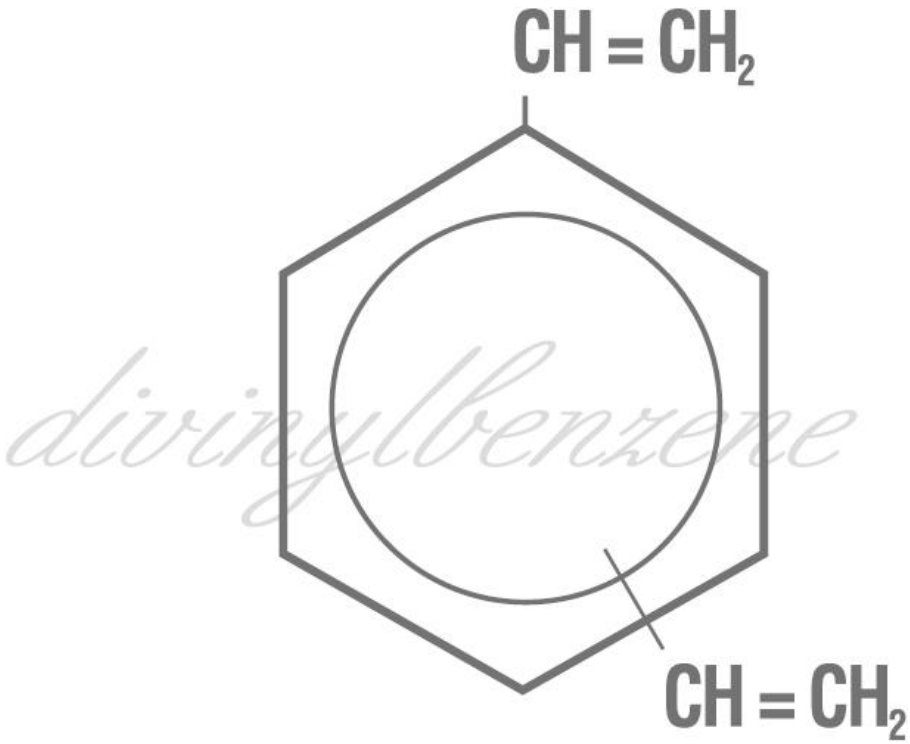
DuPont Water Solutions

Divinylbenzene (DVB) Technical Manual



Version 3

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1 Introduction

About this manual

This manual is designed to provide quick, convenient access to essential health, safety, and environmental information on divinylbenzene (DVB). DVB is a combustible, toxic, reactive material which can be handled safely only if these properties are clearly understood and proper precautions are taken. Persons handling, storing, or using DVB should be thoroughly familiar with its hazards and be trained in safe work practices.

Since the customer's specific use conditions are unknown, the precautions suggested in this manual are necessarily general in nature and cannot cover all possible situations. DuPont de Nemours Inc. will help customers establish safe work practices, but cannot accept responsibility for circumstances not under its control. Each user is fully responsible for establishing and following safe practice for use, handling, and storage.

A (Material) Safety Data Sheet ((M)SDS) for DVB is available from DuPont to help customers handle, store, and use this product. SDS are updated on a regular basis or when triggered by a relevant change. Obtain the current (M)SDS before using this product and keep a copy on hand for use by the physician in case of an emergency. Additional literature covering the use of DVB is available on request.

Emergency and technical assistance resources

IN CASE OF EMERGENCY

FOR EXPOSURE INCIDENTS:

Call DuPont Health & Safety
888-439-2988

FOR HAZMAT INCIDENTS involving Transportation, Distribution, Leaks, or Spills:

Call CHEMTREC (day or night)
Toll-free: 800-424-9300
or
Outside USA and Canada:
+1 703-527-3887
(collect calls accepted)

As part of DuPont's commitment to product stewardship, resources are available to provide essential help to protect human health and the environment in chemical emergencies. In case of emergencies involving chemical exposure or HAZMAT incidents involving transportation, distribution, leaks, or spills, call one of the phone numbers listed above or on the back cover of this manual.

2 Handling

Fire and explosion hazards

DVB is a combustible liquid requiring the same precautions against fire and explosion hazards commonly applied to other flammable liquids. When burning, this product can give off toxic byproducts such as carbon monoxide gas. Wear approved respiratory equipment to avoid breathing any fumes or smoke. Table 1 provides specific flammability and fire-fighting information.

Always take the necessary precautions to prevent the formation of explosive or combustible mixtures. If combustible mixtures are formed, make certain to avoid any actions that could lead to their ignition. Monomer handling areas must be well-ventilated, and motors must be explosion-proof or totally enclosed, fan cooled (TEFC). All equipment, tank cars, tank trucks, and hose connections must be grounded for the safe discharge of static electricity. Storage tanks and other containers that have been emptied of monomers must be flushed out with steam, nitrogen, or water to remove monomer vapor before they can be entered or worked on with welding equipment. Before entering a storage tank that has been flushed with nitrogen, check to be sure sufficient oxygen is present by using an appropriate measurement device.

Take the following precautions to assure that vapors do not ignite:

1. Conduct regular equipment inspections.
2. Repair leaks immediately.
3. Maintain good ventilation.
4. Install proper facilities to remove spills quickly.
5. Use special alloy, non-sparking tools.
6. Test pressure equipment periodically.
7. Eliminate all possible ignition sources.

At times it is also important to prevent the formation of explosive or combustible mixtures at other than normal pressures and temperatures. Although the actual operating conditions may be outside the explosive limits, the vapor system may pass through the explosive range in reaching the desired operating conditions. If the system is flushed with nitrogen or other inert gases such as helium or carbon dioxide prior to evacuation, or if such gases are used for pressurizing, potential problems can be avoided.

DVB, with its high volume resistivity, can pick up and hold a static charge during transfer from a tank truck to a storage tank. Always make sure the storage tank and the tank truck are well grounded. In addition, operators wearing rubber-soled shoes, especially on certain composition floors made of insulating materials, can pick up considerable static electricity and should exercise appropriate precautions.

For additional information and help in emergency situations, call DuPont's Distribution Emergency Response System or CHEMTREC at one of the phone numbers listed on the back cover of this manual.

Table 1. Fire and explosion hazard data

(refer to the Safety Data Sheet for the individual DVB grades)	DVB 55	DVB 63	DVB HP
Flash Point, °C (°F)	68 (155) (tag closed cup)	69 (156)	70 (158)
Autoignition Temp., °C (°F)	505 (941)	494 (921)	470 (878)
Flammable Limits (LFL) @ 85°C (185°F)	0.61	0.64	0.69
Flammable Limits (UFL) @ 120°C (248°F)	6.10	6.10	6.20
Extinguishing Media	Water fog or fine spray. Dry chemical fire extinguishers. Carbon dioxide fire extinguishers. Foam. General purpose synthetic foams (including AFFF type) or protein foams are preferred if available. Alcohol resistant foams (ATC type) may function.		
Fire and Explosion Hazards	Polymerization may take place at elevated temperatures such as in fire conditions. If polymerization occurs in a closed container, there is a possibility the container will rupture violently. Cool storage containers with water if exposed to fire. Smoke is produced when product burns.		
Fire-Fighting Equipment	Wear positive-pressure, self-contained breathing apparatus. Wear goggles if eye protection is not provided by the breathing apparatus.		

Health hazards

Persons handling, storing, or using DVB should avoid skin and eye contact with the liquid monomer and avoid breathing vapors or exposure of the eyes to vapors. While acute oral toxicity is low, this product should never be ingested. Specific health hazard information on DVB is provided in Table 2.

For additional information and help in emergency situations, call DuPont's Distribution Emergency Response System or CHEMTREC at one of the phone numbers listed on the back cover of this manual.

Table 2. Health hazard data

(refer to the Safety Data Sheet for the individual DVB grades)

Eye Contact	Causes serious eye irritation
Skin Contact	Causes skin irritation, may cause an allergic skin reaction
Skin Absorption	A single prolonged skin exposure is not likely to result in absorption of harmful amounts. The LD50 for skin absorption in rabbits in 8000 mg/kg.
Ingestion	Single dose oral toxicity is low. The oral LD50 for rats is > 2000 mg/kg (OECD 401 or equivalent). Small amounts swallowed incidental to normal handling operations are not likely to cause injury; swallowing amounts larger than that may cause injury. If aspirated (liquid enters the lung), may be rapidly absorbed through the lungs and result in injury to other body systems.
Inhalation	May cause respiratory irritation. At room temperature, vapors are minimal due to low vapor pressure. If heated or sprayed as an aerosol, excessive concentrations are attainable that could be hazardous on single exposure. Excessive exposure may cause irritation to upper respiratory tract and lungs. Lethargy may be a sign or symptom of excessive exposure. Signs and symptoms of excessive exposure may be anesthetic or narcotic effects. Vapors produced by heating divinylbenzene to 120°C or greater were toxic or lethal to rats upon short exposure.
Systemic and Other Effects	Suspected of damaging fertility or the unborn child. Toxic or very toxic to aquatic life with long lasting effects

Reactivity hazards

DVB is a reactive monomer which will polymerize with potentially hazardous results under certain conditions including high temperatures, low inhibitor concentration, low oxygen content, and contamination. The monomer evolves considerable heat during polymerization. For example, the heat of polymerization for DVB is 21 – 22 kcal per mole of monomer. If none of this heat were lost in an enclosed system, the temperature of the monomer would be raised over 350°C.

During the first stage of polymerization, the monomer is sufficiently fluid to remove excess heat by convection. But further polymerization increases viscosity and reduces convective heat transfer, allowing temperature to build. Toward the end of polymerization, the rate of heat evolution decreases because the monomer is depleted. The temperature of polymerization, purity of the monomer, and other physical and chemical factors all influence the rate of polymerization and the extent of temperature increase.

The polymerization process is autocatalytic in nature and any temperature rise accelerates the rate of polymerization, which in turn increases the rate of heat evolution. Eventually, the reaction may become explosive, especially in closed containers where the vapor pressure of the monomer builds rapidly. Table 3 gives specific reactivity data on DVB. For additional information and help in emergency situations, call DuPont's Distribution Emergency Response System or CHEMTREC at one of the phone numbers listed on the back cover of this manual.

Table 3. Reactivity data, all DVB grades

Stability (Storage conditions)	Polymerizes easily. Store below 27°C (80°F). Do not store in direct sunlight. Maintain inhibitor and dissolved oxygen concentration.
Incompatibility (Specific materials to avoid)	Acid, oxidizing material; metallic halides (salts); polymerization catalysts, clay absorbents; copper and copper alloys.
Hazardous Decomposition Products	Polymerizes upon heating, evolving heat and vaporizing monomers.
Hazardous Polymerization	May occur under certain conditions, including increased heat, monomer contamination, low inhibitor concentration, and low oxygen concentration. Store DVB in a cool place away from direct sunlight and maintain proper concentrations of inhibitor and oxygen. Avoid contact with metallic (halide) salts such as ferric and aluminum chlorides, peroxides, and other polymerization catalysts. Do not use clay absorbents.

Handling precautions

Extensive experience has shown that divinylbenzene can be handled safely if its flammability, reactivity, and toxicological properties are clearly understood and proper precautions are practiced. Table 4 lists general handling precautions that must be observed when handling, storing, or working with DVB.

Table 4. Handling precautions

(Refer to the Safety Data Sheet for the individual DVB grades)

Exposure Guidelines	ACGIH TLV and OSHA PEL are 10 ppm.
Ventilation	Use local exhaust ventilation, or other engineering controls to maintain airborne levels below exposure limit requirements or guidelines. If there are no applicable exposure limit requirements or guidelines, general ventilation should be sufficient for most operations. Local exhaust ventilation may be necessary for some operations.
Respiratory Protection	Respiratory protection should be worn when there is a potential to exceed the exposure limit requirements or guidelines. If there are no applicable exposure limit requirements or guidelines, wear respiratory protection when adverse effects, such as respiratory irritation or discomfort have been experienced, or where indicated by your risk assessment process. Use an approved air-purifying respirator when vapors are generated at increased temperatures or when dust or mist is present. Use the following CE approved air-purifying respirator: Organic vapor cartridge with a particulate pre-filter, type AP2.
Skin Protection	Use protective clothing impervious to this material. Selection of specific items such as gloves, boots, apron, or full-body suit will depend on operation. See SDS.
Eye Protection	Use safety glasses (with side shields). Safety glasses (with side shields) should be consistent with EN 166 or equivalent.
Additional Information	Practice care and caution. Hazardous polymerization can occur under certain conditions, including increased temperature, low inhibitor concentration, and low oxygen concentration. To minimize this possibility, store in a cool place away from direct sunlight and maintain proper concentrations of inhibitor and oxygen. Monitor and control the t-butyl catechol (TBC) inhibitor level at 900 – 1100 ppm. The monomer should be aerated according to the instructions given in the Storage section. Store below 29°C (85°F); ideal storage temperature is 26°C (78°F) or lower. Avoid skin and eye contact. Avoid breathing vapors.

Protective clothing and equipment

DVB is a solvent for many rubber-based and synthetic rubber products, so selection of protective clothing requires particular care. Consideration of the available chemical resistance test data for chemical protective clothing materials with DVB and similar compounds leads to the following order of preference for chemical resistance: Ethyl vinyl alcohol (EVAL) laminate, Viton® fluoroelastomer, butyl rubber, nitrile, Saranex film, and neoprene.

First aid recommendations

Table 5 provides a brief summary of first aid recommendations for DVB. A copy of the current (M)SDS for this product should be kept on hand for emergency use and transported along with the patient to a medical facility. For additional information and help in emergency situations, call DuPont's Distribution Emergency Response System or CHEMTREC at one of the phone numbers listed on the back cover of this manual.

Table 5. First aid recommendations

(see Safety Data Sheet for the individual DVB grades)

General advice	First Aid responders should pay attention to self-protection and use the recommended protective clothing (chemical resistant gloves, splash protection). If potential for exposure exists refer to Section 8 for specific personal protective equipment.
Inhalation	Move person to fresh air. If not breathing, give artificial respiration; if by mouth to mouth use rescuer protection (pocket mask, etc). If breathing is difficult, oxygen should be administered by qualified personnel. Call a physician or transport to a medical facility.
Skin contact	Remove material from skin immediately by washing with soap and plenty of water. Remove contaminated clothing and shoes while washing. Seek medical attention if irritation persists. Wash clothing before reuse. Discard items which cannot be decontaminated, including leather articles such as shoes, belts and watchbands.
Eye contact	Flush eyes thoroughly with water for several minutes. Remove contact lenses after the initial 1 – 2 minutes and continue flushing for several additional minutes. If effects occur, consult a physician, preferably an ophthalmologist.
Ingestion	If swallowed, seek medical attention. Do not induce vomiting unless directed to do so by medical personnel.
Note to Physician	Maintain adequate ventilation and oxygenation of the patient. May cause asthma-like (reactive airways) symptoms. Bronchodilators, expectorants, antitussives and corticosteroids may be of help. If burn is present, treat as any thermal burn, after decontamination. No specific antidote. Treatment of exposure should be directed at the control of symptoms and the clinical condition of the patient. Repeated excessive exposure may aggravate preexisting lung disease.

Environmental and disposal information

Table 6 provides information on disposal and action to take in the event of accidental spills. For additional information and help in emergency situations, call DuPont's Distribution Emergency Response System or CHEMTREC at one of the phone numbers listed on the back cover of this manual.

Table 6. Environmental and disposal information

Action to Take for Spills / Leaks	Small spill: Absorb with cellulose-based absorbents or absorbent polymers. Collect in suitable and properly labeled containers. Do not use clay-type absorbent sweeping compounds. Large spill: Dike area to contain spill. Pump with explosion proof equipment. Eliminate all sources of ignition in vicinity of spill or released vapor to avoid fire or explosion. Check area with combustible gas detector before reentering area. Ground and bond all containers and handling equipment. Prevent from entering into soil, ditches, sewers, waterways and/or groundwater.
Disposal Method	Incinerate in properly designed furnace. Comply with federal, state, and local regulations.

3 Storage

Preventing premature polymerization

Polymerization is generally the greatest concern during shipment and storage of DVB. Under certain conditions (i.e., increased heat, low inhibitor concentration, and low oxygen content), rapid, runaway polymerization may occur with potentially hazardous consequences such as excessive heat and pressure buildup.

TBC (4-tert-butylcatechol) is added to DVB to inhibit polymer formation and oxidative degradation. When sufficient oxygen is present, TBC prevents polymerization by reacting with oxidation products (monomer peroxy free radicals) in the monomer. In the absence of oxygen, however, polymerization will proceed as if no inhibitor were present.

Preventing polymerization and thus maintaining shelf stability of DVB involves 4 major precautions:

1. Maintaining the inhibitor level above a minimum concentration.
2. Maintaining the oxygen content of the monomer.
3. Storage at proper temperatures.
4. Using recommended materials of construction for storage and handling equipment.

Maintaining inhibitor level

The minimum TBC concentrations or “danger levels” are given in Table 7. During storage, the inhibitor level of DVB must be checked at regular intervals (Table 8) and inhibitor added as required to maintain the TBC concentration above minimum levels.

Table 7. Minimum inhibitor levels of DVB

TBC Concentration as Shipped	Minimum TBC Concentration
900 – 1,100 ppm	400 – 600 ppm

TBC loss in stored monomer

The time required for TBC concentration to fall to a dangerously low level varies greatly for different storage conditions. Figure 1 shows typical depletion rates in styrenic monomers at room temperature under laboratory conditions. Actual depletion rates may be much faster or slower depending on environmental conditions.

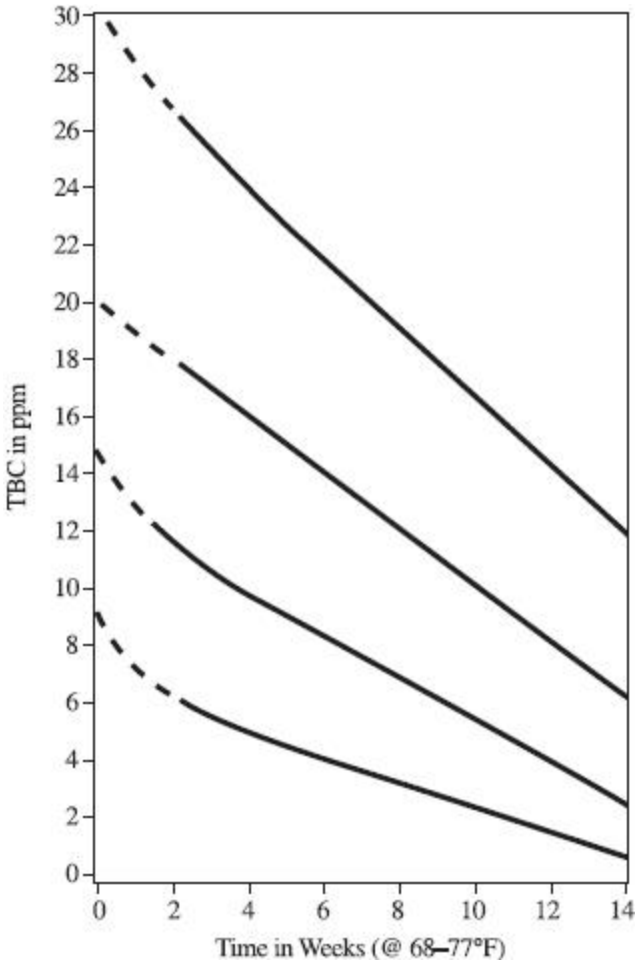

Figure 1. Typical TBC loss in styrenic monomers

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Table 8. Suggested bulk storage maintenance schedule

Check Point	DVB
Inhibitor Analysis	Monthly *
Polymer Analysis	Monthly *
Color	Monthly
Monomer Temperature	Daily
Inspection Points:	
1. Air vent	At least quarterly
2. Roof	Yearly
3. Sides	Yearly
4. Floor	Yearly
5. Vacuum pressure relief	At least quarterly
Date of Last Filling	Running log
Volume Before Filling	Running log
Volume After Filling	Running log

* In the event that temperature control is lost and storage temperature exceeds 80°F, inhibitor and polymer should be measured.

Adding TBC to stored monomer

The concentration of TBC can be measured by ASTM Method D4590 (or equivalent). The relatively small quantities of TBC required to raise the inhibitor level in stored monomer can be easily added by using a five or ten percent stock solution of TBC in the monomer. The storage tank (or drum) should always be recirculated (or mixed) after inhibitor is added. The tank or drum should also be aerated as necessary.

A concentrated stock solution of TBC in DVB can be prepared by dissolving 704 grams of pure TBC in 1 gal of the monomer (186 grams/liter). At this concentration, 1 cc of the concentrate will raise the level of inhibitor 1 ppm in a drum of DVB with a net weight of 410 lb.

Adding TBC to polymerizing monomer

If the inhibitor has been depleted and polymerization has already begun, TBC should be added immediately and DuPont de Nemours Inc. or its representative notified as soon as possible (Call DuPont's Distribution Emergency Response System phone number listed on the back cover of this manual). If unstable monomer is not treated promptly, it may become unsalvageable and may also cause excessive heat and pressure build-up.

Do not add solid TBC to polymerizing monomer. Use a five or ten percent stock solution of TBC in the monomer or other compatible hydrocarbons, such as ethylbenzene or toluene. Anyone storing or handling quantities of these monomers should keep stock TBC solutions on hand for emergencies. Refer to the TBC (M)SDS for handling precautions.

Maintaining oxygen content

TBC is an effective inhibitor only when dissolved oxygen levels in the monomer are adequate. If the oxygen level is allowed to drop below the minimum shown in Table 9, rapid polymerization can occur with potentially hazardous results. An effective test to determine whether polymer is forming in the monomer is ASTM Method D2121 "Standard test methods for Polymer Content of Styrene Monomer and AMS (alpha-methylstyrene)". This test, used in conjunction with the test for TBC level, provides a quick means of monitoring monomer condition on site.

Table 9. Minimum oxygen content in stored monomer

Monomer	Oxygen Content as Shipped	Minimum Oxygen Content
DVB	28 – 30 ppm (saturated)	10 – 15 ppm

The importance of storage temperature

Other factors that affect the depletion of TBC are exposure to heat, caustic soda, aluminum oxide, and ion exchange beads. Temperature in the monomer storage area should not be allowed to exceed 27°C (80°F) for DVB. In hot climates or during hot seasons where temperatures exceed these limits, the monomer bulk storage installation (or stored drums) should be refrigerated.

Drums of monomer should not be kept in the sun. As soon as monomer is received, it should be placed in a cool, shaded area. In very hot weather, drums can be temporarily cooled with water spray. It is advisable to keep monomer inventories to a minimum during hot weather, and to use drums in the order they are received so that monomer is not stored any longer than necessary.

Recommended storage conditions

Effective storage lifetime of divinylbenzene is entirely contingent on management of product storage temperature, TBC level (ASTM Method D4590), and dissolved oxygen content, which can be managed via timely aeration. If all three of these factors are managed carefully, divinylbenzene can be stored indefinitely so long as polymer formation is not observed (ASTM Method D2121).

Timely aeration is key to extending the viable storage time of DVB. A 5 – 10 minute air sparge is recommended on a monthly basis for drums and pails stored at temperatures between 21 – 27°C (70 – 80°F). DVB containers stored at temperatures from 4 – 21°C (40 – 70°F) need to be aerated according to Table 10. With aeration and maintenance of p-tert butyl catechol (TBC) level above 400 – 600 ppm the clock is effectively reset to the recommended storage times.

Table 10 describes the recommended aeration schedule and testing frequency for polymer formation and inhibitor concentration under maximum ambient storage temperatures. If the DVB cannot be tested for polymer formation and inhibitor concentration, then it is recommended that the maximum storage in absence of testing be followed as shown in Table 10.

Table 10. Recommended storage conditions and retest frequency of DVB (all grades)

Storage Temperature	Testing Frequency	Aerate Within	Maximum Storage in absence of testing
< 4°C (40°F)	Monthly	6 months	12 months
4 – 10°C (40 – 50°F)	Monthly	6 months	8 months
10 – 16°C (50 – 60°F)	Monthly	4 months	4 months
16 – 21°C (60 – 70°F)	Monthly	2 months	2 months
21 – 27°C (70 – 80°F)	Monthly	1 month	1 month

In the event that temperature control is lost and storage temperature exceeds 80°F, inhibitor and polymer should be measured and temperature control returned.

4 Bulk storage of DVB

DVB is similar in many respects to styrene and can be stored in bulk for relatively long periods if carefully prescribed storage conditions are met. In addition to the usual precautions taken with combustible liquids, conditions conducive to polymerization and oxidation must be prevented.

This can be accomplished by designing a bulk storage system that prevents excessive temperatures and contamination of the monomer. The system must also conform to insurance underwriters' codes and to local fire and building regulations. Figure 2 shows a typical monomer storage layout suitable for DVB.

Copper-containing alloys should never be used in storage and handling equipment for DVB. Oxidation products from copper alloys can interfere with normal polymerization. Rubber parts should also be avoided because the monomers are solvents for natural rubber and most synthetic rubbers.

Three different design philosophies are considered in the development of bulk storage solutions for DVB. They are ranked here, in order of preference:

1. Continuous air addition with recirculation and cooling. This is the best storage option for DVB as it incorporates all best practices for preventing DVB polymerization.
2. Air addition and recirculation. Even without active cooling, keeping DVB moving and aerated is the second best option.
3. Intermittent air addition and recirculation. This is the least preferred method as temperature and storage time become increasing concerns due to intermittent handling of aeration and recirculation.

Special problems in the storage of DVB

Air presents a complex problem in the bulk storage of DVB. While TBC is not an effective inhibitor in the complete absence of dissolved oxygen, excessive amounts of oxygen in the storage tank can also lead to problems such as formation of unstable peroxides.

The major problem is that monomer vapors above the liquid level in the tank are uninhibited. When these vapors condense, the droplets are readily oxidized by oxygen and polymerize quite rapidly.

The polymer adheres to porous surfaces of unlined tank roofs and sidewalls, forming a coating of stalactites (polymer "icicles") above the liquid level. The same condition, although less severe, will also occur in lined tanks.

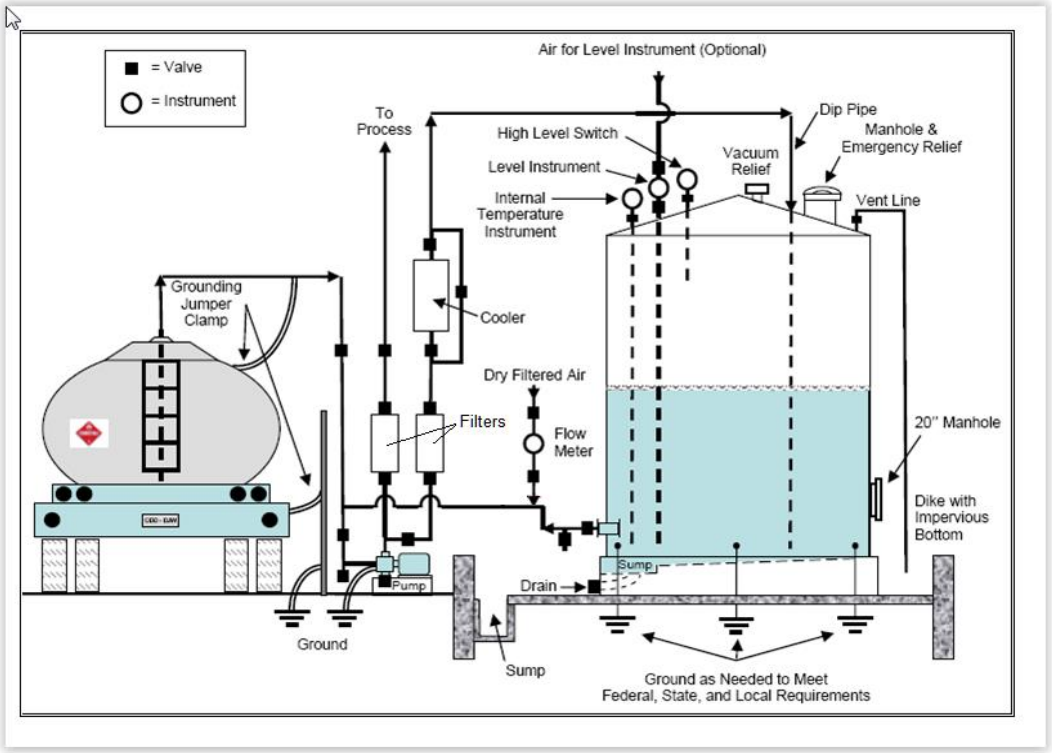


Figure 2. Monomer storage installation

The polymer deposited under these conditions will be discolored, crosslinked, and high in peroxides, aldehydes, and other oxidation products. Deposits of contaminated polymer will eventually produce serious color and polymer problems in monomer stored under air in unlined steel tanks. Internal reflux (the vaporization and condensation due to normal temperature differentials) will dissolve small amounts of this polymer and carry it back into the tank, increasing the polymer content of the stored monomer. Minimizing mechanical structures at the top part of the storage tank will help reduce this problem.

While too much oxygen causes problems, the complete elimination of oxygen from the vapor area will lead to depletion of dissolved oxygen in the liquid monomer. If this dissolved oxygen is not replaced and is allowed to drop below 15 ppm, the inhibitor becomes ineffective and rapid polymerization may result. Do not blanket with nitrogen. If an inert blanket of nitrogen is suspected of being used, a 10,000-gallon tank should be aerated with 1 standard cubic feet of dry air per hour or 0.028 standard cubic meters per hour for 4 hours.

DVB stored in drums should be air sparged for 5 – 10 minutes at a frequency in accordance with Table 10 of this publication. The air hose should be clean and dry. Avoid water contamination, since water will react with TBC and iron to form a black sediment, contaminating the monomer.

Reducing oxidation and side reactions

To reduce oxidation and hold side reactions to a minimum, stored DVB must be kept cool. Depending on the storage location, various methods can be used including refrigeration, reflective painting, and shading.

Large above-ground tanks with a low throughput or turnover rate should be insulated and cooled by external refrigeration with circulation of the contents.

Painting exterior storage tanks with white or other light-reflecting paint also minimizes the absorption of sunlight, reducing heat gain. Slatted shade in open areas where ventilation is assured has proven satisfactory for the protection of small above-ground tanks, pumps, filters, and other handling equipment.

Removing polymer build-up

Polymer deposits in tanks cause difficult removal and cleaning problems. If stalactites are allowed to grow, their weight may even damage the roof or roof-supporting structure of large vertical storage tanks. Polymer build-up on the inside of storage tanks should be removed by draining the tank completely, then discharging live steam into the open tank for 4 – 5 days. The condensate water must be removed from the tank during the heating process to ensure that all tank surfaces are adequately heated. This will harden polymer formations so that they can be removed mechanically. Note: Tanks must be tested and found to be free of harmful vapors and contain sufficient oxygen concentration before entry is made.

Containers for DVB

Selection of the proper container for DVB is important for maintaining monomer purity and stability. Lined and unlined black iron, aluminum, and stainless steel are all satisfactory for shipment or storage containers.

Avoid copper and copper-bearing alloys such as brass and Monel alloy. The oxidation products of copper are picked up by the monomer and by the organic oxidation products present in the monomer. This yields soluble copper salts which inhibit polymerization. The presence of copper salts can be detected by the greenish blue color they sometimes impart to the stored monomer. Some common reagents such as sulfuric acid, phosphoric acid, hydrochloric acid, iron chloride, and other metallic halides catalyze violent polymerization reactions of DVB. Before refilling used containers, make sure they are inspected and cleaned to remove reagent residues or old monomer that contains polymer and oxidation products that could cause contamination or reaction. Drums used for DVB should not be reused or resold. DuPont recommends that customers properly wash the containers, then scrap or destroy them in accordance with local, state, and federal regulations.

Tank construction

Black-iron storage tanks are generally the most economical. Vertical tanks are generally used for large volume storage. Horizontal tanks are also satisfactory, but are more suited for smaller installations.

A self-supporting, dome-type roof is recommended for vertical storage tanks. This simplifies the installation of linings and permits rapid drainage of uninhibited vapors back into the liquid monomer—thus reducing polymer and stalactite problems. The roof and sidewall openings above the normal liquid level should be large in diameter, and kept to a minimum number. Large diameter openings are easily lined and can often serve dual purposes.

Inlet and outlet lines for vertical tanks are usually located near the bottom of the tank. If external refrigeration is used, the inlet and outlet lines should be kept as far apart as possible so eddy currents induced by temperature differences between the chilled and stored monomer will cause relatively uniform mixing. In addition, an elbow on the inlet line inside the tank helps to direct cooled fluid upward for better temperature control of the monomer. The discharge should always be below the liquid level to prevent static buildup.

You can fill the storage tank from the bottom, or from the top with a line extending to the bottom. The monomer should not be allowed to fall through free air space in the tank due to the possibility of static build-up.

Tank linings

Smooth, non-porous, not-wettable tank linings help control polymer and stalactite formation by causing condensed, uninhibited monomer to quickly drain back into the pool of inhibited monomer before polymerization can take place.

Baked phenolic, modified epoxy, and catalyzed epoxy lining are all satisfactory. While these coatings are non-conductive, it is recommended that the bottom and lower 6 – 8 inches of vertical storage tanks be coated with inorganic zinc silicate linings to provide electrical grounding.

Although other comparable coatings are available, you should check their resistance characteristics and obtain information on their suitability for monomer storage from the manufacturer before use. Rubber-based linings should never be used.

Pumps

Pumps made of most materials other than copper or plastic are suitable for DVB. Centrifugal pumps with enclosed impellers and mechanical seals are most widely used, but displacement pumps are also satisfactory.

Make sure that pumps are not allowed to run when valves are closed. The heat evolved by pumping against a "deadhead" may be enough to polymerize monomer in the pump and cause contamination.

Totally enclosed, fan-cooled pump motors are acceptable. Their switching gear should be of an approved type listed in the National Electrical Code, with particular attention to Articles 250, 500, 501, and 515; and to sections covering Class 1, Division 2 locations. All metal should be properly grounded to avoid the danger of static charge build-up.

Installation design should allow for complete drainage of the storage system and recirculation of the monomer through the system. This is especially important when equipment is in intermittent service or where monomer is stored for extended periods.

Lines and valves

Thermal expansion in blocked lines exposed to the sun without relief protection can result in failures of gaskets, pump seals, and pump housings. Lines should be laid out to allow for complete drainage. Transfer lines should be blown out with air after use.

Lines may be constructed of iron or galvanized pipe. Do not use copper or bronze pipe. Oxidization products of these metals can inhibit polymerization. Transfer lines are typically joined by welded joints or flanges, but threaded joints are also satisfactory. Pipe dope can be dissolved by the monomer, causing discoloration and contamination. You can avoid this by wrapping the pipe threads with plastic tape coated with Teflon resin.

A fusible link or equally effective internal safety shut-off valve should be included to close off the lines if excessive heat develops. You should also include separate drain lines, properly valved and closed, to allow complete drainage of the system when necessary. Drainage from horizontal tanks can be assisted by sloping the tanks toward the drains. Floors of large vertical tanks can be tilted toward a small built-in sump with a bottom drain.

All valves below the liquid level should be steel or ductile iron to prevent breakage from freezing or mechanical stress. Lubricated plugcocks and non-lubricated ball-type valves lined with Viton® fluoroelastomer give excellent service with stainless steel balls and are highly recommended.

Seals and gaskets

DuPont recommends that all seals and gaskets used in handling DVB be made of Viton® fluoroelastomer or Teflon resin. Table 11 lists specific pump seals and gaskets that have proven satisfactory. Similar materials from other manufacturers may work equally well.

Breathers

Air-blanketed, non-pressurized storage tanks for DVB should be fitted with approved vents according to local codes. You should also install additional venting facilities for pressure and vacuum relief to protect the tank in case of sudden pressure buildup or vent plugging. Frangible safeties or vacuum-pressure safety relief valves are recommended for this purpose on smaller units. On larger storage facilities, manhole emergency pressure relief venting as well as vacuum-pressure relief valves are recommended to assure protection against tank collapse under vacuum. In addition, inspect all vents at least every 6 months for polymer plugging.

Monitoring instrumentation

Float-type, dial-reading gauges are acceptable, but for remote readings we recommend flange-mounted differential pressure transmitters. All storage tanks should also contain either a local temperature indicator, or a temperature sensor for remote reading.

Flexible transfer hoses

Static-conductive composition hoses and flexible metal hoses are widely used for handling DVB. Of the composition hoses, those made of Viton® fluoroelastomer give the best service. Neoprene hoses do not have sufficient aromatic resistance. Of the flexible metal hoses, woven metal types are the most satisfactory, but require more attention than composition hoses to prevent damage and to keep properly cleaned. All lines should be adequately grounded to discharge static electricity.

Never allow monomer to stand in composition hoses. DVB can attack the interior of the hose, shortening hose life and causing monomer contamination.

Completely remove all residual monomer and thoroughly clean all transfer lines in intermittent service. Lines should be carefully inspected for structural integrity before use. We recommend preventative maintenance for flexible transfer lines.

Table 11. Recommended seals and gaskets for DVB

Pump seals	Gaskets
John Crane Type 9T – V wedge coated with Teflon Resin; carbon face seal; Runs against tungsten carbide seat; Stainless steel hardware.	Flexitallic 316SS – Flanged joint, spiral wound, with expanded graphite filler and inner ring. Flexitallic Gasket Co., http://www.flexitallic.com/contact
John Crane Type 8-1T– O-ring coated with Viton® fluoroelastomer; carbon face seal; Runs against carbon seat; Stainless steel hardware.	Unilion BS2815 Grade A BS1832, 1/16 inch compressed. https://www.jameswalker.biz/en/locations
John Crane Type 20R – Glass filled; coated with Teflon resin; carbon face seal; Runs against tungsten carbide seat; Stainless steel hardware.	

5 Appendix

Table 12. Typical chemical analysis

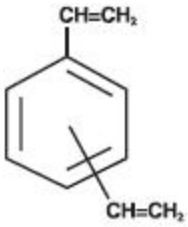
Divinylbenzene			
Structural Formula			
			
	DVB-55	DVB-63	DVB-HP
Total Divinylbenzene	~56%	~63.5%	~80.0%
Meta:Para Divinylbenene isomer ratio	2.3	2.3	2.3
Total Ethylvinylbenzene	~43.0%	~35.5%	~19.0%
Meta:Para Ethylvinylbenzene isomer ratio	2.3	2.3	2.3
Diethylbenzene	< 0.05%	< 0.05%	< 0.05%
Naphthalene	< 0.04%	< 0.04%	< 0.04%
Benzene content	Not detectable	Not detectable	Not detectable
t-Butyl Catechol inhibitor	900 – 1100 ppm	900 – 1100 ppm	900 – 1100 ppm
Color (Gardner)	< 4	< 4	< 4
Polymer	< 5 ppm	< 5 ppm	< 5 ppm

Table 13. Physical properties of DVB

		Divinylbenzene		
Property	Temp. °C	DVB 55	DVB 63	DVB HP
Molecular Weight		130.191	130.191	130.191
Boiling Point, °C (°F) at 760 mmHg		195 (383)	197 (387)	200 (392)
Density, g/cc	20	0.9123	0.9151	0.9211
	25	0.9084	0.9111	0.9167
	30	0.9044	0.907	0.9124
Density, lb/gal	20	7.61	7.64	7.69
	25	7.58	7.6	7.65
Flammable Limits, Volume % in air		0.67 – 6.1	0.64 – 6.1	0.69 – 6.2
Flash Point, °C (°F), tag closed cup		68 (155)	69 (156)	70 (158)
Auto Ignition Temp., °C (°F)		505 (941)	494 (921)	470 (878)
Freezing Point, °C		< -50	< -50	< -50
Heat of Polymerization, ΔHv, cal/mole	25	~-32		
Heat of Vaporization, ΔHv, cal/g	25	101.3	96.9	94.9
	@ BPt	83.8	79.4	77.4
Refractive Index, D-Line	25	1.5585		
Solubility of Water in, %	25	0.054	0.054	0.054
Surface Tension, dynes/cm	25	32.10	0.054	0.054
Vapor Pressure, mmHg	0	0.07	0.08	0.08
	25	0.6	0.6	0.6
	50	3.0	2.9	2.8
	75	11.7	11.4	10.7
	100	36.2	35.0	33.0
	125	93.8	91.1	86.3
	150	212.4	207.1	197.7
	175	406.5	422.3	
	200	764.8	788.2	
Viscosity, cP	25	1.0	1.0	1.0
Cubical Coefficient of Expansion	20	8.66×10^{-4}	8.66×10^{-4}	8.65×10^{-4}
	30	8.74×10^{-4}	8.74×10^{-4}	8.70×10^{-4}

Table 14. Recommended materials of construction

	DVB
Materials Specifically Not Recommended	Avoid copper and copper-bearing alloys such as brass and Monel alloy. Avoid rubber-based and synthetic rubber materials.
Conditions Specifically Not Recommended	Avoid any conditions that accelerate the depletion of TBC, including exposure to heat, caustic soda, aluminum oxide, and ion exchange resins.
Tanks	Black-iron tanks are generally the most economical.
Pumps	Most pumps, except those made of copper or plastic, are suitable.
Lines and Valves	Iron or galvanized pipe is acceptable. Do not use copper or bronze. Valves below liquid level should be steel or ductile iron to prevent breakage from freezing or mechanical stress. Plugcocks. and stainless steel ball valves lined with Viton fluoroelastomer are recommended.
Gaskets and Seals	Gaskets made of Viton fluoroelastomer or Teflon resin are recommended. Pump seals made of these materials run against carbon or tungsten carbide seats with stainless steel hardware have proven satisfactory.
Flexible Transfer Hoses	Composition hoses made of Viton fluoroelastomer give the best service. Flexible metal hoses are also satisfactory, but require more care to keep clean.

Table 15. Regulatory informationDangerous Goods transport classifications for DVB 55, 63, HP

Please note, the classifications below only apply to bulk shipments, so the most severe classification. For the classifications related to the specific shipment quantity please refer to the shipping documents accompanying that shipment.

DVB 55 (Real sub 101198772)	
	Sea (IMDG) / Air (IATA) / European road/rail (ADR) / Canada (TDG) and major country regulations UN3532, POLYMERIZING SUBSTANCE, LIQUID, STABILIZED, N.O.S. (Divinylbenzene, Benzene, ethenylethyl-) + Environmentally hazardous
	United States road/rail (CFR) NA1993, Combustible liquid, n.o.s. (Divinylbenzene, Benzene, ethenylethyl-)
	Argentina, Uruguay, Paraguay UN3082, ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S. (Divinylbenzene, Benzene, ethenylethyl)
DVB 63, HP (Real sub 101199473 and 101198491)	
	Sea (IMDG) / European road/rail (ADR) / Canada (TDG) and other major country regulations UN3532, POLYMERIZING SUBSTANCE, LIQUID, STABILIZED, N.O.S. (Divinylbenzene)
	Air (IATA) UN3534, POLYMERIZING SUBSTANCE, LIQUID, TEMPERATURE CONTROLLED, N.O.S. (Divinylbenzene) – Forbidden for air transport by regulation
	United States road/rail (CFR) NA1993, Combustible liquid, n.o.s. (Divinylbenzene, Benzene, ethenylethyl-)
	Argentina, Uruguay, Paraguay UN3082, ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S. (Divinylbenzene)

IN CASE OF EMERGENCY

FOR EXPOSURE INCIDENTS:

Call DuPont Health & Safety
888-439-2988

FOR HAZMAT INCIDENTS involving Transportation, Distribution, Leaks, or Spills:

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or
Outside USA and Canada:
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(collect calls accepted)

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