Electronic Specialty Materials US Standards and Regulations

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Code

A code is a document containing only mandatory provisions, using the word "Shall" to indicate requirements. Examples of codes are the American Society of Mechanical Engineers (ASME), Boiler and Pressure Vessel Code and the National Electrical Code (NEC).

Standard

A standard is a document containing both mandatory provisions ("shall" rules) and advisory provisions ("should" recommendations). It is referred to as "that which is established by authority, custom or general consent as a model or example; criterion; test." An example of a standard is the ISO publication "Gas cylinders — Cylinder valves — Specification and type testing ISO 10297:2014

Regulation

A regulation is a law created or administered by a national, regional (e.g., a U.S. state), or local governmental entity. Prime examples are the regulations of the U.S. Department of Transportation (DOT).

Major US Regulations That Affect Electronic Specialty Materials

US Dept of Transportation (DOT), 49 CFR
OSHA Worker Safety and PSM, 29 CFR
EPA Toxic Air Emissions and RMP, 40 CFR
DHS Security (CFATS)
International Fire Code (IFC)
International Building Code (IBC)

US Standards That Address Electronic Specialty Materials

National Fire Protection Association (NFPA)
International Standards Organization (ISO)
International Harmonization Council (IHC)
Compressed Gas Association (CGA)
Semiconductor Equipment Manufacturers (SEMI)
Insurance (FM Global, UL)

Hazardous materials must be packaged in approved cylinders/containers for transportation
In the US all hazardous materials shipments are regulated by DOT. Materials Shipping Names and other requirements are summarized in the 49CFR172.101 Hazardous Materials Table (http://www.myregs.com/dotrspa/)

							(8) Packaging (173,***)			(9) Quantity limitations		(10) Vessel storage	
Symbols (1)	Hazardous material description & proper shipping names (2)	Hazard class of Division (3)	Identification numbers (4)	PG (5)	Label codes (6)	Special provisions (7)	Exceptions (8A)	Non bulk (8B)	Bulk (8C)	Passenger aircraft/ rail (9A)	Cargo aircraft only (9B)	Location (10A)	Other (10B)
	Nitrogen, compressed	2.2	UN1066		2.2		306	302	314, 315	75 kg	150 kg	A	

Compressed Gases are packaged in cylinders which are designed and tested based on specifications outlined in 49CFR178 178.35 - 178.68

Other Hazardous Materials are Packaged in Performance Oriented Packaging Standards (POPS) packaging which have been tested as outlined in 49CFR178.500. Testing is defined by the products' physical property and Hazard Level.

Packing Group I	Great Danger
Packing Group II	Medium Danger
Packing Group III	Minor Danger

Gas Cylinders

Carbon Steel

Chrome/Molybdenum Alloy (3AA)

Light weight - high strength (HC series)

Open Hearth, electric or basic oxygen process steel (low pressure welded)

Aluminum

Fiber Wrapped Aluminum

Stainless Steel

Specialty Alloy (Nickel or Monel)

Cylinder Fill Density (ratio)

The transportation regulations define the maximum amount that a cylinder can be filled to.

This is defined as the fill density or ratio

Cylinders can rupture due to overfilling. "Liquid Full"

Some liquefied gases can reach their critical point and overpressurize the cylinder by gas pressure

A seamless carbon steel cylinder will rupture by tearing along the sidewall. It will stay in one piece

Prior to rupture, the cylinder dia will expand uniformly for about an ½". Will not be noticeable.

US 49 CFR 173.300

1. Pressure in the cylinder at 70°F (21°C) less than or equal to the rated pressure of the cylinder . Reference 173.301.
2. The cylinder not to be liquid full at any temperature up to 131°F (55°C). Ref. 173.304(b).
3. The pressure in the cylinder at 131°F(55°C). less than 5/4 the cylinder's rated pressure. Ref. 173.301 (a) 8

Many users heat low vapor pressure gases such as BCl_3, DCS, ClF_3 to increase flow rate.

These heaters must have a independent temperature cutoff at 130°F (55°C) or less

Some gases have reduced fill densities due to other factors

Overpressure from decomposition reaction

Acetylene

Diborane

Germane
Nitric Oxide
Stibine

Reaction Pressure

Fluorine (limited to 400 psig)
Fluorine Mixtures (limit partial pressure of F2 to 400 psig)
Nitrogen Trifluoride (<1450 psig, Adiabatic Compression Heat)
Tetrafluorohydrazine (limited to 100 psig)

Stress Corrosion Cracking

Carbon monoxide pure and mixtures in carbon steel cylinders

DOT Special Permits

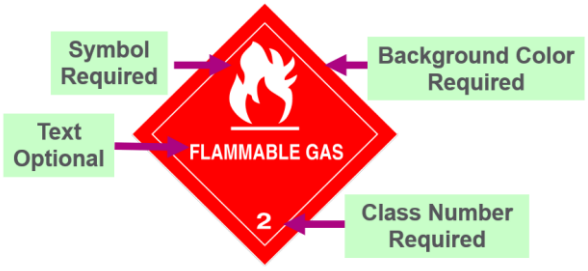
Special permits, formerly known as exemptions, are alternative methods for complying with the Hazardous Materials Regulations (HMRs). When a company has a new product, procedure or technology that does not fit precisely within the requirements of the HMRs, the company may apply for a special permit for alternative compliance as long as the applicant can show that the new product, process or technology will afford an equivalent level of safety.

Some ESM Special Permits

Increased diborane fill density
Emergency Response Containment Vessels (ERCV)
Ultrasonic cylinder testing
Tube trailer acoustic emission testing

The UN Committee of Experts on Transport of Dangerous Goods develops transportation recommendations that are adopted by countries as part of the global harmonization process

International Shipping Hazard Label



The UN references the ISO standards developed for gases

Toxicity (ISO10298)
Flammability (ISO10156)
Oxidizing (ISO10156)
Corrosive (ISO13338)

These apply to pure gases and their mixtures

In the absence of testing the gas supplier can use the estimated values to characterize gas mixtures

Fire and Building Codes

Hazardous materials code requirements are based on both the International Fire Code (IFC) and the International Building Code (IBC).

IBC requirements are driven by the Group H occupancy classification assigned to a building.

IFC requirements are driven by the specific materials stored or used.

The majority of the Fire Codes throughout the US are based on the International Fire Code (IFC). This is a model code that is developed and maintained by the International Code Council. It is adopted as a regulation by state agencies or local jurisdictions. The code is updated every three years. Most jurisdictions lag behind by a few years in adopting the most recent edition.

The IBC occupancy classifications are based on the stored materials being physical or health hazards (or both – which is very common).

When quantities of hazardous materials presenting a physical hazard exceed the MAQ, the occupancy containing such materials is classified as a Group H-1, H-2 or H-3.

H-1 Occupancies with materials that present a detonation hazard

H-2 Occupancies with materials that present a deflagration hazard or a hazard from accelerated burning.

H-3 Occupancies with materials that readily support combustion or present a high physical hazard.

H-4 Occupancies having materials that are health hazards

H-5 Semiconductor fabrication facilities and comparable research and development areas in which hazardous production materials (HPM) are used and the aggregate quantity of materials is in excess of those listed in IBC Tables 307.1(1) and 307.1(2)

To apply code requirements, hazardous materials must be identified, evaluated and classified to fit into the classification framework used by model codes

Situations

- Storage
- Use (open or closed)

Locations

- Interior
- Exterior

Physical Hazard

- Aerosols
- Compressed gases and cryogenic fluids
- Explosives, fireworks and model rocketry
- Flammable and combustible liquids

- Flammable solids
- LPG and LNG
- Organic peroxides
- Oxidizers
- Pyrophoric materials
- Unstable (reactive) materials
- Water-reactive materials

Chemical Hazards

- Highly toxic
- Toxic
- Corrosives

Difference in toxic definition

- DOT LC_{50} of 5,000 ppm or less
- OSHA, IFC, NFPA LC_{50} of 2,000 ppm or less

Hydrogen Chloride which has an LC_{50} of 3,120 ppm would be classified as a toxic gas by DOT while the IFC, OSHA and NFPA it would be classified as a corrosive.

Hazardous Material quantity is used as the primary basis of regulation, and to address the other risk factors, the code varies maximum allowable quantities (MAQs) in non-hazardous uses based on:

- Different hazard categories.
- Different states of material (solid, liquid or gas).
- Different situations (storage, use-closed or use-open).
- Different protection features.

MAQs are the maximum quantities of hazardous materials that may be stored or used in an area before the area must be designated as a hazardous occupancy.

For indoor control areas, the IBC and IFC allow the quantity of hazardous materials established in the tables to be increased when isolated and/or protected by an approved sprinkler system. Each doubles the MAQ, thus a 4 fold increase

Control areas containing hazardous materials which are separated by fire-resistive occupancy separation to isolate adjacent hazards. A building can have multiple areas Each can have hazardous materials up to the MAQ.

Fabrication area is an area within a semiconductor fabrication facility and related research and development areas in which there are processes using hazardous production materials. Such areas are allowed to include ancillary rooms or areas such as dressing rooms and offices that are directly related to the fabrication area processes.

Work Station is a defined space or an independent principal piece of equipment using HPM within a fabrication area where a specific function, laboratory procedure or research activity occurs. Approved or listed hazardous materials storage cabinets, flammable liquid storage cabinets or gas cabinets serving a workstation are included as part of the workstation. A workstation is allowed to contain ventilation equipment, fire protection devices, detection devices, electrical devices and other processing and scientific equipment.

Micron code change to allow more than 2 l of pyrophoric liquids/solids at a workstation

TABLE 5003.1.1(1)—continued
MAXIMUM ALLOWABLE QUANTITY PER CONTROL AREA OF HAZARDOUS MA

MATERIAL	CLASS	GROUP WHEN THE MAXIMUM ALLOWABLE QUANTITY IS EXCEEDED	STORAGE[b]			
			Solid pounds (cubic feet)	Liquid gallons (pounds)	Gas cubic feet at NTP	S po (cubi
Organic peroxide	UD	H-1	1[c, g]	(1)[c, g]	Not Applicable	0.
	I	H-2	5[d, e]	(5)[d, e]		
	II	H-3	50[d, e]	(50)[d, e]		5
	III	H-3	125[d, e]	(125)[d, e]		1
	IV	Not Applicable	Not Limited	Not Limited		Not L
	V	Not Applicable	Not Limited	Not Limited		Not L
Oxidizer	4	H-1	1[g]	(1)[c, g]	Not Applicable	0.
	3[k]	H-2 or H-3	10[d, e]	(10)[d, e]		
	2	H-3	250[d, e]	(250)[d, e]		2
	1	Not Applicable	4,000[e, f]	(4,000)[e, f]		4,(

In addition to Chapter 50, IFC has other compressed gas chapters that list additional requirements

Alternate Means and Methods

The IFC is flexible in that it allows for the use of alternative and innovative materials and performance-based methods in achieving code compliance

The code enforcement official must find that the proposed design, use or operation satisfactorily complies with the intent of the fire code and that the method of work performed or operation is, for the purpose intended, at least equivalent to that prescribed in the fire code in quality, strength, effectiveness, fire resistance, durability and safety

NFPA

NFPA (National Fire Protection Association) has more balanced group representing all aspects of the product/system. The typical technical committee will have representation by

- Users
- Manufacture
- Fire Agency
- Other government agencies
- Consultants
- Insurance Company
- Industrial Associations

NFPA standards are more comprehensive and many are incorporated into the IFC by reference

- Material Specific
- Use Specific
- Extract policy
- Revised every 4 years

NFPA 55 “Compressed Gases and Cryogenic Fluids Code” which covers all compressed gases.

NFPA 400 “Hazardous Materials Code” which merged all of the hazardous materials standards for pyrophoric liquids, solids, corrosives, reactives into one standard

Use specific codes will extract sections directly from the materials specific codes. For example section on compressed or cryogenic gases will be from NFPA 55 for NFPA318 “Standard for the Protection of Semiconductor Fabrication Facilities”

Compressed Gas Association

Members include gas suppliers, cylinder manufacturers, valve manufacturers, waste disposal companies
Standards are developed by committee
Some are incorporated into regulations by reference ANSI/CGA G-13, Storage and Handling of Silane and Silane Mixtures” is referenced in the IFC and NFPA standards. DOT references S1.1
Key standards that are referenced

- S1.1 – Pressure Relief Device Standards-Part 1-Cylinders for Compressed Gases
- S1.2 - Pressure Relief Device Standards-Part 2-Portable Containers for Compressed Gases
- S1.3 - Pressure Relief Device Standards-Part 3-Stationary Storage Containers for Compressed Gases
- S-7 - Standard Method for Selecting Pressure Relief Devices for Compressed Gas Mixtures in Cylinders
- V-1 – Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections
- V-7 - Standard Method of Determining Cylinder Valve Outlet Connections for Industrial Gas Mixtures
- V-9 - Standard for Compressed Gas Cylinder Valves

ANSI Standard

For a standard to be referenced by the International Fire Code it must be ANSI (American National Standards Institute) approved
This approval process insures that the public and others affected by the standard has the ability to review and comment on the proposed standard.
The comment period is 60 days. The Task Force or Committee must address all comments. If the standard is changed as a result, the approval process must be conducted again
Globally Harmonized Standard
Comprehensive safety standard for a Specialty gas
Generally developed jointly between Gas Associations

- Asia Industrial Gas Association (AIGA)
- Compressed Gas Association (CGA)
- European Industrial Gas Association (EIGA)
- Japan Industrial and Medical Gas Association (JIMGA)

Globally harmonized standard adopted by all four Association with only changes to reflect regional regulations

Code of Practice	AIGA	CGA	EIGA	JIMGA
Arsine	050/08	G-16	163/10	050/08
Nitrogen trifluoride	029/10	G-14	92/10	
Nitrous oxide	080/13	G-8.4	116/07/E	
Phosphine	051/08	G-17	162/10	37/08
Silane	052/08	G-13	160/10	
Safe Handling of ESG	018/10			62/10

Insurance

FM Global 7-7 “Semiconductor Fabrication Facilities”

FM Global 7-108 “Silane”