade of release and the ventilation. Proper layout, separation distances, facility sitings, and proper design, maintenance, and operation of the plant will carry out the risk mitigation for such significant releases. Consequently, the hazardous area classification relied upon a meticulous, systematic understanding of the interrelationship between processes and potential hazards [18].

Hazardous area classification helps identify and evaluate the risks associated with flammable or explosive materials. Appropriate safety measures can be implemented to prevent accidents and protect personnel and equipment by identifying the hazards. Hazardous area classification also helps to ensure that emergency response plans are appropriate for the risks present in the area. This can help minimize the impact of accidents and improve the effectiveness of response efforts. Overall, hazardous area classification is a critical process in ensuring the safety of personnel and equipment in areas where flammable or explosive materials are present. By correctly identifying and evaluating the risks, appropriate safety measures can be implemented to minimize the risk of accidents and protect personnel and equipment [4]. Thus, it provides a common language for communication between designers, engineers, and safety professionals by ensuring that all parties clearly understand the hazards and appropriate safety measures. The primary purpose of this classification is to facilitate the proper selection and installation of the apparatus to be used safely in that environment, considering the properties of the flammable materials that will be present.

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2. Method approach to Facility Hazardous Zone Analysis

All areas of the installation shall be either classified as hazardous or non-hazardous. A hazardous area is defined as a three-dimensional space in which a flammable atmosphere may be expected to be present at such frequencies as to require special precautions for controlling potential ignition sources, including fixed electrical equipment [15]. Classification of areas handling or storing hazardous material shall be a prerequisite for selecting equipment for use in those areas [19].

The overall methodology involves the following steps:
(i) Identify sources of release
(ii) Determine the grade of release, fluid category, and temperature class
(iii) Establish zone classification
(iv) Determine the hazard radius of the source of release
(vi) Determine the overall hazardous area of the facility

Identify the Source of the Release
The starting point for any area classification is determining all potential release sources. A source of release is defined as a point from which a flammable gas, vapor, or liquid may be released into the atmosphere [21]. Point sources can leak (e.g., flanges, valves, seals, instrument connections) or a system or equipment that may release hydrocarbons into the atmosphere.

Determine the Grade of Release, Fluid Category, and Temperature Class
In principle, the classification procedure entails the consideration of all actual and potential sources of flammable release. All continuous and primary grade release sources should be identified and assessed to determine the extent of the resulting Zone 0 and Zone 1 hazardous areas; wherever possible, by design, they should be reduced in number and extent. The extent of vapor travel, and hence the hazard radii for each point source to be assessed, will be a function of the fluid characteristics and vapor-forming conditions during release, including mass or mass rate and the rate of vaporization [22].

a) Grade of Release
The release grade depends solely on the release's frequency and duration. It is entirely independent of the rate and quantity of the release, the degree of ventilation, or the characteristics of the fluid, although these factors determine the extent of vapor travel and, in consequence, the dimensional limits of the hazardous area. Three release grades are defined in terms of their likely frequency and duration. The grade of release and fluid category are tabulated in Table 1 and Table 2. The allocation of the grade of release should be reviewed during the design stages to determine if practicable and economical design or engineering improvements can be made to reduce the number of continuous and primary grade releases.

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Table 1: Grade of Release at Simultaneous Production and Drilling

Grade of Release	Description
Continous	Sources of release that are continuous or are expected to occur for extended periods (1000 or more hours/year)
Primary	A source that can be expected to occur periodically or occasionally during Simultaneous Production and Drilling (10 < hours/year < 1000)
Secondary	A source of release that is not expected to occur in Simultaneous Production and Drilling operation and, if it does occur, is likely to do so only for short periods (less than 10 hours/year)

b) Fluid Category

When the flammable fluid is a liquid, its volatility is crucial since it will determine the extent of vapor formation from any release. In typical processing units, variations in temperature, pressure, and fluid composition affect the volatility of material released.

Table 2: Fluid Category at Simultaneous Production and Drilling

Fluid Category	Description
Category A	A flammable liquid that, on release, would vaporize rapidly and substantially. This category includes: • Any liquefied petroleum gas (Class 0) or lighter flammable liquid. • Any flammable liquid at a temperature sufficient to produce, on release, more than about 40% volume vaporization with no heat input other than from the surroundings.
Category B	A flammable liquid, not in category A, but at a temperature sufficient for boiling to occur on release.
Category C	A flammable liquid, not in Category A or B, but which can, on release, be at a temperature above its flash point or form a flammable mist.
Category G(i)	A typical methane-rich natural gas
Category G(ii)	Refinery hydrogen

c) Temperature class

To select equipment appropriate to the zone classification, the apparatus sub-group and Temperature class should be determined during the area classification based on the flammable substances that can be released, and this information should be added to the drawing and records. This is related to an apparatus's maximum temperature to the gas's ignition temperature. Ignition temperature is the minimum temperature at which a material will spontaneously ignite without an external ignition source, for example, a spark or flame, being present [26]. Apparatus having a lower maximum surface temperature, i.e., higher temperature class, may be used instead of a higher maximum surface temperature (lower temperature class), but not conversely. The relationship between temperature and maximum surface temperature of the apparatus is from Table 3 in Energy Institute Model Code of Safe Practice Part 1 is as follows;

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Table 3: Temperature of Apparatus (Source: Energy Institute Model ContinuousCode of Safe Practice Part 1)

'T' class	Maximum Surface Temperature (°C)	Typical substances in 'T' class
T1	450	Methane Hydrogen Chloromethane
T2	300	Ethylene Butane Acetylene Ethanol
T3	200	Naphtha Kerosene
T4	135	Diethyl ether Benzaldehyde
T5	100	-
T6	85	Carbon disulphide

The most restrictive apparatus sub-group and Temperature class should be specified when a release is a mixture of substances. If gases belonging to more than one electrical apparatus sub-group and Temperature class are present in non-overlapping areas, then showing different groups and classes is acceptable.

Establish Zone Classification

The Zone classification is determined based on the release grade, the flammable atmosphere duration, and the ventilation degree. For unrestricted open air, hazardous areas are subdivided into three zones based on the likelihood of occurrence and duration of a flammable atmosphere [30], as follows:

Table 4: Zone Classification in Simultaneous Production and Drilling Mode

Fluid Category	Description
Zone 0	That part of a hazardous area in which a flammable atmosphere is continuously present or present for long periods (usually continuous grade release).
Zone 1	That part of a hazardous area with a flammable atmosphere will likely occur in regular operation (usually primary grade release).
Zone 2	That part of a hazardous area in which a flammable atmosphere is not likely to occur in regular operation, and if it does, will exist only for a short period (usually secondary grade release).
Non-Hazardous	Areas that do not fall into any of the above

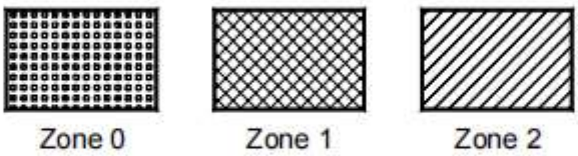

Figure 1: Hazardous Area Classification shading convention (Source: International Electrotechnical Commission 60079-10)

Determine Hazard Radius

The hazard radius of a source is defined as the most considerable horizontal extent of the hazardous area generated by the source when situated in an open area [32]. The hazard radius defines the three-dimensional form and extent of the hazardous area envelope around identified point sources. It is a function of the characteristics of the potentially released flammable fluid and the size of the release.

Table 5: Hazard radius appropriate to the release hole size

Fluid category	Release pressure see note 4 (bar(a))	Hazard radius R_1 (m)				Hazard radius R_2 (m)			
		Release hole diameter				Release hole diameter			
		1 mm	2 mm	5 mm	10 mm	1 mm	2 mm	5 mm	10 mm
A	5	2	4	8	14	2	4	16	40
	10	2,5	4	9	16	2,5	4,5	20	50
	50	2,5	5	11	20	3	5,5	20	50
	100	2,5	5	11	22	3	6	20	50
B	5	2	4	8	14	2	4	14	40
	10	2	4	9	16	2,5	4	16	40
	50	2	4	10	19	2,5	5	17	40
	100	2	4	10	20	3	5	17	40
C	5	2	4	8	14	2,5	4	20	50
	10	2,5	4,5	9	17	2,5	4,5	21	50
	50	2,5	5	11	21	3	5,5	21	50
	100	2,5	5	12	22	3	6	21	50
G(i)	5	< 1	< 1	<1	1,5	< 1	< 1	1	2
	10	< 1	< 1	1	2	< 1	< 1	1,5	3
	50	< 1	1	2,5	5	< 1	1,5	3,5	7
	100	< 1	1,5	4	7	1	2	5	11
G(ii)	5	< 1	<1	1,5	3	< 1	< 1	2	4
	10	< 1	1	2	4	< 1	1	2,5	5
	50	< 1	2	4	8	1	2	6	11
	100	1	2	6	11	2	3	8	14
LNG	1,5	2,5	3	6	10	2	3	7	30
	5	3	5	10	17	2	4	11	40
	10	3	5,5	10	20	2,5	4,5	13	37,5

The relationship between the hazard radius R1 (as determined above) and the full three-dimensional envelope of the hazardous area is determined using Figure 5 shape factor for pressurized release shown below source from standard Energy Institute Part 15. Table 3 of Energy Institute Part 15 estimates the ground effect hazard radius. R2 is Hazard Radius at ground level based on Figures 2 (a) to (c) of Energy Institute Part 15. R2 is applicable primarily if there is plating or ground underneath a potential source of release.

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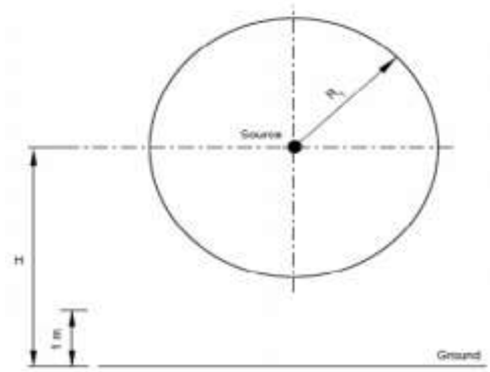

Figure 2 (a): Releases where H>R1+1m

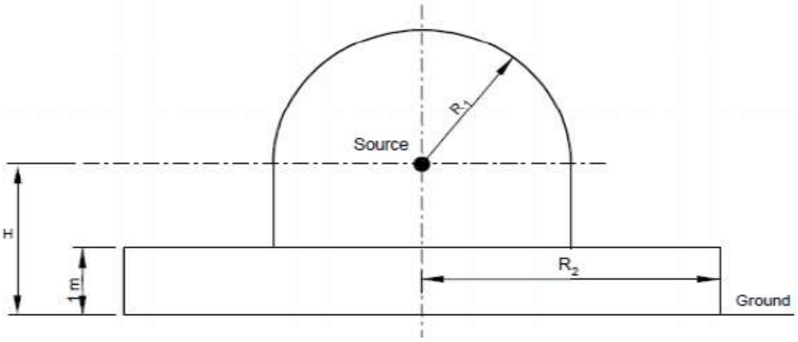

Figure 2 (b): Releases where 1m<H>R1+1m

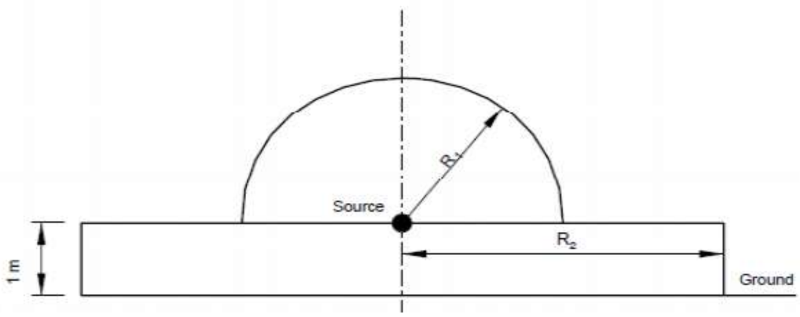

Figure 2 (c): Releases where H < 1m

Generally, hazard radii for rotating equipment depends on the fluid category being handled, operating pressure, and shaft diameter. If the rotating equipment is provided with double (or more) mechanical seals (high integrity equipment with proper seal plan), the seal shall contain any hydrocarbon within the seal system in the event of seal damage [31]. For conservative measures, an equivalent hole size of 2 mm is used for the hazard radius. The hazard radius is also from the flanges and valves around the equipment. Figure 4 shows a typical radius for illustration purposes of hazard radii from rotating equipment in a non-enclosed, adequately ventilated area (open area).

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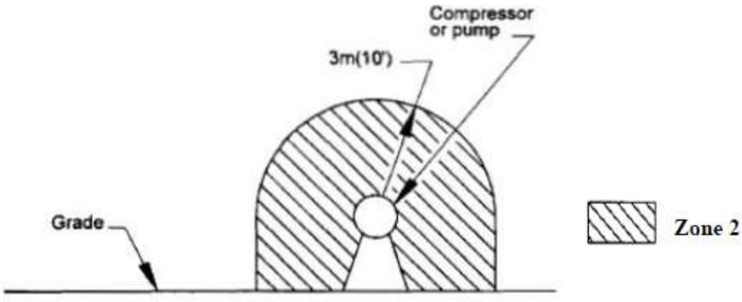

Figure 3: Hazard Radii for Rotating Equipment

Process vents may release hydrocarbons undiluted with air, gas, or vapor mixtures with air of any composition. The pressure driving the release will often be much greater than atmospheric. The hazard radii for process vents have been calculated for a matrix of venting rates and vent diameters for a lighter and heavier-than-air release in conjunction with Figure 4 of Energy Institute Part 15. Venting into the atmosphere safely shall be away from the fresh air intake for pressurization, ventilation, and engine combustion air for the platform. A safe location is in an open-air situation where vapors will be readily dispersed, and vapors will not likely come into contact with operating personnel [28]. Vent potentially discharging toxic vapors should be routed at least to the platform's edge and away from areas where vapors may accumulate to maximize dispersion. Vents potentially discharging flammable vapors shall be subject to hazardous area implications dependent upon the vapor's composition and the release frequency. The final locations of these vent outlets must also consider ease of access for maintenance. Flame arrestors shall be fitted on all vents discharging flammable vapors. No electrical equipment shall be located in the direct path of vent outlets.

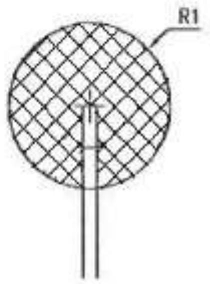

Figure 4: Process Vent Hazard Radii

The following shows the area classification for wellheads during drilling, wire lining, and workover. During Simultaneous Production and Drilling operations, when the wireline operation is carried out with the main drilling rig, the hazard radii are Zone 1. When the drilling rig is absent, the hazardous area is defined as Zone 2. The following schematics in Figure 6 show a typical radius for illustration purposes [33].

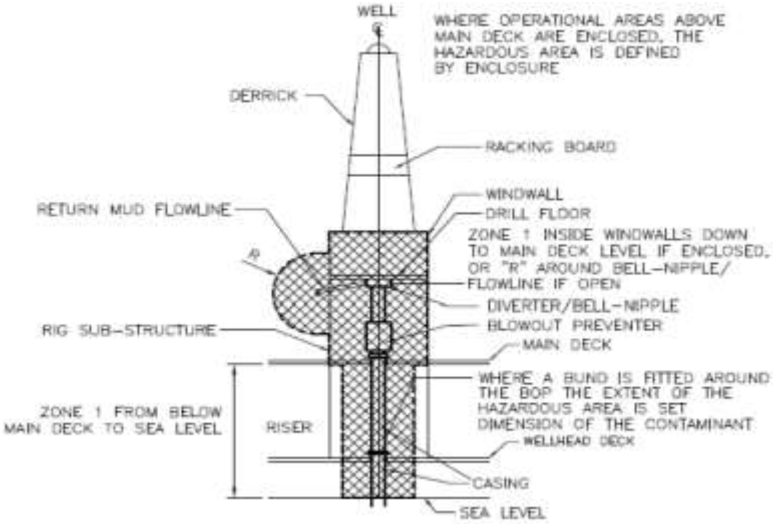

Figure 5: Well-bay area Hazard Radii

Determine Overall Hazardous Area

A specific dispersion modeling of actual process fluids and venting conditions is used to determine the vertical and horizontal extent of the hazardous area. Some vents may have a continuous or primary grade release during regular operation, with a more significant secondary grade release during abnormal or emergency operations [27]. The hazardous area for such a vent is defined by a Zone 0 or 1 hazardous area corresponding to the continuous or primary grade release, surrounded by a larger Zone 2 hazardous area corresponding to the secondary grade release. As a conservative approach, areas of the top deck falling under the rig cantilever envelope are considered Zone 1. However, zone 1 shall only apply around the well being drilled. Hazardous area classification around the wellhead being drilled changes over the different phases of Simultaneous Production and Drilling [29].

3. Results and Discussion

Area classification should be incorporated into a company's Safety, Health, and Environmental (SHE) Management System. The person responsible for coordinating the area classification should be identified and competent in this field. The work, which requires an interdisciplinary approach, should be carried out by persons with full knowledge of the process systems and equipment in consultation with process safety, loss prevention, and electrical engineering personnel, as appropriate. Agreements on the area classification should be formally recorded, regularly reviewed, and updated. Records, such as area classification schedules, should include details on the type of protection selected to meet the zone requirements.

In classifying a new facility or modifying an existing facility, the area classification should be carried out before the design and layout of equipment are finalized. At this stage, making considerable improvements at little cost may be possible. The area classification should constantly be reviewed, and drawings modified, if necessary, on completion of the design and before any change is made to existing plants handling flammable fluids.

Following the standard of Energy Institute-15, 4th Edition, a Hazardous Area Classification Schedule shall be prepared for all the stages of Simultaneous Production and Drilling and the newly added wellheads. The extent of the hazardous areas during Simultaneous Production and Drilling shall be indicated on the dedicated plan and elevation drawings. The hazardous area

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classification drawings are of sufficient scale to show all the main equipment items and all the buildings in both plan and elevation. The boundaries of all hazardous areas and zones present shall be marked using the straightforward shading convention for Zone 0, Zone 1, and Zone 2. The tables for the hazardous area schedule have been used to display the extent of the hazardous area classification in the Hazardous Area Classification Drawings during Simultaneous Production and Drilling, as shown in Table 6. The radius shown in the table depends on the release source's release pressure.

Table 6: Typical Hazardous Area Classification Schedule for Simultaneous Production and Drilling Operation

Equipment	Material Handled	Fluid Category	Tempe-rature Class	Source	Grade	Hole Size (mm)	R1 (m)	R2 (m)	Zone
Diesel Transfer Pump	Hydrocarbon Liquid	C	T3	Flanges, Valves & Pump seal	Secondary	2	4	4	Zone 2
Test Manifold	Hydrocarbon Well Fluid	C & G(i)	T3	Flanges, Valves	Secondary	1	2.5	3	Zone 2
HP Oil Production Manifold	Hydrocarbon Well Fluid	C & G(i)	T3	Flanges, Valves	Secondary	1	2.5	3	Zone 2
LP Oil Production Manifold	Hydrocarbon Well Fluid	C & G(i)	T3	Flanges, Valves	Secondary	1	2.5	3	Zone 2
Gaslift Header	Hydrocarbon Gas	G(i)	T3	Flanges, Valves	Secondary	1	<1	1	Zone 2
LP Oil Well	Hydrocarbon Well Fluid	C & G(i)	T3	Flanges, Valves	Primary	2	3	-	Zone 1
Wellhead (Note 1)	Hydrocarbon Well Fluid	C & G(i)	T3	Flanges, Valves	Primary	1	2.6 - 3	-	Zone 1
HP Oil Well	Hydrocarbon Well Fluid	C & G(i)	T3	Flanges, Valves	Primary	2	3	-	Zone 1
Closed Drain Vessel	Hydrocarbon Gas and Liquid	C & G(i)	T3	Flanges, Valves	Secondary	1	<1	1	Zone 2
Closed Drain Pump	Hydrocarbon Liquid	C	T3	Flanges, Valves & Pump seal	Secondary	2	4.5	4.5	Zone 2
Wellhead Equalisation Pump	Hydrocarbon Liquid	C	T3	Flanges, Valves & Pump seal	Secondary	2	5	6	Zone 2

Note 1: Refer to Figure 5. For good workover and drilling operations, hazard radius during Simultaneous Production and Drilling mode, Zone 1 of 2.6 m and 3 m is applied around the wellhead being drilled or worked over (with rig) with an area extending vertically and horizontally.

Table 7 has been used to display the extent of the hazardous area classification for Simultaneous Production and Drilling operations.

Table 7: Hazardous zoning area for Simultaneous Production and Drilling operation

HAC Requirement	Zoning
Zones	All Zone 2 except for the wellhead area: Zone 1
Point Source	Piping System - flanges, valves, instrument fittings; Pump – seals, flanges, valves; Wellhead – wellhead Simultaneous Production and Drilling, flanges, valves, instrument fittings
Hazard Radii	Varies concerning the type of equipment, category of fluids operating pressure and hole size.

4. Conclusion

While area classifications at refineries, production and drilling facilities, and pipeline facilities need to agree to some extent, there are differences in production, drilling, transportation, and refining facilities. Some differences include the process conditions, types and quantities of products handled, the physical size of typical facilities, and varying housing and sheltering practices.

In conclusion, the purpose of area classification is to avoid ignition of those releases that may occasionally occur in the regular Simultaneous Production and Drilling operation of facilities handling flammable fluids. The approach reduces the probability of the coincidence of a flammable atmosphere and an electrical or other ignition source. Area classification does not aim to prevent the ignition of major accidental releases of flammable materials that could extend to large distances from the release source. These more significant accidental releases, which may result from central or catastrophic failure of process or storage equipment, should be handled by risk assessment and other procedures or processes, including the requirements of relevant legislation. Effective use of hazardous area classification information plays a key role in process electrical safety, and a team approach lies at the heart of managing, applying, and updating hazardous area classification information. Information in the hands of a few limits the ability of the team to play a proactive role in the management of process safety. Clear communication should be a goal and a key step in engaging the team in using hazardous area classification information efficiently and effectively.

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