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Revision Memo

12/01 Complete rewrite to condense and simplify the information. Minor editorial revisions to Fireproofing section. Appendices deleted.

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SCOPE

- ▶ This section describes the fundamental assumptions and basic design criteria for establishing and specifying blast resistance requirements for new buildings that are being considered as part of new processing facilities or for existing buildings in the vicinity of new processing facilities. The requirements specified in this subsection are the **maximum** requirements for such buildings, and are generally applicable to buildings being specified as part of grassroots processing facilities. These requirements may be relaxed, especially in the case of new buildings being constructed in the vicinity of existing facilities, by conducting a site specific study, as described in the *Blast Technology Manual (TME 065)*. The *Blast Technology Manual* complements this Design Practice and includes detailed procedures for specifying the blast resistance requirements of new and existing buildings based on individual plant conditions (site specific buildings and release scenarios) and risk management methodology.
- ▶ The methodology discussed in this section is based on the Multi-Energy Method developed by TNO, a consortium of industry and government in The Netherlands (see **REFERENCES**), which is a recognized industry practice. The model is based on the premise that the building damage from vapor cloud explosions (VCE's) that have occurred has been determined by the size of a **domain** (space) in which there is congestion of equipment, an accumulation of a combustible vapor-air mixture originating from some source either within or outside the domain, and the distance between the damaged building and an apparent origin (epicenter) of the explosion. The two parameters which are used to model such a VCE are the combustion energy available at stoichiometric concentration of combustible vapor within a domain, and an explosion strength determined by the degree of congestion. Detailed knowledge of this methodology is not necessary for use of this Design Practice.
- ▶ The contents of this subsection include a comprehensive screening methodology for new buildings. The screening methodology is based on the following assumptions:
 1. The **potentially explosive vapor** is assumed to be propane, which is considered medium reactivity.
 2. The release occurs within a refinery or chemical plant having a degree of congestion or confinement typical of units that satisfy the spacing criteria given in **DP Section XV-G** (equivalent to medium congestion in the TNO Multi-Energy Calculation Methodology).
 3. The overpressure estimates are based on the use of Curves 5 and 7 of the TNO Multi-Energy Method (*Blast Technology Manual*, Section 4).
 4. The postulated release rates are high enough that the **Potential Explosion Domain** can be assumed to be filled entirely before ignition occurs.
- ▶ When more than one of these conditions deviate significantly from the above assumptions, a site specific study using the methodology in the *Blast Technology Manual* may be conducted, taking into account the actual reactivity of the **Potentially Explosive Vapor** and the actual volume and degree of confinement of the **Potential Explosion**.
- ▶ Blast protection requirements for existing buildings located in the vicinity of existing facilities are discussed in the *Blast Technology Manual*.
Detailed procedures to design and engineer "blast-resistant buildings" are covered in **Section XXIX-I** and the *Blast Technology Manual*.
The design of buildings as "safe havens" in the event of toxic gas releases is outside the scope of this subsection.

REFERENCES

DESIGN PRACTICES

- ▶ **Section XV-C** Pressure Relief
- Section XV-G** Equipment Spacing
- Section XXIX-I** Blast Resistant Structures

GLOBAL PRACTICES

- GP 4-3-1 Plant Buildings for Operation and Storage
- GP 4-3-2 Blast Resistant Buildings
- GP 4-3-3 Shelters for Process Analyzers
- GP 4-3-4 Special Category 3 Blast Resistant Buildings
- GP 14-3-1 Fireproofing
- GP 16-6-1 Substation Layout

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REFERENCES (Cont)

OTHER REFERENCES

1. *Plant Building Blast Protection Reassessment of Design Requirements*, ER&E Report No. EE.30E.91.
2. J. of Hazardous Materials, Vol. 12, 1 - 10, 1985, *The Multi-Energy Method - A Framework for Vapor Cloud Explosion Blast Prediction*.
3. *Blast Technology Manual*, EMRE Manual No. TMEE 065.

PHILOSOPHY

Vapor Cloud Explosions (VCE's) are rare events but when they do occur the consequences can be severe. In particular, the associated overpressures have the potential to impact buildings that may be occupied and/or may be critical to the continued operation of the facility. Therefore, it is prudent to include features which provide a degree of blast protection and/or resistance for such buildings from the effects of credible VCE scenarios into the design of processing facilities.

All buildings which house people within a refinery or chemical plant should incorporate basic construction features intended to reduce the likelihood of their occupants becoming injured from the effects of a VCE. These features are specified in **GP 4-3-1** and include, among others, the use of non-load bearing walls and protection of the occupants from flying glass. The requirements of **GP 4-3-1** are applicable to all such buildings, regardless of whether or not they are likely to be affected by a VCE.

In general, the only occupied buildings to be located near equipment having a potential for a VCE are those directly associated with the operation and maintenance of processing units. All other buildings which house people should be located outside areas likely to be subjected to overpressure. However, occasions arise when alternative locations do not exist or there are sound logistic and operational reasons to locate such buildings where they may be subject to overpressure. Any building likely to be so affected shall be designed to an appropriate level of blast resistance in excess of the requirements of **GP 4-3-1**. The intent is that the buildings would not collapse even when subjected to an extreme design basis VCE (described as VCE-3 elsewhere in this section).

Similarly, blast resistance should be built into those buildings (whether or not they are occupied) which, if damaged, would result in widespread production debits, e.g., multi-unit control centers, multi-unit electrical substations and multi-unit remote instrument modules. The intent with these types of building is to provide an assured level of blast resistance such that the buildings can continue to operate following a design basis VCE (described as VCE-1 and VCE-2 elsewhere in this section) in one of the operating areas. Hence essential process control and electrical supply are maintained to non-affected units and emergency actions can be taken for the affected area.

DEFINITIONS

Building Spacing Category - Four Building Spacing Categories (0 through 3) are defined for the purpose of blast resistant design based on spacing from a credible VCE hazard. The higher the category number, the lower the blast resistance requirements. **GP 4-3-2** details the construction requirements for each building category. The required **Building Spacing Category** is a function of the distance from the building to the **edge** (not the epicenter) of **Potential Explosion Domains**, the mass of the release of **Potentially Explosive Vapor** and the volume of the **Potential Explosion Domain**. Based on conservative assumptions about the magnitude of releases of **Potentially Explosive Vapor** and of the volume of **Potential Explosion Domains**, the default **Building Spacing Category** as a function of distance from the edge (not the epicenter) of the nearest **Potential Explosion Domain** is as follows:

DISTANCE TO EDGE OF POTENTIAL EXPLOSION DOMAIN ft (m)		DEFAULT BUILDING SPACING CATEGORY
50-100	(15-30)	Category 0
> 100-200	(> 30-60)	Category 1
> 200-400	(> 60-120)	Category 2
> 400-700	(> 120-215)	Category 3

Plant buildings that do not fall in any of the four categories should be constructed according to **GP 4-3-1**.

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DEFINITIONS (Cont)

- ▶ **Critical Operations Building** - A building containing equipment and/or instrumentation essential to the control and/or operation of two or more processing units or operating areas, which can operate independently of each other indefinitely. Examples of **critical operations buildings** include **Multi-Unit Control Houses**, **Multi-Unit Substations** and **Multi-Unit Remote Instrument Module (RIM's)**.

Explosion Epicenter - The point within an exploding vapor cloud which gives rise to the highest pressure and from which pressure shock waves are assumed to propagate out radially.

- ▶ **Multi-Unit Control House** - An **occupied building** containing the control equipment, e.g., instrumentation, computers, work stations, etc. for two or more processing units or operating areas which can operate independently of each other indefinitely.
- ▶ **Multi-Unit Remote Instrument Module (RIM)** - An unoccupied indoor assembly of various process control instrumentation equipment, typically TDC controller and shutdown system equipment, termination racks for multicore cables, etc., which provides and receives process control signals to/from two or more processing units or operating areas capable of operating independently of each other indefinitely.
- ▶ **Multi-Unit Substation** - An assembly of indoor metal-clad switchgear, housed inside an unoccupied building and supplied directly by electrical feeders or by adjacent transformers, which feeds, entirely or in part, two or more processing units or operating areas capable of operating independently of each other indefinitely.
- ▶ **Occupied Building** - The local Plant Safe Operations Committee will define the criteria for **Occupied Buildings**. Some of the considerations in developing these criteria are:
 - A building housing persons who are regularly assigned there and perform the majority of their job function within the building are normally classified as "**Occupied Buildings**." This includes multi-unit control houses, single unit operating control rooms, office buildings, main laboratories, central maintenance workshops, gate houses and smaller offices within larger buildings such as warehouses and fire stations.
 - Buildings which are only occupied for part of the working day, such as local operator shelters, change houses, locker rooms, mess rooms, dining rooms, meeting rooms, rooms used for issuing work permits, rooms for conducting training sessions, etc., should be classified as "**Occupied Buildings**" when criteria defined by the local Safe Operations Committee are met. Examples of buildings typically considered as "**Occupied Buildings**" include the following:
 - a. Buildings having an occupancy equal to or greater than 400 person-hours per week.
 - b. Buildings having a periodic peak occupancy of 20 or more persons at any one time.
 - c. Buildings in which one or more persons spend 50% or more of their time during a typical workday.
 - d. Any building in which personnel are present 50% or more of the time.
 - Buildings which are seldom occupied, such as electrical substations, analyzer houses, smoking pens, unmanned storerooms, rest rooms, etc., are **not** normally classified as "**Occupied Buildings**" but as "**Unoccupied Buildings**."

Potential Explosion Domain - The space (onsite or offsite) immediately surrounding operating equipment, e.g., drums, exchangers, towers, pumps, loading racks, pipe racks, steelworks, etc., or other obstacles, which can potentially be engulfed and filled by a flammable fuel-air mixture, and which is sufficient in size to give rise to a vapor cloud explosion. Criteria for establishing the existence and boundaries of potential explosion domains are presented under **PROCEDURE TO DETERMINE BLAST RESISTANCE AND SPACING REQUIREMENTS FOR BUILDINGS**, Step 4.

- ▶ **Potentially Explosive Vapor** - Gas or vapor below its autoignition temperature which has the potential to form an explosive mixture when mixed with ambient air and could give rise to a vapor cloud explosion. For the purposes of this Design Practice, this includes:
 - Flammable gases having a molecular weight greater than 21.
 - Vapors arising from flashing liquids having a closed-cup flash point less than 100°F (38°C) and a volume average boiling point less than or equal to 350°F (175°C)

Process Equipment - drums, exchangers, towers, pumps, compressors, etc., which contain flammable or combustible material. Piping in pipe racks is generally not considered to be process equipment.

Source of Release - A single piece of operating equipment, such as a drum, exchanger, tower, pump, piping or valve, etc., which can release **Potentially Explosive Vapor** should it leak or fail catastrophically. Isolated pipe racks outside process area battery limits containing only valves, vents and drains, and which are protected adequately from overpressure, including thermal expansion, and contain no dead-legs, are not considered as a **Source of Release** for the purposes of this Design Practice. When determining whether a **Source of Release** can release sufficient **Potentially Explosive Vapor** to form a **Potential Explosion Domain**, only single equipment catastrophic failures should be considered.