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Revision Memo

12/98	Page 3:	Expanded definition of Auto-Ignition Temperature. Revised definitions of Blast Protection, BLEVE, and Critical Exposure Temperature.
	Page 4:	Revised definitions of Deflagration, Emergency, Detonation and Vapor Cloud Explosion. Added ethylene oxide and propylene oxide to list of fuels that increase probability of a detonation. Added oxygen enriched air to conditions that increase probability of detonation. Added definition of Exposure Limits / TLVs.
	Page 5:	Revised definitions of Flammable and Combustible Liquids.
	Page 6:	Revised definitions of High and Low Flash Stocks, and Hazard. Added definition of High Integrity Protective System.
	Page 7:	Expanded scope of Safety Critical Devices. Added definition of Safety Integrity Level. Included discussion of Inherent Safety under <i>Managing Control of Hazards</i> .
	Page 8:	Modified pressure limitation for equipment at temperatures below the CET for consistency with Section II .
	Page 9:	Revised reference to High Integrity Protective Systems. Revised safe location criteria for the discharge of atmospheric vents.
	Page 10:	Added reference to oxygen under <i>Control of Oxidants</i> . Included additional examples of potentially unstable processes.
	Page 13:	Updated references to NFPA 325 to reflect latest edition. Added TABLE 2 - EXAMPLES OF SAFETY CRITICAL CHECK VALVE APPLICATIONS .



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SCOPE

This section describes the basic principles which underlie the application of safety considerations in plant design.

DEFINITIONS

The following definitions cover terms which are commonly used in safety design. They are listed in alphabetic order. Further definitions of terms particularly associated with pressure relief are included in [Section XV-C](#).

Auto-Ignition Temperature

- The Auto-Ignition Temperature, AIT (also Ignition Temperature, or Spontaneous Ignition Temperature or Self-Ignition Temperature) is the lowest temperature required to cause self-sustaining combustion, without initiation by spark or flame. Auto-ignition temperatures of the majority of hydrocarbons fall in the range of 400 to 1000°F (200 to 500°C) (see [Table 1](#)). In certain phases of safety design, an arbitrary auto-ignition temperature of 600°F (315°C) is used (e.g., in layout, [Section XV-G](#)). This is judged to be a conservative estimate in the absence of experimental data. When experimental data is available, the actual value of the AIT or 600°F (315°C), whichever is lower, should be used as the governing criterion for equipment spacing and any other design features where AIT is a consideration.

Hydrocarbon liquids or vapors can be heated to the AIT by coming into contact with hot equipment when released in an uncontrolled manner. The auto-ignition mechanism may also work just by releasing a hot product above AIT. If the equipment surface temperature is at or above the AIT, spilled liquids are likely to ignite. However, ignition of vapors is a function of temperature and exposure time. Vapors are likely to ignite if they come into short contact with equipment whose temperature is 400°F (200°C) above the AIT. Only if vapors are allowed to contact equipment at lower temperatures for prolonged time is an ignition probable. (See API PSD 2216 "Ignition Risk of Hot Surface in Open Air", July 1980.)

If insulation around piping or vessels becomes soaked with oil, ignition and fire may occur at a temperature considerably below AIT. This phenomenon is called Wicking Action and results from the combination of fibers largely increasing the oil surface area and prolonged exposure to heat from the equipment. It is therefore essential to maintain insulations free of oil.

Blast Protection

- Blast Protection is adding design features to a building such that it will be capable of withstanding an external explosion of defined magnitude. The strength of the potential explosion and the distance between the building and the potential explosion domain are critical parameters in determining blast protection requirements. For more details see [Section XV-H](#).

BLEVE

- BLEVE is the acronym for a **B**oiling **L**iquid **E**xpanding **V**apor **E**xplosion. This type of explosion occurs if a vessel containing superheated hydrocarbon liquid fails catastrophically when fire exposure results in overheating and yielding of a pressure vessel.

Contingency

A contingency is an abnormal event which causes an emergency. A single contingency is a single abnormal event causing an emergency. A remote contingency is the result of a single extremely low probability event, or of two remotely related events which may happen to occur simultaneously. A single contingency is part of the design basis for the facility. Remote contingencies are not part of the design basis. However, since remote contingencies may occur, even though the probability of such an occurrence is extremely low, equipment should be checked to ensure it will not fail if subjected to loads resulting from a single remote contingency.

A double contingency would be the simultaneous occurrence of two or more unrelated events between which there is no process, mechanical, or electrical inter-relationship. Double contingencies are not used as a basis for designing equipment.

Critical Exposure Temperature

- Refer to [Section II, DESIGN TEMPERATURE, DESIGN PRESSURE AND FLANGE RATING](#), for the definition of Critical Exposure Temperature (CET) for pressure vessels, tanks and piping. When the metal temperature of equipment or piping is below the CET, there is a risk of brittle fracture if the stresses from the operating pressure or other loads exceed some percentage of the design allowable stress.

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DEFINITIONS (Cont)

Deflagration

- ♦ A deflagration is an explosion in which the burning process of the flammable mixture (vapor or dust) is governed by heat and mass transfer. The resulting flame front propagates below sonic velocity and the pressure increase (if in a vessel) is typically between 8 to 10 times the initial pressure. When explosions occur in the Hydrocarbon Industry, they are mostly deflagrations. Equipment is designed and operated such that the potential for internal explosions to occur is avoided. However, when internal explosions cannot be ruled out in certain pieces of equipment, it may be desirable to design against an explosion either by containment (increasing design pressure) or by relief (weak parts to rupture or open in a controlled manner).
- ♦ A **Vapor Cloud Explosion (VCE)** can occur if a gas or vapor release forms a large flammable cloud in a congested area. Ignition may be caused by the cloud drifting to a fired heater or ignition source outside the plant (cars). The resulting explosion can be devastating. Prevention of loss of containment and minimizing the potential for ignition are the keys to avoiding such an event.

Detonation

- ♦ A detonation is a high severity explosion. In this type of explosion, the propagating flame front travels as a supersonic shock wave that is closely followed by a combustion zone which releases the energy needed to maintain the shock wave. The resulting pressure rise may be between 100 to 1000 times the initial pressure. Highly destructive energies are produced if pressure wave formation, reflection, and impact reinforce one another in confined areas. Detonations are unlikely to develop in unconfined areas.

If a highly confined flammable vapor/air mixture is ignited, the probability of the resulting explosion being a detonation is increased if:

- The fuel is rich in hydrogen, acetylene, ethylene, ethylene oxide or propylene oxide.
- Pure oxygen, or oxygen enriched air, is present.
- The vapor/air mixture is turbulent.
- The mixture is contained in equipment of long narrow shape, e.g., piping.
- The mixture is initially at high pressure and temperature.
- The mixture is in detonable range (narrower than flammable range and approximately equal to stoichiometric conditions).

Detonation arresters can be used to design against the propagation of a detonation in low pressure (near atmospheric) piping systems such as vapor recovery systems. Another way of stopping detonations in such systems is to rapidly close a valve which then prevents passage of the detonation wave. To do this, the pressure wave must be remotely sensed far enough upstream so that the valve has time to shut. If pressures higher than 2 - 3 psig (14 - 20 kPa) are involved it is not feasible to mechanically design against detonations and the only valid approach is to avoid conditions that favor detonations.

Specific design details for elimination of fire and explosion hazards are covered in [Section XV-B](#).

Emergency

- ♦ An emergency is an interruption from normal operation in which personnel, equipment, or the environment may be endangered or harmed in some manner.

Exposure Limits

- ♦ Occupational exposure limits are used for evaluating exposures to toxic hazards and assessing the potential need for control. Occupational exposure limits usually refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. Several organizations have established exposure limits. A widely accepted set of exposure limits are the Threshold Limit Values (TLVs), which are regularly updated and published annually by the American Conference of Governmental Industrial Hygienists (ACGIH).

Exxon Occupational Exposure Limits (OELs) are the Company equivalent of the chemical agent TLVs. Exxon OELs are adopted as needed for substances which do not have TLVs, or where there is reason to modify the TLV. Together with the list of adopted TLVs, they form a uniform set of occupational exposure limits recommended by the Medicine and Occupational Health Functional Organization for use throughout Exxon.

Local regulations may specify exposure limits that are more strict than the Exxon OEL or TLV. Also, unless otherwise specified by local regulations, an Exxon OEL for a substance takes precedence over the TLV for that substance. For example, the Exxon OEL for benzene is 1 part per million (ppm) whereas its TLV is 0.5 ppm.

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DEFINITIONS (Cont)

Three categories of TLVs are used: Time Weighted Average (TLV-TWA), Short-Term Exposure Limit (STEL), and Ceiling Limit (TLV-C):

- **Threshold Limit Value - Time-Weighted Average (TLV-TWA)** - The time-weighted average concentration for a conventional 8-hour workday and a 40-hour workweek, to which it is believed that nearly all workers may be repeatedly exposed, day after day, without adverse effect.
- **Threshold Limit Value - Short-Term Exposure Limit (TLV-STEL)** - The concentration to which it is believed that workers can be exposed continuously for a short period of time without suffering from: 1) irritation, 2) chronic or irreversible tissue damage, or 3) narcosis of sufficient degree to increase the likelihood of accidental injury, impair self-rescue or materially reduce work efficiency, and provided that the daily TLV-TWA is not exceeded. It is not a separate independent exposure limit; rather, it supplements the time-weighted average (TWA) limit where there are recognized acute effects from a substance whose toxic effects are primarily of a chronic nature. STELs are recommended only where toxic effects have been reported from high short-term exposures in either humans or animals.

A STEL is defined as a 15-minute TWA exposure that should not be exceeded at any time during a workday even if the 8-hour TWA is within the TLV-TWA. Exposures above the TLV-TWA up to the STEL should not be longer than 15 minutes and should not occur more than four times per day. There should be at least 60 minutes between successive exposures in this range. An averaging period other than 15 minutes may be recommended when this is warranted by observed biological effects.

- **Threshold Limit Value - Ceiling (TLV-C)** - The concentration that should not be exceeded during any part of the working exposure.

Both TLVs and Exxon OELs are based on an 8-hour workday and a 40-hour work week. For unusual work shifts or work weeks, the exposure limits should be adjusted. To determine the appropriate exposure limit, consult your local Industrial Hygiene contact, regional Industrial Hygiene Coordinator, or Exxon Biomedical Sciences, Inc. (EBSI).

Flammable (or Explosive) Limits

Flammable (or explosive) limits are the minimum and maximum concentrations (expressed as volume fraction or %) of a flammable vapor (or aerosol/mist) in air which are capable of supporting combustion. These limits are usually abbreviated to LFL (Lower Flammable Limit) and UFL (Upper Flammable Limit) or LEL/UEL. Flammable limits in the literature are normally given at atmospheric conditions. An increase in oxygen contents will widen the flammable range (i.e., the LFL will be lower and the UFL will be higher). A decrease in oxygen contents (adding inert gas) will narrow the flammability range to the point where combustion stops. Increase in pressure or temperature will also widen the flammable range (or reduce the amount of oxygen required to support combustion). Typical flammable limits are listed in **Table 1**.

In the case of combustible dusts, the lower flammable limit is the minimum concentration of the dust in the air (usually as weight per unit volume) that will propagate a flame. There is no corresponding upper flammable limit and any suspension of a combustible dust above the LFL should be considered flammable. Flammable limits are normally recorded at atmospheric pressure and temperature conditions. Increased temperature and/or pressure will lower the LEL.

- **Flammable Liquids** are liquids with a closed-cup flash point below 100°F (38°C), and liquids having a closed-cup flash point of 100°F (38°C) or higher when handled at temperatures above or within 15°F (8°C) of their flash points. The National Fire Protection Association (NFPA) classifies liquids with a closed-cup flash point below 100°F (38°C) as Class I liquids. Class I liquids are further subdivided into Class IA, IB and IC depending on their actual flash point and boiling point. Refer to NFPA 30, Flammable and Combustible Liquids Code for additional information on the classification of flammable liquids.
- **Combustible Liquids** are liquids having a closed-cup flash point of 100°F (38°C) or higher when handled at temperatures lower than their flash point minus 15°F (8°C). The NFPA classifies liquids having a closed-cup flash point of 100°F (38°C) or higher as Class II, Class IIIA or Class IIIB liquids depending on their actual flash point. Refer to NFPA 30, Flammable and Combustible Liquids Code for additional information on the classification of combustible liquids.

Flash Point

The flash point is the lowest temperature at which a liquid exposed to the air gives off sufficient vapor to form a flammable mixture near the surface of the liquid, or within the test apparatus used, that can be ignited by a suitable flame. Flash points are determined by one of the following standard test methods:

- Tag Closed Cup (ASTM Test D-56). This is the normal test method used for materials with flash points below 200°F (93.4°C).