

Safe Handling & Storage of  
*Benzene*

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# *Benzene Brochure*

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## PRODUCT STEWARDSHIP

Chevron Phillips Chemical Company LP (“Chevron Phillips Chemical Company”) is committed to being a good Product Steward of the products we produce. We want anyone who comes in contact with one of our products to have access to information that will help them to understand its potential risk and how to use it safely. The thrust of our Product Stewardship program is the implementation of an Operation Excellence Management System (OEMS) initiative, which makes health, safety and environmental protection an integral part of our products. Successful implementation of this system must include a shared responsibility of all those who come in contact with a product throughout its life cycle. Chevron Phillips Chemical Company will continue to work with customers and others to help ensure that all who use and handle our products follow safe and environmentally sound practices.

**The information contained in this technical bulletin is not intended to, nor does it amend or replace the Chevron Phillips Chemical Company Material Safety Data Sheet for benzene. The most current MSDS can be obtained from Chevron Phillips Chemical Company by calling (800) 852-5530 and should be carefully examined prior to working with this product.**

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## INTRODUCTION

Benzene was first extracted from coal gas by oil scrubbing in the 1860's by Badische Company in Germany. It is probably the most thoroughly studied and best known of all organic compounds. One of the first important early uses of benzene was to manufacture phenol (for antiseptic properties) by reaction with sulfonic acid to form benzene sulfuric acid which was fused with caustic soda to form phenol. By the 1930's, about 1.5 million tons of benzene was recovered worldwide from coal gas. World War II upset the traditional supply/demand balance and created a need to recover benzene from petroleum. Petroleum sources now provide 97 percent of the benzene. Benzene is produced from five main sources (i.e., catalytic reforming of naphtha, dealkylation of toluene, recovery from ethylene plant pyrolysis gasoline, coke oven and selective toluene disproportionation). Other new technologies such as Chevron Phillips Chemical's Aromax® benzene production technology are expected to be utilized more in the future.

Chevron Phillips Chemical Company LP manufactures 210 million gallons of high purity benzene at its Pascogoula Chemical Operations in Mississippi and 145 million gallons at its Saudi Chevron Phillips JV plant in Al Jabail, Saudi Arabia. This benzene is primarily transported by vessel and barge but a limited quantity is transported by pipeline. Chevron Phillips Chemical Company does not ship benzene in tank cars or tank trucks.

Benzene has many uses and demand continues to grow despite increasing restrictions and environmental regulations. Styrene monomer is the largest use of benzene, followed by cumene/phenol, cyclohexane, and nitrobenzene. Those derivatives are used to produce a wide range of plastics, fibers, resins and films. Benzene is also an excellent solvent for waxes, resins, rubber and various other organic materials, but toxicological properties greatly limit use. Benzene like other aromatics has a high octane number and was a valued gasoline blending component until its use was restricted by the Clean Air Act.

Special precautions must be taken in storing and handling benzene because of its relatively high freezing point and toxicity. Consequently, additional information is included on vapor recovery systems, sampling devices, and safety topics that may be included in employee training. This information is provided only as a guide and may not necessarily be the best industry practice.

The various ASTM specifications for benzene are based mainly on end-use requirements. The ASTM D-835 Refined Benzene 485 Grade specification is the least stringent, D-2359 is higher quality and the D-4734 Refined Benzene 545 is an even higher quality. D-5871, (standard specification for Benzene for Cyclohexane Feedstock) is the highest quality specification because it limits the amount of toluene, methylcyclohexane, methylcyclopentane and n-hexane impurities. Chevron Phillips Chemical Company benzene typically meets all ASTM benzene specifications. The latter three ASTM specifications are listed on page 7 for informational purposes.

**NOTE: THIS BROCHURE DOES NOT AMEND OR REPLACE OFFICIAL PUBLICATIONS, SAFETY REGULATIONS NOW IN USE, MATERIAL SAFETY DATA SHEETS OR COMMERCIAL TERMS OF SALE. CHEVRON PHILLIPS CHEMICAL COMPANY LP MAKES NO GUARANTEE OF THE ACCURACY OF THE CONTENTS OF THIS BROCHURE OR ANY WARRANTY OF ANY KIND EITHER EXPRESSED OR IMPLIED WITH RESPECT TO THE USE OF THIS INFORMATION OR ITS APPLICABILITY. THE USER ASSUMES ALL RISK AND LIABILITY ASSOCIATED WITH THE INFORMATION IN THIS BROCHURE.**

## PART 1

### PROPERTIES, SPECIFICATIONS AND TEST METHODS

#### PHYSICAL PROPERTIES OF BENZENE

Aniline Point <sup>(2)</sup>	<-30°C (<-22°F)		
API Gravity, <sup>(2)</sup> 15.56° C (60°F)	28.5		
Autoignition <sup>(8)</sup>	498°C (928°F)		
Boiling Point <sup>(1)</sup>	Atmospheric pressure		Boiling point
		mm of Hg.	°C
		760	80.099
		700	77.8
		600	73.1
		463	65
		394	60
		273	50
		184	40
		122	30
		76	20
	46	10	
	26	0	
Calorific Value (gross) <sup>(5)</sup> , at 25°C	10102.4 cal/g		
	18172 BTU/lb		
Calorific Value (net) <sup>(5)</sup> , at 25°C	9698.4 cal/g		
	17446 BTU/lb		
Coefficient of Expansion <sup>(5)</sup> , at 20°C	0.001209		
	at 40°C	0.001261	
Color	Colorless		
Critical Density <sup>(1)</sup> , gm/cm <sup>3</sup>	0.3044		
	lb/ft <sup>3</sup>	19.00	
Critical Pressure <sup>(1)</sup> , Atmosphere	48.98		
	lb/in <sup>2</sup>	710.4	
Critical Temperature <sup>(1)</sup> ,	°K	562.16	
	°C	288.84	
	°R	1011.89	
	°F	552.22	

Critical Volume <sup>(1)</sup> , cm <sup>3</sup> /gm-mole	256.6		
ft <sup>3</sup> /lb-mole	4.110		
ft <sup>3</sup> /lb	0.053		
Critical PV/RT <sup>(1)</sup>	0.2689		
Density of the Liquid <sup>(2)</sup> ,	<u>Temperature °C</u>	<u>g/cm<sup>3</sup></u>	
	15	0.88415	
	20	0.87889	
	25	0.87368	
Enthalpy of Combustion -ΔH <sub>c</sub> °, at 25°C and constant pressure <sup>(1)</sup> liquid	<u>H<sub>2</sub>O (liquid) and CO<sub>2</sub> (gas)</u> kJ/gm-mole	3267.5	
	J/gm	41,832	
Flammability Limits <sup>(9)</sup> , Vol %	1.2 lower to 7.8 higher		
Flash Point, <sup>(3)</sup> TCC	-11°C, (12°F)		
Freezing Point (dry benzene) <sup>(1)</sup>	5.53°C, (41.96°F)		
Ideal Gas Thermodynamic Properties <sup>(5)</sup>	<u>°C</u>	<u>Heat Capacity cal/gm-mole - °C</u>	<u>Enthalpy cal/gm-mole</u>
	0	17.70	0
	25	19.52	465
	100	24.93	2123
	500	44.23	16,500
	1000	54.94	41,650
Latent Heat of Vaporization <sup>(5)</sup>	<u>°C</u>	<u>Calories/gm</u>	
	60	97.47	
	80	94.17	
	80.10	94.14	
	100	90.57	
	140	82.59	
	180	74.08	
	220	62.09	
	289.5	0	
Molecular Formula	C <sub>6</sub> H <sub>6</sub>		
Molecular Weight <sup>(2)</sup>	78.11		
Odor	Distinct, sweet odor		
Odor Threshold in Air <sup>(7)</sup>	2.7-12 ppm		
Refractive Index <sup>(1)</sup> , n <sub>D</sub> ,			
20°C	1.50112		
25°C	1.49792		

Relative Density <sup>(2)</sup> , (Specific Gravity)	<u>Temperature °F</u>	<u>gm/cm<sup>3</sup></u>	
	40	0.8959	
	60	0.8844	
	80	0.8727	
	100	0.8609	
Relative Vapor Density, (Air = 1) <sup>(6)</sup>	2.77		
Solubility of Water in Benzene <sup>(4)</sup> , 20°C (68°F)	580 ppm		
Solubility of Benzene in Water <sup>(6)</sup> , 20°C (68°F)	1780 ppm		
Specific Heat (Heat Capacity) <sup>(5)</sup> , at 25°C, cal/gm°C	0.24999		
Standard Heat of Vaporization <sup>(1)</sup> , $\Delta h_v^\circ$ , at 25°C, kcal/mole	8.102		
Standard Free Energy of Vaporization <sup>(1)</sup> , $\Delta F_v^\circ$ , at 25°C, kcal/mole	1.233		
Surface Tension <sup>(5)</sup>	<u>°C</u>	<u>dynes/cm</u>	
	15	29.6	
	20	28.9	
	40	26.4	
Vapor Pressure <sup>(2)</sup> , at 100°F, psia	3.224		
Viscosity <sup>(1)</sup>	<u>Temperature</u>	<u>Absolute viscosity</u>	<u>Kinematic viscosity</u>
	<u>°C</u>	<u>centipoises</u>	<u>centistokes</u>
	10	0.771	0.8513
	20	0.654	0.7357
	50	0.449	0.5415
80	0.318	0.389	
Viscosity of Benzene Vapor <sup>(5)</sup>	<u>Temperature</u>	<u>Absolute viscosity</u>	
	<u>°C</u>	<u>micropoise</u>	
	0	65	
	100	90	
200	113		

## **REFERENCES**

- 1) American Petroleum Institute Research Project 44
- 2) ASTM Data Series DS4A
- 3) Dangerous Properties of Industrial Materials, Sax, 4th edition
- 4) Solubility Data Series Vol 37, Hydrocarbons with Water and Seawater Part 1: Hydrocarbon C5-C7 Pergamon Press
- 5) Benzene and its Industrial Derivatives, E. R. Hancock
- 6) Handbook of Environmental Data of Organic Chemicals, Van Nostrand Reinhold
- 7) American Conference of Governmental Industrial Hygienists, Documentation of Threshold Limit Values and Biological Exposure Indices, 6th Edition
- 8) Fire Protection Guide for Hazardous Materials, 10th Edition
- 9) NFPA, 1994

## ASTM BENZENE SPECIFICATIONS

<u>Property</u>	<u>ASTM D-2359-02</u> <u>Refined Benzene - 535</u>	<u>ASTM D-4734-04</u> <u>Refined Benzene - 545</u>	<u>ASTM D-5871-04</u> <u>Benzene for Cyclohexane</u> <u>Feedstock</u>
Acid Wash Color	Pass with 1	Pass with 1	Pass with 1
Bromine Index		20 max.	
Appearance	A	A	A
Color	20 max.	20 max.	10 max.
Relative Density, 15.56°C/15.56°C			.882 to .886
Solidification Point	5.35°C min.	5.45°C min.	5.45°C min.
Thiophene	1 mg/kg max.	0.6 mg/kg max.	0.6 mg/kg max.
Non-aromatic Hydrocarbons	0.15 wt % max.	0.10 wt % max.	
Benzene	99.80 wt % min.	99.90 wt % min.	99.90 wt % min.
Sulfur	(If needed)	1.0 mg/kg max.	1.0 mg/kg max.
Toluene	0.10 wt% max.	0.05 wt % max.	
Toluene & Methylcyclohexane			150 mg/kg max.
Methylcyclopentane			100 mg/kg max.
n-Hexane			80 mg/kg max.
Nitrogen	(If needed)	(If needed)	
1,4 Dioxane	(If needed)	(If needed)	
Water	(If needed)	(If needed)	(If needed)

A) Clear liquid free of sediment and haze when observed at 18.3 to 25.6°C (65 to 78°F)

## **RECOMMENDED TEST METHODS**

The following ASTM methods are recommended for the analysis of benzene:

1. D-848 Acid Wash Color of Industrial Aromatic Hydrocarbons
2. D-852 Solidification Point of Benzene
3. D-1209 Color of Clear Liquids (Platinum-Cobalt Scale)
4. D-1492 Bromine Index of Aromatic Hydrocarbons of Coulometric Titration
5. D-1685 Traces of Thiophene in Benzene by Spectrophotometry
6. D-3505 Density or Relative Density of Pure Liquid Chemicals
7. D-4017 Water in Paints and Pain Materials by Karl Fischer Method
8. D-4045 Sulfur in Petroleum Products by Hydrogenolysis and Rateometric Colorimetry
9. D-4052 Density and Relative Density of Liquids by Digital Density Meter
10. D-4492 Analysis of Benzene by Gas Chromatography
11. D-4629 Trace Nitrogen in Liquid Petroleum Hydrocarbons by Syringe/Inlet Oxidative Combustion and Chemiluminescence Detection
12. D-4735 Determination of Trace Thiophene in Refined Benzene by Gas Chromatography
13. D-5386 Color of Liquids Using Tristimulus Colorimetry
14. D-5713 Analysis of High Purity Benzene for Cyclohexane Feedstock by Capillary Gas Chromatography
15. D-5776 Bromine Index of Aromatic Hydrocarbons by Electrometric Titration
16. D-6069 Trace Nitrogen in Aromatic Hydrocarbons by Oxidative Combustion and Reduced Pressure Chemiluminescence Detection
17. D 6212 Total Sulfur in Aromatic Compounds by Hydrogenolysis and Rateometric Colorimetry
18. D-6304 Determination of Water in Petroleum Products, Lubricating Oils, and Additives by Coulometric Karl Fischer Titration
19. D-6313 Total Sulfur in Aromatic Compounds by Hydrogenolysis and Sulfur Specific Difference Photometry
20. D-6366 Total Trace Nitrogen and Its Derivatives in Liquid Aromatic Hydrocarbons by Oxidative Combustion and Electrochemical Detection
21. D-6428 Total Sulfur in Liquid Hydrocarbons and Their Derivatives by Oxidative Combustion and Electrochemical Detection
22. D-7011 Determination of Trace Thiophene in Refined Benzene by Gas Chromatography and Sulfur Selective Detection
23. E-1064 Water in Organic Liquids by Coulometric Karl Fischer Titration

## **PART 2**

### **SAMPLING AND HANDLING**

#### **TRAINING**

In any workplace where benzene is handled, used, stored or transported, a training program must be implemented to ensure worker's awareness of benzene's properties, toxicity, and safety procedures and to meet the requirements of the OSHA Benzene Standard (29CFR 1910.1028). The training program should include the following:

1. Benzene properties, such as high vapor pressure and flash point.
2. Benzene health hazards.
3. Benzene physical hazards including the potential for fire and explosion.
4. Benzene's primary routes for entry into body.
5. Safe work and good housekeeping practices.
6. The importance of protection from benzene contact; the proper clothing and cleaning requirements.
7. The importance of respirators, their effectiveness, and health hazards effected by non-use. The OSHA Regulatory Protection Standard (29 CFR 1910.134) lists additional requirements when respirators are required.
8. The importance of the exposure limits, such as the OSHA Permissible Exposure limits - Time Weighted Average (1 ppm) and OSHA Permissible Exposure limit – Short term exposure limit (5 ppm).
9. Signs and symptoms of benzene exposure and action to be taken and medical conditions aggravated by exposure to benzene.
10. The care that must be taken whenever and wherever benzene is used, handled, stored and transported.
11. Emergency procedures for leaks, spills, and fires, including protective clothing to be worn in such instances.
12. The availability of written benzene usage, health hazard and training program procedures.
13. The need for and the requirements of the medical surveillance program.

It is recommended that this training program should be part of a worker's initial training and should be scheduled at least annually thereafter.

Additional accidental release, fire and health information is presented in a subsequent section of this brochure.

#### **RECOMMENDED PRACTICE FOR SAMPLING BENZENE**

This information is provided for use in establishing sampling and handling procedures. This information should only be utilized in conjunction with an existing health and safety program and cannot be used as a substitute for expert safety and medical advice. While benzene is dangerous when handled improperly, sampling and loading need not be hazardous providing the hazards are recognized and handling instructions are rigidly observed. Any person sampling and handling benzene should be sufficiently trained in sampling techniques, have specific first aid instructions and equipment available for use in the event of personal contact or exposure.

Samples may be taken through the manway opening by means of a clean, dry 1-qt. (1-L) bottle held in a clean, dry sheath of nickel or stainless steel attached to a long rod or lightweight chain of the same material. Fit the bottle with a glass stopper to which is attached a light metal chain. Lower the bottle to near the bottom of the tank and pull out the stopper with a sharp jerk of the chain. Raise it at such a rate that it is about three fourths full when it emerges from the liquid. Stopper the bottle before

attempting to rinse the material from the outside. Label the sample bottle according to OSHA Regulations.

**NOTE - FRESH AIR AND OTHER PERSONAL PROTECTIVE GEAR MAY BE REQUIRED DEPENDING ON PREDETERMINED EXPOSURE LIMITS.**

Emphasis should be placed on cleanliness and dryness. Both the sample bottle and its holder must be CLEAN AND DRY. Transfer the sample to another bottle for storage. A suitable bottle for storing the sample is one known as a "Boston Round." The closure should be a screw cap with Teflon<sup>®</sup> or aluminum foil liner.

If new bottles are used, first rinse them thoroughly with acetone or methanol and then dry in a hot-air oven. Hold in a desiccator while cooling to ambient temperature. Protect them from dirt or moisture by enclosure in a polyethylene bag. Rinse used bottles very thoroughly with water, detergents, and solvents and then treat as new bottles.

The sampling system should be bonded to the tank manway (e.g., by resting the chain on the lip of the manway) prior to sampling.

**REFERENCED DOCUMENTS RELATED TO SAMPLING**

- ASTM D 3437 Practice for Sampling Handling Liquid Cyclic Products
- ASTM E 300 Practice for Sampling Industrial Chemicals
- ANSI Z 288.1 Flammable and Combustible Liquids Code
- API RP-500A Classification of Locations for Electrical Installations in Petroleum Refineries
- OSHA Regulations, 29 CFR paragraphs 1910.1000 and 1910.2000

U.S. DOT Regulations, 49 CFR Transportation, Subchapters B and C, Parts 171-179

Take extreme care to prevent spills. In case material is spilled, wash contaminated areas thoroughly with large quantities of water and

collect the liquid in the plant chemical waste system.

**SAMPLING DEVICES**

Quality control within the process industry is of prime importance. This demands stringent checks, not only of the finished product, but also throughout the various stages of production, distribution and use.

The need for representative samples plays a critical role in ensuring product quality. Yet sampling directly often includes the risks of exposure to the operator as well as contamination and pollution to the environment. Use of a system such as the DOPAK<sup>®</sup> sampling method for process samples and HERMetric<sup>®</sup> Sampler for tank samples significantly reduces such risks. Texas Sampling Inc. also markets closed loop sampling systems.

**STATIC ELECTRICITY AND GROUNDING**

Static electricity can cause fires and explosions unless certain precautions are observed. Benzene has a high volume resistivity and can pick up and hold a static charge during transfer operations.

Key operations which have the potential of generating a flammable atmosphere and/or static include tank and container filling, splash filling, tank cleaning, sampling, gauging, switch loading, filtering, mixing/agitation, and vacuum truck operations. To minimize the hazard of static electricity during these operations, bonding and grounding may be necessary but may not, by themselves, be sufficient. For more information, refer to OSHA Standard 29 CFR 1910.106, "Flammable and Combustible Liquids", National Fire Protection Association (NFPA) 77, "Recommended Practice on Static Electricity" and/or the American Petroleum Institute (API) Recommended Practice 2003, "Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents."

Chevron Phillips Chemical Company recommends the use of insulating flanges or manufacturing hoses for marine product transfers.



## **PRODUCT LOADING/UNLOADING REQUIREMENTS**

### **When loading or unloading a vessel or barge:**

The shipment of benzene by barge is regulated by the United States Coast Guard (USCG). 49 CFR 176 defines the requirements for shipments of flammable liquids such as benzene by water. Barges used for transport of benzene are regulated by 46 CFR Part 151, Subchapter O, as a dangerous cargo. Refer to the current International Safety Guide for Oil Tankers and Terminals (ISGOTT) and United States Coast Guard (USCG) rules 46 CFR 153 for regulations governing transportation by ship.

Benzene accumulates static charges during product transfer operations. The flow rates with which the product is transferred affects the amounts of static charge generated.

During the initial stages of loading into each individual tank, the flow rate in its branch line should not exceed a linear velocity of 3 feet/second.

After all splashing and surface turbulence has ceased and the tank suction bellmouth or other inlet into the tank has been covered, the flow rate can be increased to the maximum permitted (22 feet/second), provided that increasing the rate creates no turbulence or splashing in the tank and is consistent with the proper control of the operation.

To assist in calculating the volumetric loading rate which corresponds to a linear velocity in a branch line of 3 feet/second, the table for initial and maximum flow rates can be used.

Pipeline Diameter in <u>Inches</u>	Initial Flow Rate 3 fps <u>Barrels/Hour/Tank</u>	Maximum Flow Rate 22 fps <u>Barrels/Hour/Tank</u>
4	170	1,250
6	400	2,940
8	700	5,130
10	1,100	8,060
12	1,500	11,000
14	1,900	13,900
16	2,400	17,600
18	3,100	22,700
20	3,900	28,600

**NOTE: THE PIPELINE DIAMETER IS THE**

**DIAMETER OF THE SMALLEST PIPE OR TUBING THROUGH WHICH THE LIQUID WILL FLOW. ALSO THE DIAMETERS GIVEN ARE NOMINAL DIAMETERS WHICH ARE NOT NECESSARILY THE SAME AS THE ACTUAL INTERNAL DIAMETERS. RATES SHOULD BE CONTROLLED AT THE PUMP AND NOT BY THROTTLING BACK ON VALVES ON TERMINAL OR VESSEL.**

Maximum flow rates will be determined by Design of Vessel, Shore Pipeline and Pumping Systems and must be consistent with the proper control of the operations.

The loading and unloading of benzene should be planned and controlled to limit personnel exposure and environmental releases. OSHA and the U.S. Coast Guard have published regulations applicable to people involved in the handling of benzene. Some of the key elements are:

- Exposure Limits
- Employee Training
- Personal Protective Equipment
- Monitoring, Regulated Areas and Warning Signs.

To avoid exposure of personnel, gauging on the barge must consist of a closed device for use during transfer of product and a restricted device to determine product quantity during transfer. Vapor return lines are also required in some states and countries to control vapor releases.

Clean stainless steel, rust-free mild steel tank or suitably washed steel tanks are acceptable for transport of benzene. Barges are carefully selected by Chevron Phillips Chemical Company to ensure that product quality is not negatively affected during transport.

Qualified contractors should be used to inspect, clean and repair barges in which benzene is shipped. The contractor should have facilities to dispose of residual product in an acceptable manner.

Refer to current ISGOTT and USCG rules.

**Caution! WHEN LEAKING VALVES OR FITTINGS ARE TO BE TIGHTENED WHEN AMBIENT TEMPERATURE IS BELOW 46°F (8°C), IT IS DESIRABLE TO PRE-STEAM THE AREA TO BE REPAIRED TO MELT ANY FROZEN BENZENE. PROPER PROTECTIVE GEAR AND PROCEDURES SHOULD BE USED WHEN PERFORMING THIS TASK.**

## **SAFETY REFERENCES**

The following publications are excellent references for product handling, safety and fire control:

**NFPA NO. 10-**  
Portable Fire Extinguisher

**NFPA NO. 11-**  
Foam Extinguishing Systems

**NFPA NO. 30 -**  
Flammable and Combustible Liquids Code as adopted by National Fire Protection Association.

**NFPA NO. 70 -**  
National Electrical Code as adopted by National Fire Protection Association.

**NFPA NO. 77 -**  
Recommended Practice of Static Electricity as adopted by National Fire Protection Association.

**Manual Sheet TC-4, Chemical Manufacturer's Association**  
Recommended Practice for Unloading Flammable Liquids from Tank Cars

## PART 3

# BENZENE STORAGE

## STORAGE TANKS

Internal floating roof storage tanks are recommended for the bulk storage of benzene. Storage tanks should be designed to eliminate fugitive emissions. Diking, drainage, and tank supports should be designed to conform with local regulations. A rule of thumb commonly used for determining the size of customer storage facilities suggests that storage facilities be 1½ times the size of shipments received. Some facilities may require larger inventories because of seasonal transportation problems.

The storage tank inlet should be located at the bottom of the tank. The fill pipe should be connected electrically to both the tank flange and the transfer pipeline. The purpose of this electrical connection is to dissipate any static charge, which builds up during filling.

Benzene is usually stored as a liquid at temperatures above 46° F (8°C) to avoid freezing.

Storage tanks for benzene may be equipped with external heating pads or internal coils and insulation to maintain storage temperatures.

Heating pads, useful only for relatively small tanks, can be steam or electric. Usually, heat padding is placed intermittently over the bottom of the tank. The entire tank should be appropriately insulated.

Internal steam coils may also be used to maintain benzene at the proper storage temperature. Coils offer the advantage of faster heat-up time than external pads - an advantage if benzene storage is less likely to be continuously maintained at elevated temperatures.

**NOTE: SECONDARY CONTAINMENT SHOULD BE PROVIDED TO COLLECT 1.5 TIMES THE VOLUME OF THE TANK CONTAINING THIS PRODUCT SHOULD A LOSS OF PRODUCT OCCUR.**

**THE SECONDARY CONTAINMENT REQUIREMENTS AS WELL AS TANK LAYOUT AND SPACING REQUIREMENTS SHOULD BE IN ACCORDANCE WITH NFPA 30. ROTATING EQUIPMENT SUCH AS PUMPS SHOULD BE KEPT OUTSIDE OF THE SECONDARY CONTAINMENT AREA.**

Care should be taken to not expose heating coils or pads.

Tanks should be periodically inspected for leaks and serviced in accordance with the principle of API Standard 653.

Specific bulk storage designs must conform to Insurance Underwriters codes and local fire and building regulations. Critical design, placement, installation and maintenance requirements are usually addressed in these codes and regulations must be followed.

**Workers should never be permitted to enter an empty tank which has been used for benzene until the requirements of the OSHA confined space standard (29 CFR 1910.146) and the safe entry recommendation of API Standard 2015 have been met, including, but not limited to, required concentrations for oxygen and limitations on concentrations of benzene.**

## API AND ANSI DESIGN REFERENCES

API Petroleum Institute  
1220 L Street, N. W.  
Washington, DC 20005

### Part I Design

API RP-520: *Sizing, Selection and Installation of Pressure Relieving Devices in Refineries*

## Part II Installation

API 601: *Metallic Gaskets for Raised-Face Pipe Flanges and Flanged Connections (Double-Jacketed Corrugated and Spiral-Wound)*

API 620: *Recommended Rules for the Design and Construction of Large Welded, Low-Pressure Storage Tanks*

API 650: *Welded Steel Tanks for Oil Storage*

API Standard 653: *Tank Inspection, Repair, Alteration and Reconstruction*

API RP-2000: *Venting Atmospheric and Low-Pressure Storage Tanks*

API RP-2003: *Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents*

API Standard 2015: *Safe Entry and Cleaning of Petroleum Storage Tanks*

API RP-2028: *Flame Arresters in Piping System*

API RP-2210: *Flame Arresters for Vents of Tanks Storing Petroleum Products*

API RP-2350: *Overfill Protection for Petroleum Storage Tanks*

**American National Standards Institute  
11 West 42nd Street  
New York, New York 10036**

ANSI B16.21 *Nonmetallic Flat Gasket for Pipe Flanges*

ANSI B31 *American National Code of Pressure Piping*

## **PARTICULATE MATTER**

Benzene should be free of particulate matter when shipped. However, some particulate matter in benzene originates from outside contamination via the receiving-transfer system.

Particulate matter in benzene may be avoided by:

1. Paying careful attention to cleanliness.
2. Filtering benzene to remove particulate matter before use.

## **FILTERS**

Since small amounts of foreign matter may enter storage tanks and transport vessels from various sources, a filter in the transfer piping between the tank and processing equipment is recommended. A cartridge-type filter with a fine or medium replaceable cartridge or bag filters are suggested. Polyester, Rayon, Nomex™ and Nylon bag filters are compatible with benzene. Flow rates and pressures should be used to determine the proper filter for specific applications.

Filter cartridges should be inspected and renewed periodically.

Contact Chevron Phillips Chemical Company's Aromatics Customer Technical Service Group at (800) 852-5531 for specific recommendations.

## **HOSES**

Hard piping is preferred to the use of hoses where possible and practical. If hoses are needed for loading or unloading operations, they should be inspected and pressure tested at the intervals required by the various regulations. A satisfactory type hose is Goodyear, rough-bore, style WH-7 with Viton® tube, or the equivalent. Multi-layered polypropylene is also recommended. U.S. Coast Guard regulations 33 CFR Parts 154.500 and 156.710 apply to hoses used for bulk transfers to and from tank vessels.

## **PUMPS**

Liquid benzene can be transferred by pump or vacuum. For most benzene handling, centrifugal pumps with mechanical seals perform satisfactorily. The pump manufacturer can recommend the proper type of pump if the following parameters are known: (1) flow in gallons per minute, (2) the size and length of suction and discharge lines, (3) the suction and discharge pressures and (4) the temperature of the benzene.

A drain valve should be installed at the lowest point in the system so that the pump and all piping can be completely drained and washed before any maintenance work is done. Totally enclosed fan cooled (TEFC) motors are recommended; however, local fire and insurance codes should be

consulted to determine if an explosion-proof motor must be used. Pump scale must be capable of meeting EPA emission standards - this requires tandem or double seals.

The following practices are recommended to minimize the possibility of pump leakage.

1. Mechanical seals in conformance with API 682, 1st edition.
2. Pumps in conformance with API 610, 8th edition are recommended.
3. The pump should be designed so that pump bearings will be able to carry thrust at no flow. Consider selecting non-metallic (PEEK) wear rings to minimize damage if the pump runs dry.
4. The pump shaft should be highly polished.
5. Pumps should not be subjected to forces or beyond specified pump tolerances.
6. Vibration monitoring with automatic pump shutdown may be applicable in certain situations.

## **VALVES**

Full-bore ball valves are preferred for pigged pipelines. Gate valves, butterfly valves or ball valves may be used for pipelines that are not pigged. These valves should be made of case steel or other recommended materials. Valves should be packed with a lubricated Teflon<sup>®</sup> or other approved material.

## **INCOMPATIBLE MATERIALS**

Polyvinyl chloride (PVC), neoprene, nitrile rubber, butyl rubber and natural rubber are not recommended for use with benzene.

## **PIPELINES**

The following are recommended practices in engineering pipelines for benzene.

1. A minimum of flanged connections should be used on benzene pipelines. Flanges should be avoided due to leak potential.

2. Benzene lines should not be buried because of the difficulty of checking for leakage.
3. All lines carrying benzene should be sloped so that they can be completely drained for maintenance.
4. All newly installed benzene pipelines should be pressure-tested by an approved method before insulation is applied.
5. Bellows valves for 2 inch and smaller are recommended to eliminate emissions from packing.

## **HEAT TRACING AND INSULATION**

Heat-traced lines, valves, and pumps are necessary to prevent benzene from freezing during handling below 6°C (43°F). It is recommended that benzene should be kept above 8° C (46°F) during transfer operations.

Lines can be traced either by steam or electrical tracing. Steam tracing frequently involves tracing lines with tubing covered by insulation adequate for worst-case weather conditions. Three-eighths inch copper tubing has been found to be effective. Electrical tracing of lines with appropriate insulation may also be used; however, lines heat up more rapidly to the temperature required for benzene transfer operations when traced with steam.

Horizontal pipes are traced by running the tracing along the bottom of the pipe. Vertical lines are traced by running the tracing line with the pipe. If steam tracing is being used, a minimum of one steam trap should be used for each tracer and every 150 feet of tracing. Sixty to seventy-five psig steam is recommended in the tracing. Traced pipes should be effectively insulated.

Proper thermal pressure relief must be provided. Care should be taken in design to avoid the possibility of overheating and boiling.

## **VAPOR CONTROL SYSTEMS**

With the implementation of the Clean Air Act by Federal and local governments, benzene terminals must control evaporative emissions from loading and storage operations. For control

of these vapor emissions, the U.S. EPA has recognized two types of systems as the “Best Demonstrated Technologies.” The two recognized technologies are Hydrocarbon Vapor Recovery using the Carbon Adsorption-Absorption process and Hydrocarbon Vapor Combustion.

In absence of a regulatory requirement, closed loading should be carried out with vapor return to shore when these facilities are available.

Generally, vapor recovery systems are favored in medium-to-large terminals where a sufficient quantity of product can be recovered to justify the higher capital cost. Other factors which favor vapor recovery include easier permitting and inherent safety advantages.

**Note – Recommendations concerning the construction of either type vapor recovery systems are listed in the USCG Regulations in 33 CFR.**

## PART 4

### **ACCIDENTAL RELEASE, FIRE AND HEALTH INFORMATION**

Although benzene is considered to present potential health and flammability hazards, this material can be handled safely if proper precautions are practiced.

MSDS for benzene is available from Chevron Phillips Chemical Company to help customers satisfy their own safe handling and disposal needs, and OSHA Hazard Communication Rule requirements. Such information should be requested and studied prior to working with this product. Please call Chevron Phillips Chemical Company at (800) 852-5530 to request the MSDS for benzene.

**NOTE: THIS BOOKLET DOES NOT SUBSTITUTE FOR THE MSDS.**

#### **ACCIDENTAL RELEASE MEASURES**

If a transportation incident involving benzene does occur, the Chemical Transportation Emergency Center (CHEMTREC) should be contacted for immediate assistance. CHEMTREC is a public service organization established by the American Chemistry Council to provide assistance in hazardous material incidents. **FOR A CHEMICAL EMERGENCY CALL CHEMTREC AT (800) 424-9300 toll free in the United States, Canada, Puerto Rico, and the Virgin Islands. For emergency calls outside the United States call (703) 527-3887.**

CHEMTREC will provide the caller preliminary emergency assistance in the form of Material Safety Data Sheet (MSDS) information. In all cases once CHEMTREC determines the incident involves a Chevron Phillips Chemical material, CHEMTREC will immediately contact the on-call Chevron Phillips Chemical Company Crisis Management Team (CMT) member at 1-866-4HAZMAT (442-9628). The contacted Chevron Phillips Chemical CMT member will then be responsible for coordinating an appropriate response to the transportation incident. In addition, if the CMT member determines that the incident involves exposure or potential health effects, the on-call Chevron Phillips Chemical toxicologist will also be contacted.

Eliminate all sources of ignition in the vicinity of a spill or released vapor. Stop the source of the leak or release. Clean up releases as soon as possible, observing personal protection precautions (see below). Contain liquid to prevent further contamination of soil, surface water or groundwater. This material is toxic to aquatic organisms and should be kept out of sewage and drainage systems and all bodies of water. Clean up small spills using appropriate techniques such as sorbent materials or pumping. Contact local environmental or health authorities to notify them of the spill and for approved disposal of this material. The Reportable Quantity (RQ) for benzene under CERCLA section 302.4 is 10 pounds.

#### **SPILLS**

If benzene has been spilled, it can be removed safely for disposal. All spill activities must meet the requirements of the OSHA Hazardous Waste Operations and Emergency Response (HAZWOPER) standard 29 CFR 1910.120. If the concentration of benzene in air surrounding the spill has not been determined, assume the worst case and use the highest level of respiratory and protective clothing. Before attempting to clean up the spill, be sure that the flow of liquid has been stopped and that all sources of ignition are eliminated. Small spills (non-marine) can be removed by covering the spill with sand or a suitable absorbent. Claymax<sup>®</sup>, a loose "vermiculite-like" material has proved to be one of those effective absorbents. Claymax<sup>®</sup> may be purchased from:

Road Fabric, Inc.  
Environmental Division  
P.O. Box 1  
McCook, IL 60535  
Phone: (708)447-0088

(Contact local environmental or health authorities for guidance on how to dispose of the used absorbing agent.) If the spill is on a hard surface, the area should be scrubbed with soap and water after the bulk of the benzene has been removed.



## **DISPOSAL**

All disposal procedures are to be carried out in strict conformance to federal, state and local regulations. Recovered liquid benzene from a spill, vessel cleaning or contaminated product may be reprocessed, but if it can not be reprocessed it must be disposed of in a legally acceptable manner. Recovered material may be incinerated in a properly designed furnace. Please contact Chevron Phillips Chemical Company's Aromatics Customer Technical Service Group at (800) 852-5531 if additional assistance is required.

## **FIRE HAZARDS**

This material is extremely flammable and a fire hazard. Liquid very quickly evaporates even at low temperatures) and forms vapor (fumes) which can catch fire and burn with explosive violence. Invisible vapor spreads easily and can be set on fire by many sources such as pilot lights, welding equipment and electrical motors and switches.

For fires involving this material, do not enter any enclosed or confined fire space without proper protective equipment. This may include self-contained breathing apparatus to also protect against the hazardous effects of normal products of combustion or oxygen deficiency. Normal combustion forms carbon dioxide and water vapor; incomplete combustion can produce carbon monoxide.

Extinguish with foam, dry chemical or carbon dioxide. Use water in flooding quantities as fog; solid streams of water may be ineffective. Cool exposed containers with water.

Drainage and runoff should be controlled and collected in a remote location for recovery. Minimize spread to reduce clean up cost.

Flash Point: 12 ° F Closed Cup  
Flammable Limits in Air: 1.2 - 7.8 vol %  
Autoignition Temperature: 498°C (928°F)  
Electrical Hazard: Class 1, Group D

Behavior in Fire:

Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back

Burning Rate:

6.0 mm/min.

NFPA Fire Hazard Rating: 4

## **PERSONAL PROTECTIVE EQUIPMENT**

Do not breathe vapor or fumes. Use process enclosures, local exhaust ventilation, or other engineering controls to control airborne levels below the recommended exposure limits.

OSHA Permissible Exposure Limit: Time Weighted Average PEL - TWA = 1 ppm.

OSHA Permissible Exposure Limit – short term Exposure limit (PEL – STEL) = 5 ppm. Action level = 0.5 ppm.

Determine if airborne concentration is below recommended exposure limits for benzene. The OSHA Benzene Standard (29CFR 1910.1028) contains detailed requirements for training, exposure monitoring, respiratory protection and medical surveillance triggered by the action level and exposure limits. Refer to the OSHA Standard before using benzene. See section below on Respiratory Protection for Benzene.

Do not get in your eyes, on skin or on clothing. Wash thoroughly after handling. Wear chemical goggles and a face shield. Wear impervious protective clothing to prevent skin contact. Selection of protective clothing may include gloves, apron, boots, and complete facial protection and will depend on operations conducted. User should determine acceptable performance characteristics of protective clothing. Consider physical requirements and other substances present when selecting protective clothing. Published literature indicates that the best protection is provided by gloves and clothing made from material such as Viton<sup>®</sup> and polyvinyl alcohol (PVA). Suggested materials for protective gloves include: 4H, Silver Shield, Viton<sup>®</sup>, Polyvinyl Alcohol or PVA – Note: Avoid contact with water. PVA deteriorates in water. Additional information may obtained from (Schwope, A. et. al. "Guidelines for the Selection of Chemical Protective Clothing," ACGIH, Cincinnati, OH.).

## **ANSI REFERENCES**

ANSI Z38.1	Emergency Eye Wash and Showers Equipment
ANSI Z41.1	Safety for Footwear
ANSI Z87.1	Occupational and Educational Eye and Face Protection
ANSI Z88.2	Practices for Respiratory Protection
ANSI Z89.1	Protective Headwear for Industrial Workers

## **RESPIRATORY PROTECTION FOR BENZENE**

<b>AIRBORNE CONCENTRATION OF BENZENE OR CONDITION OF USE</b>	<b>RESPIRATOR TYPE</b>
(a) Less than or equal to 5 ppm.	(1) Half-mask air-purifying respirator with organic vapor cartridge.
(b) Less than or equal to 25 ppm.	(1) Full face piece respirator with organic vapor cartridges. (2) Full face piece gas mask with chin style canister. <sup>1</sup>
(c) Less than or equal to 50 ppm.	(1) Full face piece powered air purifying respirator with organic vapor canister. <sup>2</sup>
(d) Less than or equal to 500 ppm.	(1) Supplied air respirator with full face piece in positive-pressure mode. <sup>3</sup>
(e) Greater than 500 ppm or unknown concentration.	(1) Self-contained breathing apparatus with full face piece in positive-pressure mode. <sup>3</sup> (2) Full face piece positive-pressure supplied-air respirator with auxiliary self-contained air supply. <sup>3</sup>
(f) Escape	(1) Any organic vapor gas mask; or (2) Any self-contained breathing apparatus with full face piece. <sup>3</sup>
(g) Fire fighting	(1) Full face piece self-contained breathing apparatus in positive-pressure mode. <sup>3</sup>

<sup>1</sup>Based on 0.5 ppm American Conference of Governmental Industrial Hygienist Threshold Limit Value (ACGIH TLV).

<sup>2</sup>Canisters must have a minimum service life of four (4) hours when tested at 150 ppm benzene, at a flow rate of 64 LPM, 25° C, and 85% relative humidity for non-powered air purifying respirators. The flow rate shall be 115 LPM and 170 LPM, respectively, for tight fitting and loose fitting powered air purifying respirators.

<sup>3</sup>OSHA requires annual fit testing for respiratory equipment.

## **HEALTH HAZARDS AND FIRST AID**

**EYES:** Contact with the eyes causes irritation. Symptoms of eye irritation may include pain, tearing, reddening, swelling, and impaired vision. Flush eyes with water immediately while holding the eyelids open. Remove contact lenses if worn, after initial flushing, and continue flushing for at least 15 minutes. Get medical attention if irritation persists.

**SKIN:** Contact with the skin causes irritation. Symptoms of skin irritation may include pain, reddening, swelling and blistering. Prolonged or frequently repeated contact may cause the skin to become cracked or dry from the defatting action of this material. Benzene is absorbed through the skin; see the discussion below on inhalation for more information. Wash skin immediately with soap and water and remove contaminated clothes and shoes. Get medical attention if irritation persists. Discard contaminated clothing and shoes or thoroughly clean before use.

**INGESTION:** Harmful or fatal if swallowed. Because of its low viscosity, this material can directly enter the lungs if swallowed or vomited. Once in the lungs, it is very difficult to remove and can cause severe injury or death. If swallowed, do not induce vomiting. Give a glass of water or milk to drink and get immediate medical attention. Never give anything by mouth to an unconscious person. Note to Physician: Ingestion of this product or subsequent vomiting may result in aspiration of light hydrocarbon liquid, which may cause pneumonitis.

**INHALATION:** Breathing this material at concentrations above the recommended exposure limit may cause nervous system effects. Central nervous system effects may include headache, dizziness, nausea, vomiting, weakness, loss of coordination, blurred vision, drowsiness, confusion or disorientation. At extreme exposure, central nervous system effects may include respiratory depression, tremors or convulsions, loss of consciousness, coma or death. In some individuals, benzene exposure can sensitize cardiac tissue to epinephrine which may precipitate fatal ventricular fibrillation. Move the exposed person to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention if symptoms continue.

Repeated or prolonged breathing of benzene vapors has been associated with the development of chromosomal damage in experimental animals and various blood diseases in humans ranging from aplastic anemia to leukemia (a form of cancer). All of these diseases can be fatal. The available information on the effects of benzene on human pregnancies is inadequate, but it has been established that benzene can cross the human placenta.

**This information is not intended to, nor does it, amend or replace the MSDS for benzene. The most current MSDS should be carefully examined prior to working with this product.**

## PART 5

### TRANSPORTATION INFORMATION AND REGULATORY PROFILE

#### LABELING OF BENZENE SHIPPING CONTAINERS

Containers should be labeled in accordance with applicable OSHA and DOT requirements.

Identification numbers are required on each side and each end if the packaging capacity is 1,000 gallons or more and on two opposing sides if the packaging capacity is greater than 119 gallons but less than 1,000 gallons. Markings for non-bulk packaging (119 gallons or less) include the proper shipping name, identification number preceded by UN or NA, the technical name if applicable and the consignee or consignor's name and address.

Labels are required on non-bulk packages and must be located on the same surface and near the marking.

Placards are required on each side and each end of bulk packaging.

Requirements concerning marking, labeling, placarding, and the preparation of shipping papers vary somewhat depending on the transport mode, packaging configuration, and quantity of hazardous material being transported.

Marking, labeling and placarding requirements are explained in detail in 49 CFR 172 Subparts D, E, and F respectively. Subparts E and F show sample labels and placards. Labels and placards applicable to flammable liquids are required for benzene. Bulk containers should remain placarded when emptied unless the special requirements of Subpart F are met.

Chevron Phillips Chemical Company containers are labeled in accordance with applicable OSHA and DOT requirements.

#### **CHEMICAL DESIGNATIONS**

1. CG Compatibility Class: Aromatic Hydrocarbon
2. Formula:  $C_6H_6$
3. IMO/UN Designation: 3.2/UN1114
4. DOT ID No.: UN1114
5. CAS Registry No.: 71-43-2

#### **INTERNATIONAL MARITIME ORGANIZATION (IMO)**

Proper Shipping Name:	Benzene
Class	3.2
UN Number	UN 1114
Symbol	Flammable Liquid
Pollution Category	C
European Behavior	F, E (Floater, Evaporator) Classification

### **SHIPPING INFORMATION**

1. Grades of Purity: 99+%
2. Storage Temperature: Ambient or above 6°C, if liquid state storage is desired
3. Inert Atmosphere: No requirement
4. Venting: Vapor recovery

### **HAZARD CLASSIFICATIONS**

Code of Federal Regulations: Flammable liquid

### **NAS HAZARD RATING FOR BULK WATER TRANSPORTATION**

<u>Category</u>	<u>Rating</u>
Fire	3
Health	
Vapor Irritant	1
Liquid or Solid Irritant	1
Poisons	3
Water Pollution	
Human Toxicity	3
Aquatic Toxicity`	1
Aesthetic Effect	3
Reactivity	
Other Chemicals	2
Water	1
Self Reaction	0

### **NFPA HAZARD CLASSIFICATION**

<u>Category</u>	<u>Classification</u>
Health Hazard (Blue)	2
Flammability (Red)	3
Reactivity (Yellow)	0

Various restrictions apply to the preceding classifications. Please refer to the specific regulation for details concerning classification requirements. 46 CFR, Parts 150-154 should also be referenced for information about Coast Guard regulations governing the transport of benzene.

## REGULATORY PROFILE

### Benzene

- (1) **ODCs:** Contains Class 1 or Class 2 Ozone Depleting Chemicals (ODCs)?: **NO**
- (2) **TSCA:** Is this product or its components subject to any of the following TSCA requirements of 40CFR, Part:

707	(Export Notification) (12b)	<b>NO</b>
712	(Chemical Information Reporting) (8a)	<b>NO</b>
716	(Health & Safety Data Reporting) (8d)	<b>NO</b>
721	(Significant New Use) (5e)	<b>NO</b>
723.50	(Low Volume Exemption)	<b>NO</b>
720.36	(R&D Exemption)	<b>NO</b>
720.38	(Test Marketing Exemption)	<b>NO</b>
723.25	(Polymer Exemption)	<b>NO</b>
790	(Health and/or Environmental Effects Testing) (4e)	<b>NO</b>

Is this material distribution under limitations of a 5(e) or 5(l) Consent Order? **NO**

Have there been any Section 8(e) submissions for this material? **UNKNOWN**

- (3) **INTERNATIONAL REGISTRATION:** Are all components of this material listed on the following international inventories?

TSCA	(United States)	<b>YES</b>	
AICS	(Australia)	<b>YES</b>	
DSL	(Canada)	<b>YES</b>	
SEPA	(China)	<b>YES</b>	
EINECS	(Europe)	<b>YES</b>	(EINECS reg. no. 200-753-7)
METI	(Japan)	<b>YES</b>	(METI no. (3)-1)
PICCS	(Phillipines)	<b>YES</b>	
KMOE	(Korea)	<b>YES</b>	(KMOE reg. no. 3-1016)

- (4) **FDA:** Do FDA regulations permit use of this material as a direct or indirect food additive?

DIRECT:	<b>NO</b>	
INDIRECT:	<b>YES</b>	(21 CFR 175.105)

- (5) **HAZARDOUS METALS:** Does the sum of the concentration levels of lead, cadmium, mercury and hexavalent chromium present in this materials exceed 100 ppm by weight?  
**NO**

- (6) **ADDITIONAL REGULATORY INFORMATION:** See Chevron Phillips Chemical Company MSDS for additional regulatory information.

## **Revision Statements:**

This revision updates the following sections:

April 2005

1. Introduction
2. Part 1
  - a. Physical Properties
  - b. ASTM Benzene Specifications
  - c. Recommended Test Methods
3. Part 4
  - a. Fire Hazards
4. Part 5
  - a. Regulatory Profile

## PART 6

### APPENDIX & DEFINITIONS

#### DEFINITIONS

##### DEFINITIONS FOR THIS BROCHURE AND 29CFR PART 1910 OCCUPATION EXPOSURE TO BENZENE; FINAL RULE

1. Action Level: An airborne concentration of 0.5 ppm calculated as an 8 hour time weighted average (TWA) (0.33 ppm for 12 hour shift). An exposure at the action level triggers medical surveillance, exposure monitoring and annual training.
2. Authorized Persons: Any person specifically authorized by the company whose duties require the person to enter a regulated area, such as operators, maintenance people, supervisors, engineers, contractors, etc.  
  
Any person entering a regulated area to act as a designated representative of employees to observe exposure monitoring, etc.  
  
Any person entering a regulated area authorized by the OSHA standard itself such as an OSHA compliance officer.
3. Containers: Any barrel, bottle, can, cylinder, drum, reaction vessel, storage tank or the like, but not including piping systems.
4. Emergency Exposure: Any occurrence which results in an unexpected significant release of benzene such as a fire on benzene equipment.  
  
A significant release is one which could result in a benzene exposure exceeding the Permissible Exposure Limit (PEL). This triggers respirator use and a post-exposure urinalysis.
5. Employee Exposure: Benzene exposure which would occur if employee were not using a respirator.
6. Regulated Area: Areas where the airborne concentration of benzene exceeds or could reasonably be expected to exceed the Permissible Exposure Limit (PEL).
7. Vapor Control System: Any equipment used to contain the total vapors displaced while loading benzene and the displacing of these vapors through a vapor processing system or balancing the vapors with the storage tank. Also included are systems containing the vapors displaced from the storage tank during unloading of the vessel which balance the vapors back to the vessel.
8. Permissible Exposure Limits (PEL):  
The Permissible Exposure Limit - Time Weighted Average (PEL-TWA) = 1 ppm. Employees shall not be exposed to more than 1 ppm as an 8 hour Time Weighted Average (TWA) (.67 ppm for 12 hour shift). For shifts longer than 8 hours, such as a 12 hour shift, the adjusted TWA is calculated by:  
$$\text{TWA adj} = [(\text{TWA measured}) \times (\text{length of shift})] / 8 \text{ hours}$$
9. The Permissible Exposure Limit - Short Term Exposure Limit (PEL-STEL) = 5 ppm.  
Employees shall not be exposed to more than 5 ppm averaged over ANY 15 minute period.