Demystifying Building Code Occupancy Classification

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Hazardous material use and storage inside any structure affects its building and fire code occupancy classification, which dictates its allowable design and layout features.

The use and storage of hazardous materials within a structure can subject process operations to many regulatory and permitting requirements. One of the most overlooked and misunderstood requirements is how hazardous material utilization affects the International Building Code (IBC) *(1)* and International Fire Code (IFC) *(2)* occupancy classification of a facility and determines the allowable design and layout features of the structure. Occupancy classification can present significant operational issues when an existing facility plans to increase or change the type or quantity of hazardous materials being used, including the use and storage of combustible dust.

The model building codes in the U.S., most commonly the International Code Council Series, establish strict requirements for the use of hazardous materials through the occupancy classification process. The intent is to set minimum requirements to ensure occupant and emergency responder safety and protect surrounding property (*e.g.,* minimize the spread of a fire). Since these codes are generally adopted by local and state governments, the model codes serve as legal requirements. These codes rely on the accurate determination of high-hazard, or Group H, occupancy designation to ensure proper building features are provided for occupant and facility safety.

Recent updates to the code requirements have affected occupancy classification based on the use of combustible dust. With increasing regulatory focus on combustible dust, manufacturers will need to understand the methods used for occupancy classification involving dust hazards. This article describes a three-step process to help ensure accurate occupancy classification.

Overview of the occupancy classification process

The IBC and IFC utilize occupancy classification to provide rationale criteria to match a building's use and occupancy with the features required to address fire hazard and life safety considerations. This designation is fundamental in establishing the features of construction, occupant safety requirements, building height and size limitations, means of egress, fire protection systems, and allowable interior finishes.

In general, the occupancy classification is set at the time of construction or initial occupancy of a building. Operations must conform to the requirements and restrictions imposed by this classification for the facility's lifetime, which is particularly important as the type and quantity of hazardous

Table 1. The International Building Code (IBC) categorizes high-hazard occupancies into five subgroups.		
High Hazard Group	IBC Reference	Description
Group H-1	307.3	Occupancies containing materials with a detonation potential
Group H-2	307.4	Occupancies containing materials that have a deflagration potential or that create a hazard from accelerated burning
Group H-3	307.5	Occupancies containing materials that are easily combustible or pose a physical hazard
Group H-4	307.6	Occupancies containing materials that pose a health hazard, specifically including toxic, highly toxic, and corrosive chemicals
Group H-5	307.7	Occupancies containing hazardous production materials (HPM) used in semiconductor fabrication facilities and research and development laboratories

materials in use changes over time.

Typical occupancy classifications in the manufacturing and industrial sectors include:

- Group F: Factory Industrial
- Group S: Moderate and Low-Hazard Storage
- Group H: High Hazard.

The IBC further categorizes High Hazard (Group H) occupancies into one of five subgroups. As detailed in Table 1, the most severe hazardous occupancy group is H-1 and the hazard severity gradually decreases through H-3. H-4 is used for occupancies containing materials presenting a health hazard, and H-5 is a special classification for the unique hazards presented by semiconductor fabrication facilities.

Often, buildings and structures containing hazardous materials may have hazards in more than one high-hazard subgrouping (H-1, H-2, H-3, H-4). In these cases, the structure must conform to the code requirements for each of the classified occupancies and use the most restrictive limitations when multiple groups apply.

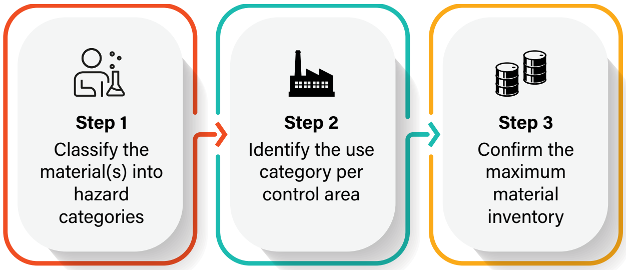
A three-step process for accurate occupancy classification

The three-step process presented in Figure 1 can help ensure accurate occupancy classification. This approach should be used during the initial design phase of a facility, or as part of the planning phase for occupying an existing structure. The limits established by this analysis should be used for ongoing oversight of the operations, particularly when contemplating operational changes (*e.g.,* as part of a management of change review).

The analysis must be documented and submitted to applicable building and fire officials in accordance with the requirements of IBC Section 414.1.3.

Hazardous material classification

The IBC and IFC sort hazardous materials into two categories: physical hazards or health hazards. A physical hazard is a chemical for which there is evidence that it is a combustible liquid; compressed gas; cryogenic material; explosive material; flammable gas, liquid, or solid; organic peroxide; oxidizer; pyrophoric or unstable (reactive) material; or water-reactive material. A health hazard is a chemical for which there is statistically significant evidence that acute or chronic health effects can occur in exposed persons.



▲ **Figure 1.** A three-step process can be used to accurately determine occupancy classification based on maximum material inventory.

The IBC further subdivides these two major categories into several subcategories that are used in the occupancy classification process (and for other code requirements). Table 2 lists the subcategories.

Some materials may have more than one classification. For example, a material that is classified as both a health hazard and a flammable liquid, or both a flammable liquid and water-reactive material. In these situations, all classifications should be documented to compare against allowable quantities for the occupancy determination.

Categorizing a chemical hazard is not difficult, but it may require some research using common reference sources, such as a safety data sheet (SDS). The recent incorporation of the Globally Harmonized System (GHS) into the Occupational Safety and Health Administration (OSHA) Hazard Communications Standard *(3)* establishes a mandatory 16-section format for SDSs, which standardizes the location of critical process safety information in the document.

Section 14, Transport Information, of a GHS-compliant SDS often provides information required for a hazard category determination. This section may indicate the exact hazardous materials classification or provide a reference to a hazard class that can be compared to the building code definitions for each hazard category in Chapter 3 of

Table 2. The IBC and IFC sort hazardous materials into two major categories — physical and health hazards — which are further subdivided into hazardous material subcategories.

Physical Hazards	Health Hazards
▪ Combustible Dust	▪ Corrosive
▪ Combustible Liquid	▪ Highly Toxic
▪ Combustible Fiber	▪ Toxic
▪ Consumer Fireworks	
▪ Cryogenics, Flammable	
▪ Cryogenics, Inert	
▪ Cryogenics, Oxidizing	
▪ Explosives	
▪ Flammable Gas	
▪ Flammable Liquid, Combination	
▪ Flammable Solid	
▪ Organic Peroxide	
▪ Oxidizer	
▪ Oxidizing Gas	
▪ Pyrophoric Material	
▪ Unstable (Reactive)	
▪ Water Reactive	

14. TRANSPORT INFORMATION

US DOT (shipped by land):

DOT Shipping Name:	UN2903, Pesticides, Liquid, Toxic, Flammable, N.O.S. (Propargite, Isopropyl Alcohol), 6.1, 3, PG II
Emergency Response Guide:	151
Marine Pollutant:	Yes
RQ:	10 lbs. (14.4 gallons of product)

IMDG (shipped by vessel):
UN2903, Pesticides, Liquid, Toxic, Flammable, N.O.S. (Propargite, Isopropyl Alcohol), 6.1, 3, PG II, Marine Pollutant

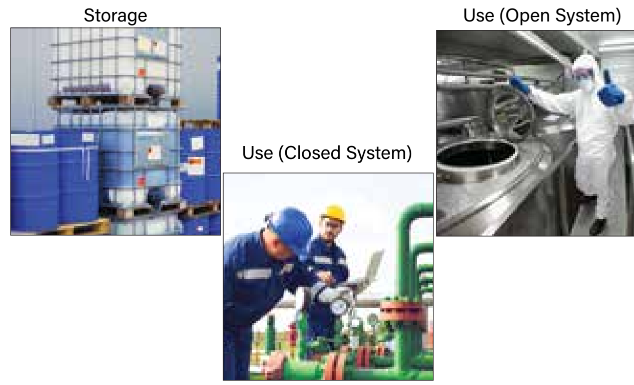
IATA (shipped by air):
UN2903, Pesticides, Liquid, Toxic, Flammable, N.O.S. (Propargite, Isopropyl Alcohol), 6.1, 3, PG II

▲ **Figure 2.** Section 14 of a Globally Harmonized System (GHS)-compliant safety data sheet (SDS) provides transport information that can help determine the hazard category. Here, the SDS for a pesticide in a flammable liquid carrier identifies this material as both a flammable liquid (physical hazard) and toxic liquid (health hazard) *(4)*.

the IBC. Figure 2 shows an example of the SDS information available in Section 14 *(4)*.

Another useful reference is found in Appendix E, Hazard Categories, of the IFC. This non-mandatory appendix provides useful information for hazard classification. The appendix is organized by hazard classification and includes chemical examples. Terminology used in Appendix E closely follows that used in the code text, so it can provide useful information that directly applies to the IBC classification. This appendix also contains useful information for evaluating the classification of mixtures.

A final source of information to aid in the hazardous



▲ **Figure 3.** The quantity of material that can be stored in each facility zone is determined by the use and storage categorization.

material evaluation is NFPA 400 (2019), “Hazardous Materials Code” *(5)*. This source provides definitions aligned with many of the IBC hazard classifications, and the appendix material provides additional classification guidance.

If these foundational resources do not provide the details required for appropriate classifications, a review of available testing information may be required to compare the material to definitions in the reference standards. Complex mixtures or newly developed molecules may require laboratory classification testing.

Use and storage categorization

Once hazardous materials are classified, it is necessary to determine the quantities of material that will be stored, as well as the quantities in use in each facility zone (called a control area in the code).

The major definitions used for this evaluation are (Figure 3):

• Storage: The keeping, retention, or leaving of hazardous materials in closed containers, tanks, cylinders, or similar vessels; or vessels supplying operations through closed connections to the vessel.

• Use (Closed System): The use of a solid or liquid hazardous material involving a closed vessel or system that remains closed during normal operations, where vapors emitted by the product are not liberated outside the vessel or systems, and the product is not exposed to the atmosphere during normal operation; and all uses of compressed gases.

• Use (Open System): The use of a solid or liquid hazardous material involving a vessel or system that is continuously open to the atmosphere during normal operation and where vapor is liberated, or the product is exposed to the atmosphere during normal operations.

The code recognizes that the hazards presented by closed systems are less than that of open systems, and generally allows larger quantities of materials in the exempt allowance for closed systems.

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Introducing the control area

A control area is defined in the IBC as “spaces within a building where quantities of hazardous materials not exceeding the maximum allowable quantities per control area are stored, dispensed, used or handled *(1)*.” IBC Section 414.2 establishes the construction criteria for control areas, which consist of fire barriers per IBC Section 707 and horizontal assemblies per IBC Section 711. The fire-resistance rating for the fire barriers and horizontal assemblies depend on the height of the control area in stories above grade, per IBC Table 414.2.2.

The number of control areas is limited to a maximum of four for the ground floor, with reductions taken for floors above and below grade. Note that the amount of hazardous material allowed per control area is reduced for all levels below or above grade. Control areas are not permitted any lower than two stories below grade. (Details are provided in IBC Table 414.2.2.) If a building has no identified control areas or fire-resistive construction required by other provisions of the IBC, the entire building must be considered a single control area.

IBC Tables 307.1(1) and 307.1(2) provide the maximum allowable quantities of hazardous materials within a control area for physical hazards and health hazards, respectively. The basic approach for this determination is to compare the amount of hazardous material present (for each hazardous material category in each control area) to the limits from the IBC. If the quantity exceeds the limit, the area should be classified as Group H occupancy.

Comparing quantities of hazardous materials in each control area with the exempt amounts

With all the basic background information collected, Section 307 of the IBC provides hazardous materials quantity limits for each physical and health hazard subcategory. If the hazardous material inventory exceeds this amount, this area must be classified as high-hazard (Group H) occupancy.

After confirming the chemical classification, locate the category in Column 1 of either Table 307.1(1) (Figure 4) for physical hazards or Table 307.1(2) (Figure 5) for health hazards. The next step is to determine the quantity allowed based on material use and storage. Column 3, Column 4, and Column 5 (circled in red in Figures 4 and 5) provide maximum quantities for storage, closed systems, and open systems, respectively. If the actual quantities used or stored exceed the quantities listed in the table, then the building must be classified per the occupancy group indicated in Column 2 (Figure 4). Table 307.1(2) does not have this column, so quantities exceeding those in this table are classified as Group H-4.

These tables have numerous footnotes, and each applicable footnote provides valuable information for the analysis. The following common footnotes provide additional hazardous materials quantity allowance per control area:

• *Sprinkler systems*. Both tables have footnotes that allow some quantities in the tables to be increased 100% if a sprinkler system is installed per National Fire Protection Association’s (NFPA’s) standard NFPA 13, “Standard for the Installation of Sprinkler Systems” *(6)*.

• *Storage cabinets*. Both tables have footnotes that allow some quantities in the tables to be increased 100% if storage is in an approved storage cabinet, exhausted enclosure, or listed safety can.

These footnotes are accumulative, which means that if both footnotes are applicable, then the allowable quantity in the table may be increased four times.

Table 414.2.2 in the IBC establishes the maximum number of control areas per floor and reduces the amount of

[F] TABLE 307.1(1)
MAXIMUM ALLOWABLE QUANTITY PER CONTROL AREA OF HAZARDOUS MATERIALS POSING A PHYSICAL HAZARD (a,j,n,m,p)

MATERIAL	CLASS	GROUP WHEN THE MAXIMUM ALLOWABLE QUANTITY IS EXCEEDED	STORAGE (b)			USE-CLOSED SYSTEMS (b)			USE-OPEN SYSTEMS (b)	
			Solid Pounds (cubic feet)	Liquid gallons (pounds)	Gas (cubic feet at NTP)	Solid pounds (cubic feet)	Liquid gallons (pounds)	Gas (cubic feet at NTP)	Solid pounds (cubic feet)	Liquid gallons (pounds)
Flammable Liquid (c)	IA IB and IC	H-2 or H-3	NA	30 (d,e) 120 (d,e)	NA	NA	30 (d) 120 (d)	N/A	NA	10 (d) 30 (d)
1		2	3			4			5	

▲ **Figure 4.** IBC Table 307.1(1) quantifies maximum quantities of a physical hazard in a control area. Here, a portion of the table is shown for the flammable liquid subcategory. Column 3, Column 4, and Column 5 (circled in red here and in Figure 5) provide maximum quantities for storage, closed systems, and open systems, respectively.

hazardous material allowed for each floor above and below grade.

The basic math in this evaluation process is:

1. Take the exempt amounts listed in Tables 307.1(1) or Table 307.1(2)

2. Adjust the quantities for any applicable footnotes to the Tables (generally, an increase)

3. Reduce the quantities for building floors above or below grade (always a decrease)

4. Compare the modified quantities with the planned inventory of each hazard class being used in the control area.

Since the basis for the quantity assumptions can be complex, document all expansions and reductions of the hazardous materials allowances in the summary report.

Code requirements for Group H occupancies

Once the requirements for Group H occupancy are met, several additional requirements arise. IBC Section 415 details many special provisions; some are general in scope and others are applicable to a specific Group H occupancy group.

General requirements include:

• automatic fire detection system (IBC Section 415.3)

• sprinkler system designed to applicable NFPA standards, installed throughout the control area (IBC Section 415.4)

• specific fire separation distances from other occupancies and facility structures that must be carefully considered (IBC Section 415.6).

Special and unique requirements include:

• explosion control is required for some chemicals that have explosive characteristics, whether they are classified as explosives or not. IBC Table 414.5.1 lists the material categories that pose an explosive hazard. For each category, the table indicates whether a barricade or explosion venting/prevention system is required.

• ventilation of vapors, dusts, and other emissions (IBC Section 414.3)

• spill control and secondary containment is required for indoor and outdoor hazardous material storage. The intent of spill control is to prevent the flow of hazardous liquids into adjacent areas (IBC Section 414.5.3, making heavy reference to the IFC, Chapter 50).

Addressing high hazard occupancy requirements

When evaluating a new building design or an existing structure, consider the existing and realistic future utilization of hazardous materials. While ensuring that building control areas that exceed exempt amounts are properly designed for Group H occupancy, it is also beneficial to take maximum advantage of quantity expanders like automatic sprinkler systems, approved storage cabinets, and other approved storage containers to expand the storage amounts. Also, consider proper fire resistance of building components and walls to enable the maximum number of control zones per floor.

Think of the occupancy certificate for a building as a contract between facility management and the building and fire official — the facility is agreeing to manage hazardous materials according to the agreed-upon limitations for storage and use throughout the life of the operation. Hazardous material management practices must comply with the IBC and IFC; these practices should not stop once the facility is granted an occupancy certificate. The organization occupying the building must have continual management commitment to oversee and evaluate conformance to the code.

Examples of critical management systems used to ensure compliance include effective use of management of change and periodic audits of hazardous materials inventories.

[F] TABLE 307.1(2)
MAXIMUM ALLOWABLE QUANTITY PER CONTROL AREA OF HAZARDOUS MATERIALS POSING A HEALTH HAZARD (a,c,f,h,i)

MATERIAL	STORAGE (b)			USE-CLOSED SYSTEMS (b)			USE-OPEN SYSTEMS (b)	
	Solid Pounds (cubic feet)	Liquid gallons (pounds)	Gas (cubic feet at NTP)	Solid pounds (cubic feet)	Liquid gallons (pounds)	Gas (cubic feet at NTP)	Solid pounds (cubic feet)	Liquid gallons (pounds)
Corrosive	5,000	500	Gaseous 810 Liquefied (150)	5,000	500	Gaseous 810 Liquefied (150)	1,000	100

1 3 4 5

▲ **Figure 5.** IBC Table 307.1(2) quantifies maximum quantities of a hazardous material in a control area. Since these are for chemicals posing a health hazard, if maximum quantities are exceeded, then the building or portion thereof must be classified as a Group H-4. Here, a portion of the table is shown for the corrosive material subcategory.

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Unique occupancy classification issues involving combustible dust

While most situations involving hazardous materials may use the three-step approach detailed in this article, the IBC and IFC handle occupancy classification involving combustible dust in a different manner. The entry in Table 307.1(1) for combustible dust requires the use of H-2 occupancy classification when the conditions referenced in Note q of the table exist — whenever combustible dust is "manufactured, generated, or used in such a manner that the concentration and conditions create a fire or explosion hazard based on information prepared in accordance with Section 414.1.3." In other words, the code does not specify a maximum allowable quantity of combustible dust.

Section 414.1.3 requires that an engineering evaluation be prepared to document and characterize the classification and quantity of hazardous materials involved. For the unique situation involving combustible dust, this evaluation requires an analysis as to whether concentrations or conditions create a fire or explosion hazard, which would typically be done through the performance of a dust hazard analysis (DHA). Numerous resources are available for conducting DHAs, including NFPA 652, "Standard on the Fundamentals of Combustible Dust" *(7)*, and the Center for Chemical Process Safety (CCPS) book *Guidelines for Combustible Dust Hazard Analysis (8)*.

Example: Using occupancy classification to ensure safety

In response to the COVID-19 pandemic, many companies with nonhazardous manufacturing facilities were eager to help the medical supply effort by retooling operations to make hand sanitizers. The typical formulations for hand sanitizer, based on World Health Organization (WHO) guidance, contain either 80% ethanol or 75% isopropyl alcohol, both Class IB flammable liquids according to NFPA classification *(9)*. The occupancy classification process can provide a perspective on the inventory limits of raw materials in process materials and finished products allowed by the building and fire code.

Step 1. Classify the materials into hazard categories. Both ethanol and isopropyl alcohol have flashpoints below 73°F (22.8°C) and boiling points above 100°F (37.8°C). They are considered Class IB flammable liquids.

Step 2. Identify the use category per control area. Most hand sanitizer manufacturing operations in response to the COVID-19 pandemic were constructed of simple blending vessels that required manual addition of raw materials and finished materials adjacent to the equipment in the same control area. Many operational designs emitted vapors to the atmosphere during normal operations, and would be considered open systems, with some adjacent storage of raw materials and finished product.

Step 3. Confirm the maximum material inventory. Figure 4 provides the applicable entry from IBC Table 307.1(1) showing maximum quantities of a hazardous material in a ground-floor control area for Class IB flammable liquids. In this case, we are limited to 30 gal of liquid in a use-open system, 120 gal in a use-closed system, and 120 gal in storage. Footnote b in this table indicates that the aggregate quantity in use and storage shall not exceed the quantity listed for storage, footnote d provides a doubling of these quantities with use of an approved sprinkler system, and footnote e allows an additional doubling of storage when approved safety drums, exhausted enclosures, or safety cans are used.

Given this framework, a hand sanitizer operation contained in a single control area without an approved sprinkler system would be limited to a total quantity of flammable liquid no greater than 120 gal (based on storage limitations from footnote b) without having to conform to Group H occupancy requirements. This includes all aspects of operation, accounting for raw materials, in-process inventory, and packaged goods. This represents a challenge for a typical low-hazard manufacturing facility that is working to produce commercial quantities of hand sanitizer.

Additional design features, including availability of an approved sprinkler system and selective use of approved storage cabinets, could increase the maximum quantity allowed to between 240 gal and 480 gal.

Case Study: Explosion in a silicone facility

On May 3, 2019, a silicone manufacturing process generated a flammable gas inside an enclosed production building at the AB Specialty Silicones facility in Waukegan, IL, while conducting manufacturing operations using a silicon-hydride-containing polysiloxane fluid *(10)*. The flammable vapor cloud subsequently found an ignition source, causing an explosion and fire, which killed four employees. The incident is under investigation by the U.S. Chemical Safety Board (CSB). Complete detailed information on the operation at the time of the incident is not yet available.

A post-incident inspection by OSHA identified several Group H Occupancy features that were deficient *(11)*, including electrical area classification and the use of fork trucks in an electrically rated area.

Step 1. Classify the materials into hazard categories. In the 2019 Factual Update *(10)*, the CSB reported that the raw material used in the process was a silicon-hydride-containing polysiloxane fluid. Using Appendix E of the IFC and other industry resources, this material appears to meet the definition of unstable (reactive) liquid Class 2 *(12)*. This is based on the characteristics of the fluid to vigorously react when exposed to heat, in the presence of contaminants, or in contact with incompatible materials.

Step 2. Identify the use category per control area. The CSB Factual Update mentions that the manufacturing tanks were not completely sealed. The tanks could not hold pressure and any gases generated during the process were vented into the production building. It appears that the manual addition of raw materials occurred in the same control area. This operation would be considered an open system, with some adjacent storage of the silicon-hydride-containing polysiloxane raw materials.

Step 3. Confirm the maximum material inventory. IBC Table 307.1(1) describes maximum quantities of a hazardous material in a control area for unstable (reactive), Class 2, liquids. In this case we are limited to 10 lb (not gal) of liquid in a use-open system, 50 lb in a use-closed system, and 50 lb in storage. Footnote b of this table indicates that the aggregate quantity in use and storage shall not exceed the quantity listed for storage, footnote d provides a doubling of these quantities with use of an approved sprinkler system, and footnote e allows an additional doubling of storage when approved safety cans or exhausted enclosures are used.

Given this framework, the use of a single drum (approximately 400 lb of material) of silicon-hydride polysiloxane liquid would exceed the storage allowances for this material, even with an approved sprinkler system. The building and operational features for a Group H Occupancy would be required for each control area using or storing this material in drum quantities.

Conclusion

Hazardous material use and storage in any structure introduces operations to several regulatory and permitting requirements that are focused on minimizing risk to occupants, emergency responders, property, and the surrounding area. Appropriate understanding and application of the IBC and IFC occupancy classification process by design and operational engineering staff helps to ensure a safe and compliant operation.

High hazard occupancy classification has impacts throughout the lifecycle of a building's use. To avoid expensive and disruptive building modifications, it is essential to understand the intended use and inventory of hazardous materials. This will ensure that the building will meet the requirements of the building code upon initial occupancy and during future growth and changes. Ongoing oversight of operations, routine audits of hazardous materials inventory, and an effective evaluation of building (fire) code implications during management of change reviews are essential for regulatory and safety success. While it may initially appear complex, the consistent and disciplined use of the three-step process introduced in this article will help provide an accurate occupancy classification. CEP

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