Shell Chemical Appalachia LLC
300 Frankfort Road
Monaca, PA 15061

December 17, 2025

Alexander Sandy
Air Quality Engineering Specialist
Air Quality Program
Pennsylvania Department of Environmental Protection

Re: Shell Chemical Appalachia LLC
Shell Polymers Monaca
Flare Gas Recovery Additional Information (Redacted)

As requested by the Pennsylvania Department of Environmental Protection ("DEP") in a November 3, 2025 letter, and in support of the Shell Polymers Monaca ("SPM") plan approval application submitted on September 13, 2024, Shell Chemical Appalachia LLC ("Shell") is providing further supporting and clarifying information in regards to Shell's conclusion that Flare Gas Recovery (FGR) is not technically feasible at the facility.

Confidential Business Information (CBI) has been redacted from this letter. The original letter dated December 5, 2025, contains information that is considered CBI under 40 CFR Part 2 and Pennsylvania Air Pollution Control Act, 35 P.S.§4013.2.

If you have any questions regarding this additional information, please contact me at (724) 709-2906 or laura.l.sabolyk@shell.com.

Sincerely,

Laura Sabolyk

Laura Sabolyk

Senior Regulatory Advisor
Shell Polymers Monaca

Executive Summary

This document provides further review and context on Lowest Achievable Emission Rate (LAER) and the LAER analyses and determinations for flares located at Shell Polymers Monaca (SPM). The document also serves to provide engineering evaluations, data, and calculations where applicable in support of the determination that flare gas recovery systems (FGRS) are not technically feasible at SPM as requested in a letter from DEP on November 3, 2025 in response to a September 23, 2025 submittal from Shell.

An overview of FGRS and SPM's flares is first provided for context. While the previous LAER analyses have been updated in the recent permitting effort, the basis behind the recommendations and subsequent DEP determinations has not changed. A summary of the conclusions presented herein is as follows:

Achieved in Practice

FGRS has not been achieved in practice at the same class or source category as SPM, and FGRS has not been achieved in practice at polyethylene (PE) manufacturing units.

While demonstration is provided in Section III that shows FGRS has not been achieved in practice for the same class or source category, a detailed technical feasibility review is provided herein to further support the determination that FGRS is not LAER at SPM.

- The recovery and use of waste gas as a feedstock, product, co-product, or by-product is not technically feasible at SPM.
- Recovery and use of waste gas as fuel gas is not technically feasible at SPM due to the quantity of the waste gas.
- Due to the quality of the gas, it is not technically feasible to use waste gas as fuel for the fuel gas combustion units at SPM. The Ethane Cracking Unit (ECU) furnace burners are not designed to combust fuels other than natural gas and tail gas, and the Cogeneration Units are not designed to combust fuels other than pipeline specification natural gas.

While demonstration is provided in Section IV.B.A that it is not technically feasible to use the facility's waste gas as fuel at the fuel gas combustion devices at SPM, a detailed review is provided herein to further support that the waste gas streams are not suitable for recovery and use as fuel gas:

- Recovery of the PE vents to the HP Flare System is not technically feasible due to nitrogen content of the vent and the infrequent nature of the venting.
- Recovery of the PE 1 and 2 episodic vents is not technically feasible due to the nitrogen content and infrequent nature of the venting.
- Recovery of the railcar loading and unloading vent streams and use of fuel gas is not technically feasible due to either the infrequent nature of the activity or due to the heavier hydrocarbons present in the materials which are loaded or unloaded.

- The recovery and use of SSM vents from the ECU as fuel gas is not technically feasible due to the absence of fuel gas consumers for the excess fuel gas created during these events and due to the infrequent nature of the venting.
- The recovery and use of the routine vents from the ECU as fuel gas is not technically feasible as the actual VOC content is not consistently available for recovery, and even if that content were consistently available, additional natural gas would be required to offset the heat content loss at the flares for NHVcz.

I. Flare Systems and FGRS Overview

A. SPM Flare Systems

SPM has three VOC Control Systems: the High Pressure (HP) Flare System, the Low Pressure (LP) System and the Spent Caustic thermal Oxidizer (SCTO). The HP Flare System includes two totally enclosed ground flares (TEGFs) and one elevated flare (HPEF). The LP System includes the Continuous Vent Thermal Oxidizer (CVTO) and the Mutli-Point Ground Flare (MPGF). The MPGF has three distinct header systems: CVTO Trip Header, Ethylene Tank Header, and PE 1 and 2 Episodic Vents Header. Figures 1 and 2 include a simplified flow diagram of the HP Flare System and LP System respectively.

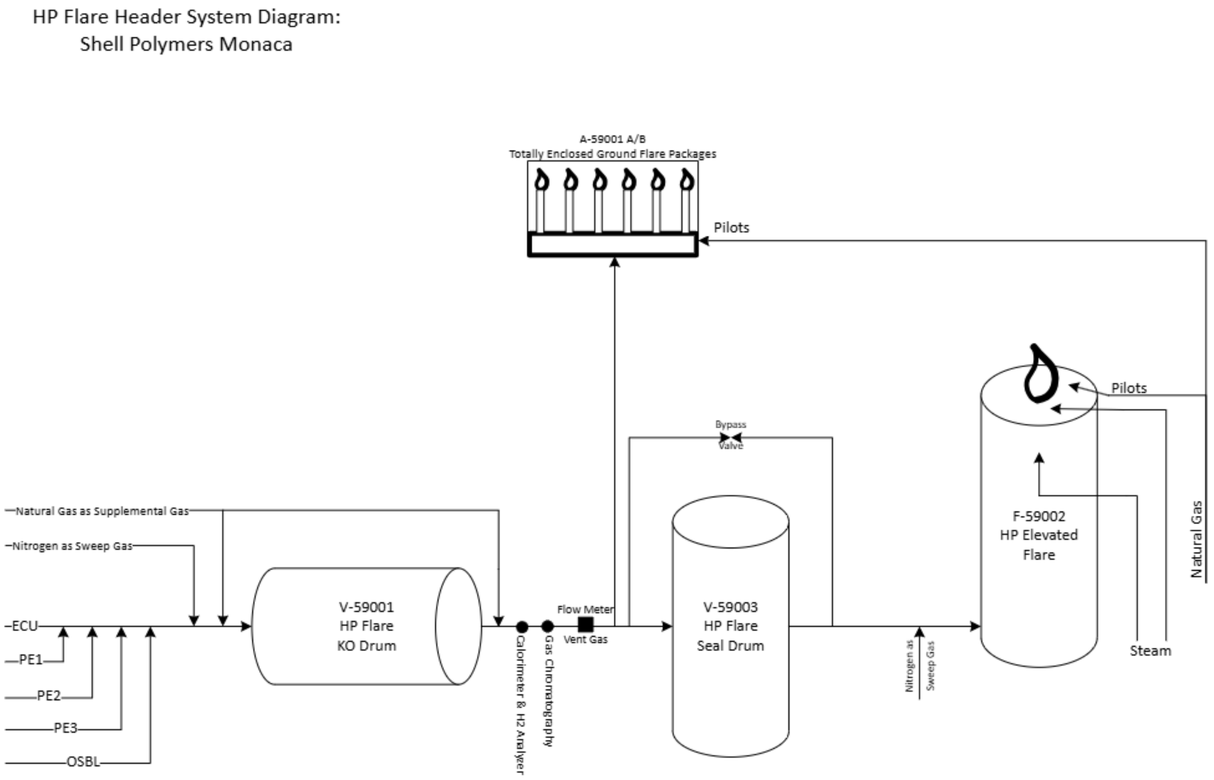

FIGURE 1: HP FLARE HEADER

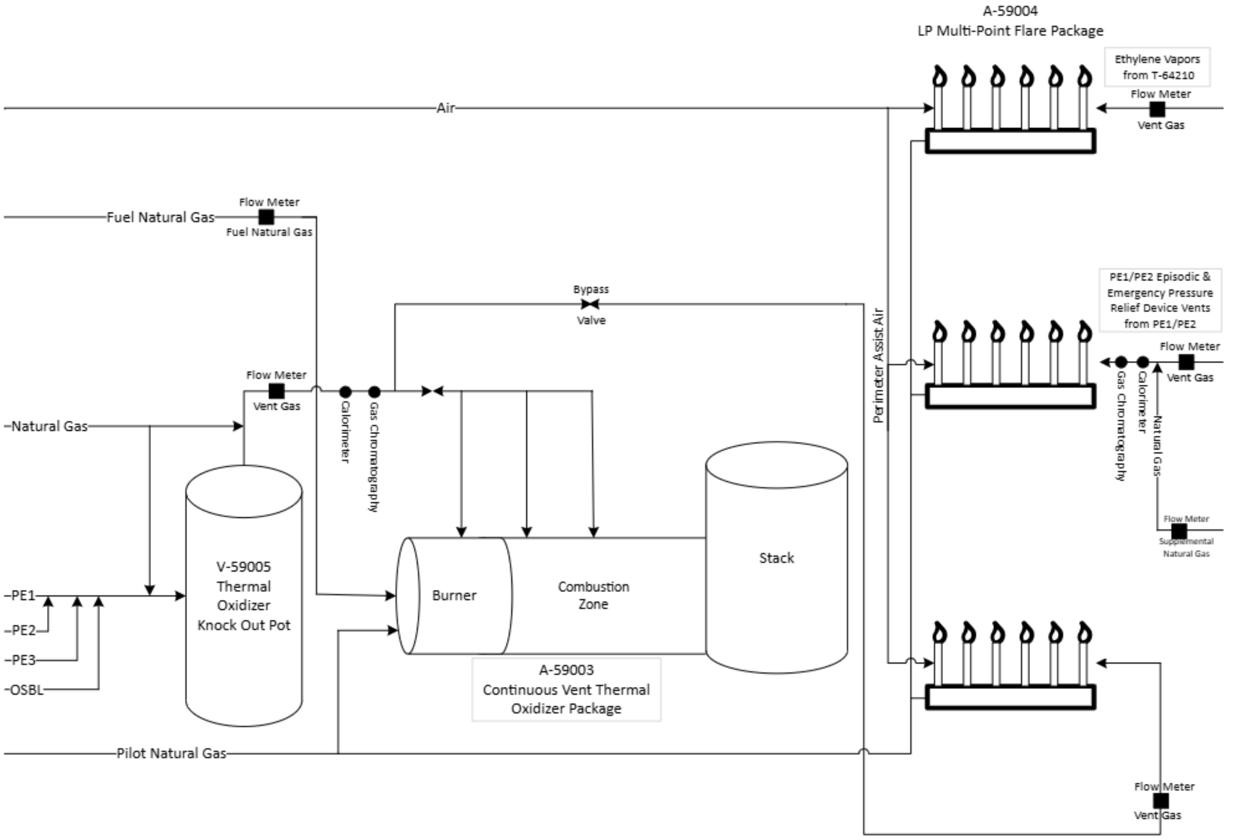

FIGURE 2: LP HEADER

Tables 1 and 2 summarize the total flows and VOC flows to the flare systems and is provided to address DEP's request for supporting information in regards to DEP's statement below.

> *"Note: In the Facility's potential to emit calculations most recently updated on September 5, 2025, annual VOC in the high-pressure header system routed to the totally enclosed ground flares and elevated flare is over 11,970 tons per year and in the low pressure header system routed to the continuous vent thermal oxidizer, with the multipoint ground flare as backup, is over 30,700 tons per year."*

As illustrated in Table 1 and as premised in the PTE, of the total flow to the HP Flare System, 12% is VOC on an annual basis. The other 88% is either inert nitrogen, hydrogen, or non-VOC hydrocarbon (methane and ethane). Of the 12%, over 98% of that VOC flow is designated as non-recoverable and the background for these conclusions is provided in later sections. This results in <0.5% of the VOC to the HP Flare System being potentially recoverable, and further discussion of the potential recovery is provided in later sections.

As provided in Table 2 and as premised in the PTE, of the total flow the LP System, 29% is VOC on an annual basis. The other 71% is either inert nitrogen, hydrogen, or non-VOC hydrocarbon. Notably, 95%

of the VOC flow is routed to the CVTO which maintains a destruction efficiency of 99.99%. Of the 5% VOC flow to the MPGF headers, the entirety is designated as non-recoverable, and the background for these conclusions is provided in later sections.

Table 1: HP Flare System Sources

Header/Source	Header Contribution of Total Flow to HP System (%)	Header Contribution of VOC Flow to HP System (%)
ECU Baseline	5.4%	2.4%
ECU Startup/Shutdown/Maintenance	21.6%	63.6%
PE Vents	59.9%	24.5%
Rail Car Loading	13.0%	9.6%
Total Tons (TPY)	96,085	11,968

Table 2: LP System Sources

Header/Source	Header Contribution of Total Flow to HP System (%)	Header Contribution of VOC Flow to HP System (%)
CVTO	85.8%	94.7%
MPGF CVTO Trip Header	3.3%	3.5%
MPGF PE 1 2 Episodic Vents Header	7.6%	1.0%
MPGF Ethylene Tank Header	3.4%	0.8%
Total Tons (TPY)	111,801	32,273
Total Tons to MPGF (TPY)	15,925	1,701

B. Flare Gas Recovery Systems

Flare Gas Recovery Systems (FGRS) are designed to recover waste gas before it is routed to a flare to repurpose those waste gases for another use. Often, the waste gas may be used as fuel at the facility if the heating value is adequate; or, the waste gas may be used as feedstock or recovered as product if it can meet specifications. The recovered gas may be used to offset feedstock or fuel purchases dependent on quantity and consistency of the waste gas stream. FGRS are comprised of one or more compressors to recover flare gas from the flare header which increases the pressure of the flare gas and piping required to transport the gas to a fuel gas system, directly to fuel gas consumers, or to other recovery uses.[1]

1. FGRS Design

A FGRS typically includes a knock-out drum, a compressor package, a liquid seal drum, and associated piping and control systems. There are several design considerations for an FGRS with notable

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[1] Sorrels, J. L., Coburn, J., Bradley, K., & Randall, D. (2019, August). Chapter 1 – Flares (Flare Cost Manual, Chapter 7). U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Air Economics Group & RTI International. Retrieved December 4, 2025, from https://www.epa.gov/sites/default/files/2019-08/documents/flarescostmanualchapter7thedition_august2019vff.pdf [epa.gov]

consideration for compressor type, backpressure control, and air ingress prevention. Typical FGRSs commonly employ reciprocating or liquid ring compressors, but screw or sliding vane compressors may also be used. Ejectors or eductors may also be used as the motive force in appropriate applications.

2. Backpressure Control and Air Ingress Prevention

For consideration of backpressure control and air ingress prevention, a liquid seal drum is required to mitigate creating a vacuum and thus explosive condition. A seal drum will provide positive pressure on the system thereby not allowing air ingress from the flare tip as well as ensuring the flare can operate without pulsing or surging. Note that seal drum design for FGRS application require higher seal depths than the typical API 521 design.[2]

The only flare at SPM with a seal drum is the HP Elevated Flare (see Figure 1), and it is used only in cases of emergency flaring or startup/shutdowns. The TEGFs do not have a seal drum as the first stage is premised to always be in service to accommodate the small routine flow from purges, compressor seals, and analyzer vents. The other stages at the TEGFs are protected by pressure control valves which open or close based on the flare header pressure.

The MPGF does not have a seal drum due to the header configuration. The CVTO Trip Header is protected by a pressure control valve which opens when the CVTO experiences over-pressure in the header. The PE 1 and 2 Episodic Vents Header is protected by natural gas (or nitrogen) purges and sweeps to ensure positive pressure on the lines. Flow to the ethylene tank header is controlled via a pressure control valve on the ethylene tank which only opens when the tank pressure gets above the maximum acceptable pressure.

3. Compressor Type

Compressor type selection is based on consideration of the material being recovered – specifically the composition and flow.[3] High variability in gas flow and pressure can create significant challenges for compressors. As provided in a review of minimization of flaring at oil and gas facilities:

> *"Refineries and oil production wells are relatively straightforward in that the gas composition has a high content of methane that can be continuously or routinely recovered. Design of the recovery compressor, design of the collection system, and determination of the use for the recovered gas have narrow constraints. However, in a chemical plant, both flowrates and compositions can vary drastically. Knowing these*

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[2] Blackwell, B., Leagas, T., & Seefeldt, G. (2016). *Gas processing association Kuwait final paper.* Zeeco, Inc. Retrieved from https://www.zeeco.com/hubfs/Zeeco-En_June_2020/pdf/GPA-Kuwait-Final-Paper-2016.pdf?hsLang=en

[3] Blackwell, B., Leagas, T., & Seefeldt, G. (2015, January). *Practical flare gas recovery.* Zeeco, Inc. Retrieved from https://www.zeeco.com/hubfs/Zeeco-En_June_2020/pdf/HE-January-2015.pdf?hsLang=en

> *flowrates and compositions and evaluating the feasibility of recovering the gases is a foundational prerequisite study in the design process of a flare gas recovery system in a chemical plant."* [4]

For the feasibility review of FGRS at SPM, the flowrate, frequency, and composition were reviewed to assess the application of FGRS to the chemical production units at the site. Note that the review, as provided in later sections, indicates that the wide variability of vent flow rates will create challenges for compressor operation.

As described above, compressors such as those needed to recover these vent streams are designed only for continuous operation. Inherent in intermittent operation are pressure swings which cause cyclic loading on various portions of the compressor and inevitably lead to dramatically increased failure rates.

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[4] Wakil, W. (2023, January). Minimize flaring in oil and gas facilities. *CEP: Chemical Engineering Progress*, *119*(1). American Institute of Chemical Engineers. Retrieved from https://www.aiche.org/resources/publications/cep/2023/january/minimize-flaring-oil-and-gas-facilities

II. Previous LAER Determinations

LAER analyses and subsequent LAER determinations have been conducted for the VOC Control Systems at SPM multiple times and are provided below for reference. The context of these determinations is being provided here considering the request from DEP that Shell reevaluate LAER for the site's flares as "recent Consent Decrees (CDs) issued since the original plan approvals have included flare gas recovery (FGR) at ethylene manufacturing facilities".

Shell May 2014 Air Quality Plan Approval Application:

> *"Each of the identified control options, except use of a flare gas recovery system, is technically feasible and is inherent in the design of the proposed Project's VOC control systems. Flare gas recovery systems are only feasible at large integrated petrochemical facilities where the recovered gas can be combined with other gases and used as fuel. As discussed below, this is not technically feasible for the proposed Project." [Continued on pages 5-227 through 5-232]*

Shell February 2015 Update for Air Quality Plan Approval Application:

> *"Each of the identified control options, except use of a flare gas recovery system, is technically feasible and is inherent in the design of the proposed Project's VOC control systems. Flare gas recovery systems are only feasible at large integrated petrochemical facilities where the recovered gas can be combined with other gases and used as fuel. As discussed below, this is not technically feasible for the proposed Project." [Continued on pages 5-233 through 5-234]*

PADEP April 1, 2015, Review Memo – PA-04-00740A:

> *"Flare gas recovery for use as fuel has been ruled out as technically infeasible because the recovered gases would have different combustion characteristics than the low carbon fuels that the furnaces and turbines will be designed to combust. Similarly, flare gas recovery for use as process feedstock has been ruled out as technically infeasible because recovered gases would be relatively impure compared to the on-site manufactured ethylene and imported co-monomers use in the polyethylene manufacturing process. Exceptions to this are the hydrogen, methane, and ethane recovered from normal operation of the ethane cracking process will be utilized as fuel for the furnaces. Unreacted ethane recovered from the ethane cracking process will be utilized as feedstock for the cracking process."*

PADEP September 22, 2020, Review Memo – PA-04-00740C:

> *"The LP Thermal Incinerator and MPGF will comply with the LAER/BACT/BAT requirements established in PA-04-00740A."*

> *"The HP Header System will comply with the LAER/BACT/BAT requirements already established in PA-0400740A."*

Shell November 20, 2023, Commissioning Report and Flare Report:

> *"The memorandum affirms Shell's 2015 Plan Approval is still representative for demonstrating LAER and indicates no new technologies or more stringent permits have been issued since Shell's Plan Approvals were originally issued."*

Shell March 31, 2023, Response to Emission Exceedance Report and Mitigation Plan:

> *"RTP summarized their findings as follows, 'although there have been several similar projects permitted and that began commercial operation since the Shell Plan Approval was issued, the original limits and work practices still represent NOx and VOC LAER for all the emission units with a few noted differences.'"* (Note that the few noted differences did not include any references to FGRS.)

Shell notes two considerations for the flares (TEGFs, HP EF, and MPGF):

1) The basis for these determinations has not changed as the design and operation of the facility has not changed in a way which would impact the technical feasibility of the technology.
2) This submittal only serves to provide additional context for the previous analyses and determinations, and Shell does not intend this to be a replacement for those previous analyses and determinations.

Shell notes three items for the Thermal Oxidizers (CVTO and SCTO):

1) FGR has not been documented as achieved in practice for thermal oxidizers based on review of the RACT/BACT/LAER clearinghouse and CDs.
2) The SCTO and CVTO operate with destruction efficiencies above 99.9%.
3) Shell does not provide further information for the CVTO or SCTO as part of the FGR discussion as FGR is not considered LAER for thermal oxidizers.

III. Achieved in Practice

While FGRS has been achieved in practice at ethylene manufacturing facilities, these facilities are not the same class or category of source as SPM which is a single train ethylene manufacturing to polyethylene manufacturing facility. Petrochemical facilities with FGRS were reviewed to identify any facility with similar operations at SPM. Several of those facilities include a co-located refinery or other hydrocarbon processing units and were designed for higher variability of mixed fuel gas. Further, review of the CDs concluded that FGRS was not installed or operated on PE manufacturing units.

A summary of the facilities and their respective source categories for which CDs were reviewed as part of the original plan approval application as well as CDs issued since 2013 is provided below. Additionally, review of the RACT/BACT/LAER Clearinghouse did not identify FGRS for PE manufacturing (as referenced in the 2015 Plan Approval Applications pages 5-223 through 5-225). An updated review conducted for 2024 Plan Approval Application did not identify any new entries as summarized in the technical deficiency response #5.

- Shell Deer Park Refining, BP Whiting Refining, Marathon Petroleum, and Country Mark Refining: petroleum refineries.
- Shell Deer Park Olefins: ethylene, propylene, heavy olefins, aromatics and phenols with a co-located refinery.
- Shell Chemical Norco: ethylene, propylene, butadiene with a co-located refinery.
- ExxonMobil – FGRS installed at three facilities.
    - Baton Rouge: ethylene, propylene, polyethylene*, polypropylene, aromatics and co-located refinery.
    - ExxonMobil Baytown: ethylene, propylene, polyethylene*, polypropylene, aromatics and co-located with refinery.
    - ExxonMobil Beaumont: ethylene, propylene, polyethylene*, polypropylene, aromatics and co-located with refinery.
- Equistar Chemicals, LyondellBasell Acetyls, and Lyondell Chemical Company (six plants) – FGRS installed at Channelview and LaPorte.
    - Channelview facility: ethylene, propylene, butadiene and derivatives.
    - La Porte: ethylene, propylene, polyethylene*, and derivatives.
- Chevron Phillips Chemical Company (three plants) – FGRS installed at Cedar Bayou.
- Cedar Bayou facility: ethylene, propylene, polyethylene*, and alpha-olefins.
- Westlake Chemical LP et al – FGRS installed at Lake Charles and Calvert City plants.
    - Westlake Lake Charles Plant: ethylene, propylene, polyethylene*, PVC, VCM, and chlor-alkali.
    - Westlake Calvert City Plant: ethylene, chlorine, caustic soda, EDC, VCM, and PVC.

- Flint Hills Resources Port Arthur (now Motiva Enterprises): propylene, ethylene, cyclohexane, and other derivatives.
- Dow Chemicals – four facilities with FGRS:
    - Freeport: ethylene, propylene, chlorine, VCM, polyethylene*, and polypropylene and other specialty chemicals.
    - Hahnville: ethylene, propylene, butadiene, butanol, polyethylene*.
    - Orange: ethylene and polyethylene*.
    - Plaquemine: ethylene, propylene, polyethylene*, and glycols.

*Review of the facilities which include PE manufacturing confirmed that FGRS is not installed on the control device(s) which service the PE manufacturing units. Review was conducted using EPA's CD database, state agency permitting databases, and industry knowledge.

Conclusion: FGRS has not been achieved in practice for polyethylene manufacturing units, and FGRS has not been achieved in practice for ethylene manufacturing units with polyethylene manufacturing units in the same systems.

IV. Technical Feasibility Analysis

A. Use as Feedstock or as Product

Recovery of waste gas and use of the gas as feedstock may be useful for facilities which are designed to process a variety of feedstocks and feedstock specifications. The SPM ECU was designed for high purity ethane as its sole feedstock with a specification of >95% ethane and <1% ethylene. The ethane feedstock is imported directly from an ethane import pipeline, and blending and piping facilities do not exist at the facility or near the facility which would allow for mixture of feeds. Additionally, these impurities from waste gases are not tolerated in the cracking feedstock as the impurities can result in rapid coking in the furnace tubes and further downstream equipment contamination for which the unit is not designed.

SPM does not transport any gaseous streams as products, co-products, or by-products offsite – all gaseous streams which are not already recovered are either waste gases as outlined here or routed to further downstream equipment and process units. There are also no users/consumers near SPM that are connected via gaseous piping or which could have useful applications of SPM’s waste gas.

Conclusion: The recovery and use of waste gas as a feedstock, product, co-product, or by-product is not technically feasible at SPM. Further, export of waste gas as a means of control is not identified in the RACT/BACT/LAER review, and thus not considered further for LAER.

B. Use as Fuel Gas

If the recovered flare vent gas can be recovered as product or used to offset fuel purchases, the value of the recovered flare gas can offset the costs of the flare gas recovery system, depending on the quantity and consistency of the flare vent gas flow[5]. Essentially, technical feasibility of an FGRS is dependent on the quantity and quality of the waste gas to be recovered and used as fuel gas.

1. SPM Fuel Gas Combustion Units

The only two fuel gas combustion sources at SPM are the ECU furnaces and the Cogeneration Units (Cogens). The ECU furnaces are “mixed” fuel gas combustion units because they are designed to burn a combination of pipeline quality natural gas and tail gas. The Cogeneration Units (Cogen) can use only pipeline quality natural gas as fuel.

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[5] Sorrels, J. L., Coburn, J., Bradley, K., & Randall, D. (2019, August). *Chapter 1 – Flares* (Flare Cost Manual, Chapter 7). U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards & RTI International. Retrieved December 4, 2025, from https://www.epa.gov/sites/default/files/2019-08/documents/flarescostmanualchapter7thedition_august2019vff.pdf

Tail gas is a mixture of hydrogen and methane recovered from the fractionation section of the ECU. A small portion of tail gas is further refined to separate hydrogen for use at the PE units, but the majority is already recovered and used as fuel gas for the ECU furnaces and as supplemental gas for the TEGFs. Because insufficient tail gas is generated to meet the fuel gas demand of the ECU furnaces, natural gas must be imported via pipeline to provide the necessary heat input.

The ECU furnace burners were specifically designed to combust this combination of tail gas and natural gas. The burners are not designed to accommodate higher molecular weight straight-chain or aromatic hydrocarbons such as those found in waste gas as shown in the burner data sheet provided in Attachment 1. Furthermore, the furnace burners were designed to be ultra-low NOX with SPM's specific fuel mixture of tail gas and natural gas. Altering the composition of the fuel gas mixture in any way is likely to compromise the manufacturer's guarantee of NOX performance from the burners. Note that the NOX performance guarantees for the ECU furnace burners are designed to meet LAER for NOX.

Likewise, the site has three Cogens which are comprised of natural gas fired gas turbine generators (GTG) and heat recovery steam generators (HRSG) with natural gas fired duct burners. The duct burners are designed to fire only pipeline specification natural gas and not designed to fire other fuels as provided in the burner data sheet in Attachment 2.

Because the GTGs are designed to fire only pipeline specification natural gas and nothing else, firing waste gas material will impact the turbines' performance guarantee, including emissions performance, and also impact the life cycle of the turbines. The performance guarantees are provided in Attachment 3 and reflect that performance guarantees including emissions performance are based on pipeline specification natural gas only. Further, only pipeline natural gas is routed to the Cogen units via piping, and fuel gas (tail gas/ import natural gas mixture) infrastructure does not exist at the Cogen units.

Conclusions: The ECU furnace burners are not designed to combust fuels other than natural gas and tail gas. Because waste gas at SPM contains significant quantities of higher molecular weight hydrocarbon compounds, its use as fuel is not technically feasible. Further conclusions regarding the use of fuel gas for the HP Flares and ECU furnaces are addressed in later sections. Due to the burner and facility design, and as specified in previous analyses, alternate fuel use at the Cogen units is not reviewed further as it is technically infeasible at the facility.

2. Polyethylene Manufacturing Vent Streams

While it was demonstrated in Section II that FGRS has not been achieved in practice for PE manufacturing, Shell is including the detailed review of the PE unit vent streams here for completeness. The following sections address PADEP's request for supporting information for the reasons and conclusions cited in the September letter in regards to:

> *These vents contain significant amounts of diluents (i.e., air and nitrogen) that make their capture and recovery for use as fuel technically infeasible.*

The resulting heating value of the mixed vent stream was determined to be below the design and engineering practices which require recovered gas to be > 25 MJ/kg to qualify as recoverable fuel.

Only intermittent vents associated with startups, shutdowns, and malfunctions and regenerations, reactor blowdowns and purges, and the PE3 degasser are routed to the HP Flare System and are very high in nitrogen content (typically above 75% N2).

<u>PE Vents to HP Flare System</u>

Table 3 provides the list of PE vent streams routed to the HP Flare System and the relevant data which were used to formulate the PTE calculations included in the most recent Plan Approval Modification Application. The table provides the category for each vent to demonstrate why each vent stream is deemed non-recoverable as well as relevant vent stream data. Relevant information regarding the vent stream category is defined further in this section.

Table 3: PE Vent Streams to HP Flare System

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Table 3: PE Vent Streams to HP Flare System

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[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 3: PE Vent Streams to HP Flare System

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]			[redacted]	[redacted]	[redacted]	[redacted]

[redacted]

As shown in this table, vent streams from the three PE units fall into one of two categories: intermittent or regeneration waste gas. Intermittent vent streams occur during startups, shutdowns, and maintenance (SSM) activities from the PE units and are not recoverable for use as fuel due to both the small quantity of gas available as well as the intermittent nature of the venting itself.

Regeneration waste gas streams occur when raw material dryers are backflushed with hot nitrogen to extend their useful lives. These vents are typically greater than 90% nitrogen by weight and are classified as "Regeneration Waste Gas Streams" as defined in recent Consent Decrees between polyethylene manufacturing facilities and the USEPA and USDOJ. These Consent Decress define these streams as non-recoverable.

> *"Regeneration Waste Gas Streams produced during the regeneration and subsequent nitrogen sweeping of the dryers, reactors, and other vessels at the Covered Plants. Regeneration Waste Gas Streams are high in nitrogen (typically approximately 90%) and have very low heating value (typically approximately 100 BTU/scf), thus they are not a useful fuel"*[6]

Conclusion: Recovery of the high-pressure SSM PE vents is not technically feasible due to a combination of the nitrogen content of the vents and the infrequent nature of the venting activity.

PE Vents to MPGF PE 1 & 2 Episodic Vents Header

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[6] Chevron Phillips Chemical Company LP Consent Decree [Civil Action No. 4:22-cv-00737]; Westlake Chemical OPCO LP et al Consent Decree [Civil Action No. 2:22-cv-01577-JDC-KK]

Table 4 provides the list of PE vent streams routed to the MPGF PE 1 & 2 Episodic Vents Header and the relevant data which were used to formulate the PTE calculations included in the most recent Plan Approval Modification Application.

Table 4: PE Vent Streams to MPGF PE 1 & 2 Episodic Vents Header

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]		[redacted]		[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]									

Episodic and emergency relief vents from PE 1 & 2 are routed to the MPGF Episodic Vents Header. The PTE includes a baseline/routine venting which includes purges and compressor seals and the PE 1 and 2 Vent Recovery Shutdown which is an SSM activity.

The purges on this header are natural gas; however, nitrogen is also available as the purge gas. Natural gas was selected as the purge to ensure good heating value was available at the flare. The compressor seals are protected by a nitrogen pad and would vent pure nitrogen with trace amounts of hydrocarbon unless a seal leak were to occur. Seal leaks are closely monitored with multiple alarmed parameters to ensure good compressor operation. The baseline venting is mostly nitrogen and has little heat content available (<4% non-VOC / natural gas).

The Vent Recovery Shutdown vents are premised to occur twice per year. Due to the infrequent nature of those vents, the vent streams are rarely available for recovery – in total, the vents are premised to occur for less than 48 hours per year.

Conclusion: Recovery of the PE 1 and 2 episodic vents is not technically feasible due to the nitrogen content and infrequent nature of the venting.

3. Rail Car Loading

Loading and unloading of rail cars of certain products and comonomers is controlled by the HP Flare System. Table 5 provides the list of railcar loading and unloading vents to the HP Flare System and the relevant data which were used to formulate the PTE calculations included in the most recent Plan Approval Modification Application.

Table 5: Railcar Loading/Unloading Vent Streams to HP Flare System

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

The loading and unloading is vapor balanced via equalization lines to the storage vessel, either a sphere or bullet. Nitrogen is used to increase pressure in railcars and to purge the lines of hydrocarbon.

While loading onto railcars from the facility, the material is pumped from storage into the railcar during which displaced vapors are routed via an equalization line back to the storage vessel or, in the case of C3+, directly to the flare. The vessels include a nitrogen pad and are controlled via pressure control to the HP Flare System. Once the loading is complete, the lines are swept with a nitrogen purge directly to the flare.

During unloading from railcars, the railcar is pressured up to a pressure setpoint with nitrogen via the vent to allow the material to be offloaded into the storage vessel via the liquid line. Once unloading is complete, the railcar is purged with nitrogen to sweep any vapor out of the railcar and to depressurize the railcar.

C3+ loading occurs most frequently and is further reviewed for potential recovery. As previously discussed, the ECU Furnace burners are not designed to combust the heavier hydrocarbons found in the C3+ material. Additionally, cyclopentadiene in the C3+ is known to polymerize at higher temperatures and will create rapid burner fouling. As provided in the hazard information, "Polymerization occurs more rapidly and extensively at higher temperatures. When heated to 180-200°C, cyclopentadiene gives polycyclopentadiene, a white waxy solid. Stronger heating breaks down polycyclopentadiene and re-generates the monomeric cyclopentadiene as a vapor. The vapor decomposes violently at higher temperatures and pressures."[7] The C3+ composition is provided in Table 6 for reference, and the SDS is provided in Attachment 4.

Table 6: C3+ Material Composition from SDS	
1,3-Butadiene	>40
Butane	5
1-Butene	3
Toluene	0.2
Benzene	11
Isoprene	0.1
Cyclopentadiene	4
Cyclopentene	1

Conclusion: Recovery of the railcar loading and unloading vent streams and use of fuel gas is not technically feasible due to either the infrequent nature of the activity in addition to the heavier hydrocarbons present in the materials which are loaded or unloaded.

4. Ethylene Manufacturing Vent Streams

The following sections provided below directly address PADEP's request for supporting information for Ethylene Manufacturing Vent Streams.

> *During normal operation of the cracking unit, no routine vent gases other than analyzer vents, natural gas purges, and supplemental fuel for heating value are directed to the flares. As a result, during normal operations there is little or no VOC gas to recover using a flare gas recovery system. Essentially, any gas that could be recovered would provide no beneficial use as fuel and the recovery would not result in the reduction of VOC emissions as there is no VOC for recovery.*
>
> *Due to the intermittent nature of the ethylene manufacturing vent streams and the composition of the streams it was determined that flare gas recovery was not technically feasible due to gas quality and quantity. [emphasis added]*

<u>ECU Startup, Shutdown, and Maintenance Vents</u>

Venting during startup, shutdown, and maintenance venting (SSM) of the ECU account for 64% of the PTE VOC flow to the flare (pre-destruction). These vents are high-flow but short-duration events during which the ECU is not under normal operations and is either in startup, shutdown, or partial startup or shutdown (maintenance events). Table 7 provides the list of ECU vent streams associated with SSM

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[7] National Oceanic and Atmospheric Administration, Office of Response and Restoration. (n.d.). *Chemical datasheet for chemical 25015* [CAMEO Chemicals]. Retrieved December 4, 2025, from https://cameochemicals.noaa.gov/chemical/25015

routed to the HP Flare System and the relevant data which were used to formulate the HP Flare System PTE calculations.

Table 7: ECU SSM Vent Streams to HP Flare System

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]									

Existing CDs with ethylene manufacturing facilities state, "Excess fuel gas and excess gases generated during planned or unplanned Startup or Shutdown or in Turnaround, caused by a gas imbalance that cannot be consumed by fuel gas consumers in the Facility (because of pressure, gas quality, and insufficient demand for the gas) are not Potentially Recoverable Gas."[8] The ECU SSM vents can be classified as non-recoverable on the same basis.

As provided in the CDs, and typical of ethylene manufacturing facilities, these vents are exempted from recovery as excess fuel gas cannot be consumed during these venting periods. At SPM, this is especially true as the ECU furnaces are the only fuel gas consumers. Thus, when the ECU is starting up or shutting down or the unit is in partial startup or shutdown, the furnaces are not available to consume the excess waste gas, and it must be flared.

The ECU maintenance venting is premised to occur only three times in a given year with only one hour in duration per event. Due to the infrequent nature of those vents, the vent streams are rarely available for recovery.

Conclusion: The recovery and use as fuel gas of SSM vents from the ECU is not technically feasible due to the absence of fuel gas consumers for the excess fuel gas created during these events or due to the infrequent nature of the venting.

<u>ECU Routine Vents</u>

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[8] Shell Chemical LP Norco Consent Decree [Civil Action. 2:18-cv-1404-EEF-JV]

During normal operation of the cracking unit, no routine vent gases other than analyzer vents, natural gas purges, compressor seals, and supplemental fuel gas are directed to the flares. Table 8 provides a breakdown of the baseline / routine vent gases to the HP Flare System, and a description of each type of vent stream is provided below.

Table 8: ECU Routine Vent Streams to HP Flare System

Vent Stream	Category	Flow (mT/hr)	# Events/ Yr	Hr / Event	Hr/Yr	N2 (wt%)	Non-VOC (wt%)	VOC (wt%)	HHV (Btu/lb)
Compressor Seals	Routine	0.2	8,760			90%	0%	10%	10,826
Analyzer Vents	Routine	0.01	8,760			0%	46%	54%	22,629
Natural Gas Purges	Routine	0.4	8,760			0%	100%	0%	23,000

Non-VOC includes hydrogen, methane, and ethane.

The compressor seals are protected by a nitrogen pad and would vent pure nitrogen with trace amounts of hydrocarbon unless a seal leak were to occur. For the PTE calculations, it is assumed that 10% of the compressor seal vent is hydrocarbon. But in practice, the hydrocarbon leakage will vary, and the PTE uses a conservative estimate. The largest compressor seals routed to the HP Flare System from ECU are the cracked gas compressor, ethylene refrigeration compressor, and propane refrigeration compressor which include heavier molecular weight hydrocarbons.

Analyzer vents are typically routed back to the process. For analyzer vents which are at too low of pressure to be routed back into process, the vent is routed to the flare system. The analyzer vents are a very small portion of the baseline flow to the flare (less than 0.1% by volume of the routine flow).

Purges are required on flare headers to maintain positive pressure on the header such that oxygen ingress does not occur. It is important to note, SPM's flare header purges are typically natural gas but could also be nitrogen. The BTU content from the natural gas is necessary for the flares to maintain the Net Heating Value in the Combustion Zone (NHVcz) above 800 Btu/scf as required per the Ethylene MACT and MON regulations. Supplemental fuel gas (tail gas and natural gas mixture) is also used to maintain the NHVcz above 800 Btu/scf at the TEGFs as required per regulations.

The baseline stream data is provided in Table 9 below. Note that the baseline assumption shown in the table does not account for the baseline supplemental gas flow.

Table 9: Baseline PTE Assumptions

Flow (mT/hr)	N2 (wt%)	Methane + Ethane (wt%)	Ethylene (wt%)	MW (lb/lbmol)	HHV (Btu/lb)	Heat Input Available (MMBtu/hr)
3.5	58%	35%	7%	22.68	9,834	75

While the PTE baseline includes routine ethylene, and thus routine heat content available, the PTE is based on a conservative estimate and does not reflect the true content available in any given hour.

Additionally, any leakage from or failure of a compressor seal will result in contamination of ECU fuel gas with heavy hydrocarbons from the compressors in cracked gas, ethylene, and propane services. As previously discussed, the ECU furnace burners are not designed for these heavier molecular weight hydrocarbons.

Additionally, because the TEGFs already require supplemental gas to maintain the required NHVcz, recovery of the 75 MMBTU/hr of baseline ethylene to the ECU furnaces would simply create an additional 75 MMBTU/hr deficit at the flares. As a result, an additional 75 MMBTU/hr of supplemental gas would need to be diverted and/or purchased and discharged to the flare. This would cause a slight increase in VOC emissions because the VOC emission factor at the TEGFs is nearly three times higher than furnaces'.

Conclusion: The VOC content in the ECU routine vent streams fluctuates and is not consistently available for recovery, and as previously discussed, will cause signficant issues for compressor realiability and mechanical integrity. Further, even if that content were consistently avaialble, additional supplemental gas would be required to offset the heat content loss at the flares for NHVcz.

Attachment 1:

ECU Furnace Burner Data Sheet

Confidential Business Information (Redacted)

[redacted]

[redacted]

[redacted]

Attachment 2:

Cogen HRSG Duct Burner Data Sheet

Confidential Business Information (Redacted)

[redacted]

[redacted]

Attachment 3:

GTG Performance Guarantee

Confidential Business Information (Redacted)

[redacted]

Attachment 4:

C3+Material SDS

SAFETY DATA SHEET

According to OSHA Hazard Communication Standard, 29 CFR 1910.1200

Shell Polymers Monaca De-ethanizer Bottoms

Version	Revision Date:	SDS Number:	Print Date: 12/02/2025
7.0	03/06/2025	800010035383	Date of last issue: 03/25/2024

SECTION 1. IDENTIFICATION

Product name	:	Shell Polymers Monaca De-ethanizer Bottoms
Product code	:	E7003, X3434
Synonyms	:	C3+
CAS-No.	:	68955-28-2

Manufacturer or supplier's details

Company	:	**Shell Chemical LP** PO Box 576 HOUSTON TX 77001 USA
SDS Request	:	
Customer Service	:	1-800-240-6737 1-855-697-4355

Emergency telephone number

Chemtrec Domestic (24 hr)	:	1-800-424-9300
Chemtrec International (24 hr)	:	1-703-527-3887

Recommended use of the chemical and restrictions on use

Recommended use	:	Chemical intermediate.
Restrictions on use	:	This product must not be used in applications other than the above without first seeking the advice of the supplier.

SECTION 2. HAZARDS IDENTIFICATION

GHS classification in accordance with the OSHA Hazard Communication Standard (29 CFR 1910.1200)

Flammable gases	:	Category 1
Gases under pressure	:	Liquefied gas
Aspiration hazard	:	Category 1
Skin irritation	:	Category 2
Eye irritation	:	Category 2A
Germ cell mutagenicity	:	Category 1B
Carcinogenicity	:	Category 1

Specific target organ toxicity - repeated exposure : Category 1

GHS label elements

Hazard pictograms :

Signal word : Danger

Hazard statements : PHYSICAL HAZARDS:
H220 Extremely flammable gas.
H280 Contains gas under pressure; may explode if heated.
H304 May be fatal if swallowed and enters airways.
H315 Causes skin irritation.
H319 Causes serious eye irritation.
H340 May cause genetic defects.
H350 May cause cancer.
H372 Causes damage to organs through prolonged or repeated exposure.

Precautionary statements :

Prevention:

P210 Keep away from heat/ sparks/ open flames/ hot surfaces. No smoking.
P264 Wash skin thoroughly after handling.
P280 Wear protective gloves/ protective clothing/ eye protection/ face protection.
P201 Obtain special instructions before use.
P202 Do not handle until all safety precautions have been read and understood.
P260 Do not breathe dust/ fume/ gas/ mist/ vapours/ spray.
P270 Do not eat, drink or smoke when using this product.

Response:

P377 Leaking gas fire: Do not extinguish, unless leak can be stopped safely.
P381 Eliminate all ignition sources if safe to do so.
P301 + P310 IF SWALLOWED: Immediately call a POISON CENTER or doctor/ physician.
P331 Do NOT induce vomiting.
P302 + P352 IF ON SKIN: Wash with plenty of soap and water.
P332 + P313 If skin irritation occurs: Get medical advice/ attention.
P305 + P351 + P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P337 + P313 If eye irritation persists: Get medical advice/ attention.
P308 + P313 IF exposed or concerned: Get medical advice/ attention.
P314 Get medical advice/ attention if you feel unwell.

Storage:

P410 + P403 Protect from sunlight. Store in a well-ventilated place.
P405 Store locked up.

Disposal:

P501 Dispose of contents and container to appropriate waste site or reclaimer in accordance with local and national regulations.

Other hazards which do not result in classification

Vapours may cause drowsiness and dizziness.
Slightly irritating to respiratory system.
Exposure to rapidly expanding gases may cause frost burns to eyes and/or skin.
Vapours may be irritating to the eye.
Possibility of organ or organ system damage from prolonged exposure; see Section 11 for details.
Target organ(s):
Blood forming organs
Reproductive system.
This material is a static accumulator.
Even with proper grounding and bonding, this material can still accumulate an electrostatic charge.
If sufficient charge is allowed to accumulate, electrostatic discharge and ignition of flammable air-vapour mixtures can occur.
Highly reactive.
May form explosive peroxides.
The vapour is heavier than air, spreads along the ground and distant ignition is possible.
May form flammable/explosive vapour-air mixture.
The classification of this material is based on OSHA HCS 2012 criteria.

SECTION 3. COMPOSITION/INFORMATION ON INGREDIENTS

Substance / Mixture : Mixture
Chemical nature : This product may contain trace levels of Naturally Occurring Radioactive Materials (NORM) as Radon 222 (CAS No. 14859-67-7) and its decay products Lead 210 (CAS No. 14255-04-0) and Polonium 210 (CAS No. 13981-52-7). Refer to Sections 7 and 11 for additional information.

Hazardous components

Chemical name	Synonyms	CAS-No.	Concentration (% w/w)
gases (petroleum, light steam-cracked, butadiene conc.	Gases (petroleum), light steam-cracked, butadiene conc.	68955-28-2	100

Contains an antioxidant (stabiliser) and antipolymerant

Further information

Contains:

Chemical name	Identification number	Concentration (% w/w)
propylene	115-07-1	30
propane	74-98-6	4

1,3-butadiene	106-99-0	>40
butane	106-97-8	5
but-1-ene	106-98-9	3
Toluene	108-88-3	0.2
Benzene	71-43-2	11
Isoprene	78-79-5	0.1
cyclopentadiene	542-92-7	4
Cyclopentene	142-29-0	1

SECTION 4. FIRST AID MEASURES

General advice : Not expected to be a health hazard when used under normal conditions.

If inhaled : Remove to fresh air. Do not attempt to rescue the victim unless proper respiratory protection is worn. If the victim has difficulty breathing or tightness of the chest, is dizzy, vomiting, or unresponsive, give 100% oxygen with rescue breathing or Cardio-Pulmonary Resuscitation as required and transport to the nearest medical facility.
Inhalation of vapours require immediate medical attention.
Call emergency number for your location / facility.

In case of skin contact : Remove contaminated clothing. Immediately flush skin with large amounts of water for at least 15 minutes, and follow by washing with soap and water if available. If redness, swelling, pain and/or blisters occur, transport to the nearest medical facility for additional treatment.
Slowly warm the exposed area by rinsing with warm water.
Transport to the nearest medical facility for additional treatment.
In the event of frostbite, slowly warm the exposed area by rinsing with warm water.
Seek medical advice.
Transport to the nearest medical facility for additional treatment.

In case of eye contact : Immediately flush eye(s) with plenty of water.
Remove contact lenses, if present and easy to do. Continue rinsing.
Transport to the nearest medical facility for additional treatment.
Slowly warm the exposed area by rinsing with warm water.
Transport to the nearest medical facility for additional treatment.

If swallowed : If swallowed, do not induce vomiting: transport to nearest medical facility for additional treatment. If vomiting occurs spontaneously, keep head below hips to prevent aspiration.
Rinse mouth.
Call emergency number for your location / facility.
If any of the following delayed signs and symptoms appear within the next 6 hours, transport to the nearest medical facility: fever greater than 101° F (38.3°C), shortness of breath, chest congestion or continued coughing or wheezing.

Most important symptoms : Respiratory irritation signs and symptoms may include a temand effects, both acute and delayed

porary burning sensation of the nose and throat, coughing, and/or difficulty breathing.
Breathing of high vapour concentrations may cause central nervous system (CNS) depression resulting in dizziness, light-headedness, headache, nausea and loss of coordination.
Continued inhalation may result in unconsciousness and death.
Skin irritation signs and symptoms may include a burning sensation, redness, swelling, and/or blisters.
Rapid release of gases which are liquids under pressure may cause frost burns of exposed tissues (skin, eye) due to evaporative cooling.
Eye irritation signs and symptoms may include a burning sensation, redness, swelling, and/or blurred vision.
Ingestion may result in nausea, vomiting and/or diarrhoea.
If material enters lungs, signs and symptoms may include coughing, choking, wheezing, difficulty in breathing, chest congestion, shortness of breath, and/or fever.
If any of the following delayed signs and symptoms appear within the next 6 hours, transport to the nearest medical facility: fever greater than 101° F (38.3°C), shortness of breath, chest congestion or continued coughing or wheezing.
Damage to blood-forming organs may be evidenced by: a) fatigue and anaemia (RBC), b) decreased resistance to infection, and/or excessive bruising and bleeding (platelet effect).

Protection of first-aiders : When administering first aid, ensure that you are wearing the appropriate personal protective equipment according to the incident, injury and surroundings.

Indication of any immediate medical attention and special treatment needed : Potential for cardiac sensitisation, particularly in abuse situations. Hypoxia or negative inotropes may enhance these effects. Consider: oxygen therapy.
Artificial respiration and/or oxygen may be necessary.
Treat symptomatically.
Call a doctor or poison control center for guidance.
IMMEDIATE TREATMENT IS EXTREMELY IMPORTANT!
Potential for chemical pneumonitis.

SECTION 5. FIREFIGHTING MEASURES

Suitable extinguishing media : Shut off supply. If not possible and no risk to surroundings, let the fire burn itself out.

Unsuitable extinguishing media : Data not available

Specific hazards during firefighting : Sustained fire attack on vessels may result in a Boiling Liquid Expanding Vapor Explosion (BLEVE).
The vapour is heavier than air, spreads along the ground and distant ignition is possible.
Contents are under pressure and can explode when exposed to heat or flames.
As the vapours become lighter than air, the vapours may reach ignition sources at ground or elevated locations.

Specific extinguishing methods : Standard procedure for chemical fires.

Further information : Clear fire area of all non-emergency personnel.

Keep adjacent containers cool by spraying with water.

Special protective equipment for firefighters : Wear full protective clothing and self-contained breathing apparatus.

SECTION 6. ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures : Avoid contact with spilled or released material. Immediately remove all contaminated clothing. For guidance on selection of personal protective equipment see Section 8 of this Safety Data Sheet. For guidance on disposal of spilled material see Section 13 of this Safety Data Sheet.
Be ready for fire or possible exposure.
Stay upwind and keep out of low areas.
Avoid contact with skin, eyes and clothing.
Isolate hazard area and deny entry to unnecessary or unprotected personnel.
Do not breathe fumes, vapour.
Do not operate electrical equipment.

Environmental precautions : Shut off leaks, if possible without personal risks. Remove all possible sources of ignition in the surrounding area and evacuate all personnel. Attempt to disperse the gas or to direct its flow to a safe location for example by using fog sprays. Take precautionary measures against static discharge. Ensure electrical continuity by bonding and grounding (earthing) all equipment. Monitor area with combustible gas meter.

Methods and materials for containment and cleaning up : Allow to evaporate.
Attempt to disperse the vapour or to direct its flow to a safe location, for example by using fog sprays.

Observe all relevant local and international regulations.

Additional advice : For guidance on selection of personal protective equipment see Section 8 of this Safety Data Sheet.
Risk of explosion. Inform the emergency services if liquid enters surface water drains.
For guidance on disposal of spilled material see Section 13 of this Safety Data Sheet.
Vapour may form an explosive mixture with air.
Notify authorities if any exposure to the general public or the environment occurs or is likely to occur.
U.S. regulations may require reporting releases of this material to the environment which exceed the reportable quantity (refer to Section 15) to the National Response Center at (800) 424-8802.

SECTION 7. HANDLING AND STORAGE

Technical measures : Avoid breathing of or direct contact with material. Only use in well ventilated areas. Wash thoroughly after handling. For guidance on selection of personal protective equipment see Section 8 of this Safety Data Sheet.

Use the information in this data sheet as input to a risk assessment of local circumstances to help determine appropriate controls for safe handling, storage and disposal of this material.
Ensure that all local regulations regarding handling and storage facilities are followed.

Advice on safe handling : Avoid inhaling vapour and/or mists.
Avoid contact with skin, eyes and clothing.
Extinguish any naked flames. Do not smoke. Remove ignition sources. Avoid sparks.
The vapour is heavier than air. Beware of accumulation in pits and confined spaces.
Use local exhaust ventilation if there is risk of inhalation of vapours, mists or aerosols.
Bulk storage tanks should be diked (bunded).
Properly dispose of any contaminated rags or cleaning materials in order to prevent fires.
Even with proper grounding and bonding, this material can still accumulate an electrostatic charge.
If sufficient charge is allowed to accumulate, electrostatic discharge and ignition of flammable air-vapour mixtures can occur.
Be aware of handling operations that may give rise to additional hazards that result from the accumulation of static charges.
These include but are not limited to pumping (especially turbulent flow), mixing, filtering, splash filling, cleaning and filling of tanks and containers, sampling, switch loading, gauging, vacuum truck operations, and mechanical movements.
These activities may lead to static discharge e.g. spark formation.
Restrict line velocity during pumping in order to avoid generation of electrostatic discharge (≤ 1 m/s until fill pipe submerged to twice its diameter, then ≤ 7 m/s). Avoid splash filling.
Do NOT use compressed air for filling, discharging, or handling operations.
Radon-222 decay products may accumulate in processing equipment (e.g., pumps, filters, piping, etc.) to a point where gamma radiation is detected outside of this equipment during normal operations. This equipment may contain internal surface deposits of radioactive radon decay products. Equipment should be checked externally while in service for gamma radiation above background levels, and internally prior to maintenance work requiring opening or entry to the equipment, and prior to disposal. Equipment emitting gamma radiation should be presumed to be internally contaminated with alpha-emitting decay products (i.e., Lead-210, Polonium-210). Equipment and piping should be checked for possible decontamination prior to maintenance or disposal. Protective equipment (e.g., disposable coveralls, gloves (rubber/leather), and a respirator with HEPA or P100 filters, or supplied air) should be worn and good personal hygiene practices should be followed by personnel entering a vessel or working on contaminated process equipment to prevent skin contamination, ingestion, or inhalation of any NORM contaminated residue.

Avoidance of contact : Strong oxidising agents.
If copper, copper alloys, monel, silver, mercury or magnesium is used during construction or maintenance, the formation of explosive acetylides can occur as a result of contact with butadiene. If Teflon® or Delrin® is used, polymer formation may result.

Product Transfer : Refer to guidance under Handling section.

Further information on storage stability : Keep away from aerosols, flammables, oxidizing agents, corrosives and from other flammable products which are not harmful or toxic to man or to the environment.
Must be stored in a diked (bunded) well- ventilated area, away from sunlight, ignition sources and other sources of heat.
Must be kept inhibited during storage and shipment as material can polymerise.
Vapours from tanks should not be released to atmosphere. Breathing losses during storage should be controlled by a suitable vapour treatment system.
Electrostatic charges will be generated during pumping. Electrostatic discharge may cause fire. Ensure electrical continuity by bonding and grounding (earthing) all equipment to reduce the risk.
The vapours in the head space of the storage vessel may lie in the flammable/explosive range and hence may be flammable.
Storage Temperature:
Ambient.
Nitrogen blanket recommended.
The product is normally supplied in a stabilized form. If the permissible storage period and/or storage temperature is noticeably exceeded, the product may polymerise with heat evolution.
Stable under recommended storage conditions.

Packaging material : Suitable material: For containers, or container linings use mild steel, stainless steel.
Unsuitable material: Copper., Copper alloys., Magnesium., Mercury., Monel., Silver.

Specific use(s) : Not applicable

Ensure that all local regulations regarding handling and storage facilities are followed.
See additional references that provide safe handling practices for liquids that are determined to be static accumulators: American Petroleum Institute 2003 (Protection Against Ignitions Arising out of Static, Lightning and Stray Currents) or National Fire Protection Agency 77 (Recommended Practices on Static Electricity).
IEC/TS 60079-32-1: Electrostatic hazards, guidance

SECTION 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Components with workplace control parameters

Components	CAS-No.	Value type (Form of exposure)	Control parameters / Permissible concentration	Basis
1,3-butadiene	106-99-0	TWA	2 ppm	ACGIH
1,3-butadiene		PEL	1 ppm	OSHA CARC
1,3-butadiene		STEL	5 ppm	OSHA CARC
1,3-butadiene		TWA	1 ppm	OSHA Z-1
1,3-butadiene		STEL	5 ppm	OSHA Z-1
propylene	115-07-1	TWA	500 ppm	ACGIH
Benzene	71-43-2	TWA	0.25 ppm 0.8 mg/m3	Shell Internal Standard (SIS) for 8-12 hour TWA.
Benzene		STEL	2.5 ppm 8 mg/m3	Shell Internal Standard (SIS) for 15 min (STEL)
Benzene		TWA	0.02 ppm	ACGIH
Benzene		STEL	2.5 ppm	ACGIH
Benzene		PEL	1 ppm	OSHA CARC
Benzene		STEL	5 ppm	OSHA CARC
Benzene		TWA	10 ppm	OSHA Z-2
Benzene		CEIL	25 ppm	OSHA Z-2
Benzene		Peak	50 ppm (10 minutes)	OSHA Z-2
butane	106-97-8	STEL	1,000 ppm	ACGIH
propane	74-98-6	TWA	1,000 ppm 1,800 mg/m3	OSHA Z-1
cyclopentadiene	542-92-7	TWA	0.5 ppm	ACGIH
cyclopentadiene		STEL	1 ppm	ACGIH
cyclopentadiene		TWA	75 ppm 200 mg/m3	OSHA Z-1
but-1-ene	106-98-9	TWA	250 ppm	ACGIH
Toluene	108-88-3	TWA	20 ppm	ACGIH
Toluene		TWA	200 ppm	OSHA Z-2
Toluene		CEIL	300 ppm	OSHA Z-2
Toluene		Peak	500 ppm (10 minutes)	OSHA Z-2
Isoprene	78-79-5	TWA	3 ppm 8.4 mg/m3	Shell Internal Standard (SIS) for 8 hour TWA.

Biological occupational exposure limits

Components	CAS-No.	Control parameters	Biological specimen	Sampling time	Permissible concentration	Basis
1,3-butadiene	106-99-0	1,2 Dihydroxy-4-(N-	Urine	End of shift (As	2.5 mg/l	ACGIH BEI

		acetylcysteinyl)-butane		soon as possible after exposure ceases)		
		Mixture of N-1 and N-2(hydroxybutenyl)valine	Hemoglobin (Hb) adducts in blood	Not critical	2.5 picomoles per gram Hemoglobin	ACGIH BEI
Toluene	108-88-3	Toluene	In blood	Prior to last shift of workweek	0.02 mg/l	ACGIH BEI
		Toluene	Urine	End of shift (As soon as possible after exposure ceases)	0.03 mg/l	ACGIH BEI
		o-Cresol	Urine	End of shift (As soon as possible after exposure ceases)	0.3 mg/g creatinine	ACGIH BEI
Benzene	71-43-2	S-Phenylmercapturic acid	Urine	End of shift (As soon as possible after exposure ceases)	25 µg/g creatinine	ACGIH BEI
		t,t-Muconic acid	Urine	End of shift (As soon as possible after exposure ceases)	500 µg/g creatinine	ACGIH BEI
1,3-butadiene	106-99-0	1,2 Dihydroxy-4-(N-acetylcysteinyl)-butane	Urine	End of shift (As soon as possible after exposure ceases)	2.5 mg/l	ACGIH BEI
		Mixture of N-1 and N-2(hydroxybutenyl)valine	Hemoglobin (Hb) adducts in blood	Not critical	2.5 picomoles per gram Hemoglobin	ACGIH BEI
Toluene	108-88-3	Toluene	In blood	Prior to last shift	0.02 mg/l	ACGIH BEI

				of work-week		
		Toluene	Urine	End of shift (As soon as possible after exposure ceases)	0.03 mg/l	ACGIH BEI
		o-Cresol	Urine	End of shift (As soon as possible after exposure ceases)	0.3 mg/g creatinine	ACGIH BEI
Benzene	71-43-2	S-Phenylmercapturic acid	Urine	End of shift (As soon as possible after exposure ceases)	25 µg/g creatinine	ACGIH BEI
		t,t-Muconic acid	Urine	End of shift (As soon as possible after exposure ceases)	500 µg/g creatinine	ACGIH BEI

Monitoring Methods

Monitoring of the concentration of substances in the breathing zone of workers or in the general workplace may be required to confirm compliance with an OEL and adequacy of exposure controls. For some substances biological monitoring may also be appropriate.
Validated exposure measurement methods should be applied by a competent person and samples analysed by an accredited laboratory.
Examples of sources of recommended exposure measurement methods are given below or contact the supplier. Further national methods may be available.
National Institute of Occupational Safety and Health (NIOSH), USA: Manual of Analytical Methods http://www.cdc.gov/niosh/
Occupational Safety and Health Administration (OSHA), USA: Sampling and Analytical Methods http://www.osha.gov/
Health and Safety Executive (HSE), UK: Methods for the Determination of Hazardous Substances http://www.hse.gov.uk/
Institut für Arbeitsschutz Deutschen Gesetzlichen Unfallversicherung (IFA) , Germany http://www.dguv.de/inhalt/index.jsp
L'Institut National de Recherche et de Securité, (INRS), France http://www.inrs.fr/accueil

Engineering measures : Use sealed systems as far as possible.
Adequate explosion-proof ventilation to control airborne concentrations below the exposure guidelines/limits.
Local exhaust ventilation is recommended.

Firewater monitors and deluge systems are recommended.
Eye washes and showers for emergency use.
The level of protection and types of controls necessary will vary depending upon potential exposure conditions. Select controls based on a risk assessment of local circumstances. Appropriate measures include:

General Information
Consider technical advances and process upgrades (including automation) for the elimination of releases. Minimise exposure using measures such as closed systems, dedicated facilities and suitable general/local exhaust ventilation. Drain down systems and clear transfer lines prior to breaking containment. Clean/flush equipment, where possible, prior to maintenance. Where there is potential for exposure: restrict access to authorised persons; provide specific activity training to operators to minimise exposures; wear suitable gloves and coveralls to prevent skin contamination; wear respiratory protection when there is potential for inhalation; clear up spills immediately and dispose of wastes safely.Ensure safe systems of work or equivalent arrangements are in place to manage risks. Regularly inspect, test and maintain all control measures. Consider the need for risk based health surveillance.

Personal protective equipment

Respiratory protection : If engineering controls do not maintain airborne concentrations to a level which is adequate to protect worker health, select respiratory protection equipment suitable for the specific conditions of use and meeting relevant legislation.
Check with respiratory protective equipment suppliers.
Where air-filtering respirators are unsuitable (e.g. airborne concentrations are high, risk of oxygen deficiency, confined space) use appropriate positive pressure breathing apparatus.
Where air-filtering respirators are suitable, select an appropriate combination of mask and filter.
If air-filtering respirators are suitable for conditions of use:
Select a filter suitable for organic gases and vapours [Type AX boiling point ≤65°C (149°F)].
Respirator selection, use and maintenance should be in accordance with the requirements of the OSHA Respiratory Protection Standard, 29 CFR 1910.134.

Hand protection
Remarks : Where hand contact with the product may occur the use of gloves approved to relevant standards (e.g. Europe: EN374, US: F739) made from the following materials may provide suitable chemical protection. When prolonged or frequent repeated contact occurs. Viton. For incidental contact/splash protection - Neoprene rubber. If contact with liquefied product is possible or anticipated, gloves should be thermally insulated to prevent cold burns. For continuous contact we recommend gloves with breakthrough time of more than 240 minutes with preference for > 480 minutes where suitable gloves can be identified. For short-term/splash protection we

	recommend the same but recognize that suitable gloves offering this level of protection may not be available and in this case a lower breakthrough time maybe acceptable so long as appropriate maintenance and replacement regimes are followed. Glove thickness is not a good predictor of glove resistance to a chemical as it is dependent on the exact composition of the glove material. Glove thickness should be typically greater than 0.35 mm depending on the glove make and model. Suitability and durability of a glove is dependent on usage, e.g. frequency and duration of contact, chemical resistance of glove material, dexterity. Always seek advice from glove suppliers. Contaminated gloves should be replaced. Personal hygiene is a key element of effective hand care. Gloves must only be worn on clean hands. After using gloves, hands should be washed and dried thoroughly. Application of a non-perfumed moisturizer is recommended.
Eye protection	: Wear goggles for use against liquids and gas, combined with face shield with chin guard.
Skin and body protection	: Wear antistatic and flame-retardant clothing. Chemical and cryogenic gloves/gauntlets, boots, and apron.
Protective measures	: Personal protective equipment (PPE) should meet recommended national standards. Check with PPE suppliers.
Thermal hazards	: When handling cold material that can cause frost burns, wear cryogenic gloves, safety hat and visor, cold resistant overalls (with cuffs over gloves and legs over boots) and heavy duty boots e.g. leather for cold resistance.
Hygiene measures	: Wash hands before eating, drinking, smoking and using the toilet. Launder contaminated clothing before re-use.

Environmental exposure controls

General advice	: Local guidelines on emission limits for volatile substances must be observed for the discharge of exhaust air containing vapour. Minimise release to the environment. An environmental assessment must be made to ensure compliance with local environmental legislation. Information on accidental release measures are to be found in section 6.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	: Liquid under pressure.
Colour	: Data not available
Odour	: strong
Odour Threshold	: Data not available
pH	: No data available
	: Data not available
Boiling point/boiling range	: -65.5 - 97.3 °C / -85.9 - 207.1 °F (1000 hPa)

Flash point : estimated value(s) -108 °C / -162 °F

Evaporation rate : Data not available

Flammability

Lower explosion limit and upper explosion limit / flammability limit

Upper explosion limit / Upper flammability limit : Data not available

Lower explosion limit / Lower flammability limit : Data not available

Vapour pressure : estimated value(s) 5.7 bar (25 °C / 77 °F)

Relative vapour density : estimated value(s) 1.75 (25 °C / 77 °F)

Relative density : estimated value(s) 0.59
Method: ASTM D4052

Density : estimated value(s) 0.590 g/cm3 (40 °C / 104 °F)
Method: ASTM D4052

Solubility(ies)

Water solubility : negligible

Solubility in other solvents : Data not available

Partition coefficient: n-octanol/water : Data not available

Auto-ignition temperature : Data not available

Decomposition temperature : Data not available

Viscosity

Viscosity, dynamic : estimated value(s) 0.139 mPa.s (40 °C / 104 °F)

Method: ASTM D445

Viscosity, kinematic : estimated value(s) 0.236 mm2/s (40 °C / 104 °F)

Method: ASTM D445

Explosive properties : No data available
Oxidizing properties : Data not available
Surface tension : Data not available
Conductivity : Low conductivity: < 100 pS/m, The conductivity of this material makes it a static accumulator., A liquid is typically considered nonconductive if its conductivity is below 100 pS/m and is considered semi-conductive if its conductivity is below 10,000 pS/m., Whether a liquid is nonconductive or semiconductive, the precautions are the same., A number of factors, for example liquid temperature, presence of contaminants, and anti-static additives can greatly influence the conductivity of a liq-

		uid
Molecular weight	:	Data not available
Particle size	:	Data not available

SECTION 10. STABILITY AND REACTIVITY

Reactivity	:	Reacts violently with strong oxidising agents.
Chemical stability	:	Oxidises on contact with air to form unstable peroxides. Unstable at elevated temperatures.
Possibility of hazardous reactions	:	Polymerisation may occur at elevated temperatures.
Conditions to avoid	:	Heat, flames, and sparks. Exposure to air.
Incompatible materials	:	Strong oxidising agents. If copper, copper alloys, monel, silver, mercury or magnesium is used during construction or maintenance, the formation of explosive acetylides can occur as a result of contact with butadiene. If Teflon® or Delrin® is used, polymer formation may result.

SECTION 11. TOXICOLOGICAL INFORMATION

Basis for assessment	:	Information given is based on product testing, and/or similar products, and/or components. Unless indicated otherwise, the data presented is representative of the product as a whole, rather than for individual component(s).

Information on likely routes of exposure
Exposure may occur via inhalation, ingestion, skin absorption, skin or eye contact, and accidental ingestion.

Acute toxicity

Product:

Acute oral toxicity	:	Remarks: May be harmful if swallowed. LD50 >2000 - <=5000 mg/kg
Acute inhalation toxicity	:	Remarks: Based on available data, the classification criteria are not met.
Acute dermal toxicity	:	Remarks: Based on available data, the classification criteria are not met.

Components:

gases (petroleum, light steam-cracked, butadiene conc.:

Acute oral toxicity	:	Remarks: Acute oral toxicity Not applicable
Acute inhalation toxicity	:	LC 50 (Rat, male and female): > 2311 ppm Exposure time: 4 h Test atmosphere: gas Method: Test(s) equivalent or similar to OECD Test Guideline

403
Remarks: Based on available data, the classification criteria are not met.
High concentrations may cause central nervous system depression resulting in headaches, dizziness and nausea; continued inhalation may result in unconsciousness and/or death.

Acute dermal toxicity : Remarks: Acute dermal toxicity
Not applicable

Skin corrosion/irritation

Product:

Remarks: Irritating to skin.

Components:

gases (petroleum, light steam-cracked, butadiene conc.:
Species: Rabbit
Method: Acceptable non-standard method.
Remarks: Slightly irritating to skin., Insufficient to classify., Rapid release of gases which are liquids under pressure may cause frost burns of exposed tissues (skin, eye) due to evaporative cooling.

Serious eye damage/eye irritation

Product:

Remarks: Eye irritation

Components:

gases (petroleum, light steam-cracked, butadiene conc.:
Species: Rabbit
Method: Acceptable non-standard method.
Remarks: Based on available data, the classification criteria are not met., Rapid release of gases which are liquids under pressure may cause frost burns of exposed tissues (skin, eye) due to evaporative cooling.

Respiratory or skin sensitisation

Product:

Remarks: Based on available data, the classification criteria are not met.

Germ cell mutagenicity

Product:

Genotoxicity in vitro : Remarks: May cause genetic defects.

Genotoxicity in vivo : Remarks: May cause heritable genetic damage

Components:

gases (petroleum, light steam-cracked, butadiene conc.:

Genotoxicity in vitro : Method: Test(s) equivalent or similar to OECD Guideline 471
Test substance: 1,3-Butadiene
Remarks: May cause genetic defects.

: Method: Test(s) equivalent or similar to OECD Test Guideline 476
Test substance: 1,3-Butadiene
Remarks: May cause genetic defects.

: Method: Test(s) equivalent or similar to OECD Test Guideline 476
Test substance: 1,3-Butadiene
Remarks: May cause genetic defects.

: Method: OECD Test Guideline 482
Test substance: 1,3-Butadiene
Remarks: May cause genetic defects.

Genotoxicity in vivo : Test species: Mouse
Method: OECD Test Guideline 474
Test substance: 1,3-Butadiene
Remarks: May cause genetic defects.

Test species: Mouse
Method: Test(s) equivalent or similar to OECD Test guideline 478
Test substance: 1,3-Butadiene
Remarks: May cause genetic defects.

Germ cell mutagenicity- Assessment : May cause genetic defects.

Carcinogenicity

Product:

Remarks: Known human carcinogen., May cause leukaemia (AML - acute myelogenous leukaemia)., May cause MDS (Myelodysplastic Syndrome).

Components:

gases (petroleum, light steam-cracked, butadiene conc.:
Species: Mouse, (male and female)
Application Route: Inhalation
Method: Test(s) equivalent or similar to OECD Test Guideline 453
Test substance: 1,3-Butadiene
Remarks: May cause cancer.

Species: Rat, (male and female)
Application Route: Inhalation
Method: Test(s) equivalent or similar to OECD Test Guideline 453
Test substance: 1,3-Butadiene
Remarks: May cause cancer.

Carcinogenicity - Assessment : May cause cancer.

IARC	Group 1: Carcinogenic to humans	
	1,3-butadiene	106-99-0
	Benzene	71-43-2
	Group 2B: Possibly carcinogenic to humans	
	Isoprene	78-79-5
OSHA	OSHA specifically regulated carcinogen	
	1,3-butadiene	106-99-0
	Benzene	71-43-2
NTP	Known to be human carcinogen	
	1,3-butadiene	106-99-0
	Benzene	71-43-2
	Reasonably anticipated to be a human carcinogen	
	Isoprene	78-79-5

Reproductive toxicity

Product:

Effects on fertility :
Remarks: Based on available data, the classification criteria are not met.

Components:

gases (petroleum, light steam-cracked, butadiene conc.:

Effects on fertility :
Species: Rat
Sex: male and female
Application Route: Inhalation

Method: OECD Test Guideline 422
Remarks: Based on available data, the classification criteria are not met.

Effects on foetal development : Species: Mouse, female
Application Route: Inhalation
Method: Other guideline method.
Remarks: Based on available data, the classification criteria

are not met.

Reproductive toxicity - Assessment : This product does not meet the criteria for classification in categories 1A/1B.

STOT - single exposure

Product:

Remarks: Based on available data, the classification criteria are not met.

Components:

gases (petroleum, light steam-cracked, butadiene conc.:
Remarks: Based on available data, the classification criteria are not met., Inhalation of vapours or mists may cause irritation to the respiratory system., Not classified due to data which are conclusive although insufficient for classification.

STOT - repeated exposure

Product:

Remarks: Blood-forming organs: repeated exposure affects the bone marrow., Contains benzene.

Components:

gases (petroleum, light steam-cracked, butadiene conc.:
Remarks: Based on available data, the classification criteria are not met., Contains 1,3-butadiene., Blood-forming organs: repeated exposure affects the bone marrow., Reproductive system: repeated exposure affects the ovaries and testes in mice., Exposure to very high concentrations of similar materials has been associated with irregular heart rhythms and cardiac arrest., Not classified due to data which are conclusive although insufficient for classification.

Repeated dose toxicity

Components:

gases (petroleum, light steam-cracked, butadiene conc.:
Species: Rat, male and female
Application Route: Oral
Method: Test(s) equivalent or similar to OECD Test Guideline 407
Target Organs: No specific target organs noted

Species: Rat, male and female
Application Route: Inhalation
Test atmosphere: vapour
Method: OECD Test Guideline 422
Target Organs: No specific target organs noted

Aspiration toxicity

Product:

Aspiration into the lungs when swallowed or vomited may cause chemical pneumonitis which can be fatal.

Components:

gases (petroleum, light steam-cracked, butadiene conc.:
Based on available data, the classification criteria are not met.

Further information

Product:

Remarks: Rapid release of gases which are liquids under pressure may cause frost burns of exposed tissues (skin, eye) due to evaporative cooling.

Remarks: Classifications by other authorities under varying regulatory frameworks may exist.

Remarks: This product may contain trace amounts of NORM as Radon and its decay products. Carcinogenicity: IARC classification / Group 1 carcinogen.

Radon rapidly decays to form other radioactive elements including lead 210, polonium 210, and bismuth 210. Therefore, processing equipment may contain build-up of radioactive contamination. The radon decay products are solids and therefore may attach to dust particles or form films in equipment. Inhalation, ingestion, or skin contact with radon decay products can lead to the deposit of radioactive material in the respiratory tract, bone or blood forming organs, intestinal tract, and kidney, which may lead to certain cancers.

Components:

gases (petroleum, light steam-cracked, butadiene conc.:
Remarks: Classifications by other authorities under varying regulatory frameworks may exist.

SECTION 12. ECOLOGICAL INFORMATION

Basis for assessment	: Incomplete ecotoxicological data are available for this product. The information given below is based partly on a knowledge of the components and the ecotoxicology of similar products. Unless indicated otherwise, the data presented is representative of the product as a whole, rather than for individual component(s).

Ecotoxicity

Product:

Toxicity to fish (Acute toxicity)	: Remarks: Physical properties indicate that hydrocarbon gases will rapidly volatilise from the aquatic environment and that acute and chronic effects would not be observed in practice.
Toxicity to daphnia and other aquatic invertebrates (Acute toxicity)	: Remarks: Physical properties indicate that hydrocarbon gases will rapidly volatilise from the aquatic environment and that acute and chronic effects would not be observed in practice.
Toxicity to fish (Chronic toxicity)	: Remarks: Data not available
Toxicity to microorganisms	: Remarks: Data not available

(Acute toxicity)

Components:

gases (petroleum, light steam-cracked, butadiene conc.:

Toxicity to fish (Acute toxicity) : LC50: 19 mg/l
Exposure time: 96 h
Method: Information given is based on data obtained from similar substances.
Remarks: Data not available

Toxicity to daphnia and other aquatic invertebrates (Acute toxicity) : LC50 (Daphnia (water flea)): 11 mg/l
Exposure time: 48 h
Method: Information given is based on data obtained from similar substances.
Remarks: Data not available

Toxicity to algae (Acute toxicity) : EC50: 7.7 mg/l
Exposure time: 96 h
Method: Information given is based on data obtained from similar substances.
Remarks: Data not available

Toxicity to fish (Chronic toxicity) : Remarks: Data not available
Toxicity to daphnia and other aquatic invertebrates (Chronic toxicity) : Remarks: Data not available
Toxicity to microorganisms (Acute toxicity) : Remarks: Data not available

Persistence and degradability

Product:

Biodegradability : Remarks: The volatile constituents will oxidize rapidly by photochemical reactions in air.

Components:

gases (petroleum, light steam-cracked, butadiene conc.:

Biodegradability : Biodegradation: 50 %
Exposure time: 3.5 d
Method: Information given is based on data obtained from similar substances.
Remarks: Readily biodegradable.

Bioaccumulative potential

Product:

Bioaccumulation : Remarks: Data not available

Components:

gases (petroleum, light steam-cracked, butadiene conc.:

Bioaccumulation	:	Remarks: Does not have the potential to bioaccumulate significantly.

Mobility in soil

Product:

Mobility	:	Remarks: Because of their extreme volatility, air is the only environmental compartment that hydrocarbon gases will be found.

Components:

gases (petroleum, light steam-cracked, butadiene conc.:

Mobility	:	Remarks: Because of their extreme volatility, air is the only environmental compartment that petroleum gases will be found.

Other adverse effects

Product:

Additional ecological information	:	Physical properties indicate that hydrocarbon gases will rapidly volatilise from the aquatic environment and that acute and chronic effects would not be observed in practice.

Components:

gases (petroleum, light steam-cracked, butadiene conc.:

Results of PBT and vPvB assessment	:	The substance does not fulfill all screening criteria for persistence, bioaccumulation and toxicity and hence is not considered to be PBT or vPvB.
Additional ecological information	:	Physical properties indicate that petroleum gases will rapidly volatilise from the aquatic environment and that acute and chronic effects would not be observed in practice.

SECTION 13. DISPOSAL CONSIDERATIONS

Disposal methods

Waste from residues	:	Recover or recycle if possible. It is the responsibility of the waste generator to determine the toxicity and physical properties of the material generated to determine the proper waste classification and disposal methods in compliance with applicable regulations. Do not dispose into the environment, in drains or in water courses. Waste product should not be allowed to contaminate soil or water. Disposal should be in accordance with applicable regional, national, and local laws and regulations. Local regulations may be more stringent than regional or national requirements and must be complied with.

Contaminated packaging	:	Drain container thoroughly. After draining, vent in a safe place away from sparks and fire. Send to drum recoverer or metal reclaimer.

SECTION 14. TRANSPORT INFORMATION

National Regulations

49 CFR

UN/ID/NA number	:	UN 1010
Proper shipping name	:	Butadienes, stabilized
Class	:	2.1
Packing group	:	Not Assigned
Labels	:	2.1
Reportable quantity		1,3-Butadiene (10 lb)
ERG Code	:	116P
Marine pollutant	:	no

International Regulations

IATA-DGR

UN/ID No.	:	UN 1010
Proper shipping name	:	BUTADIENES AND HYDROCARBON MIXTURE, STABILIZED
Class	:	2.1
Packing group	:	Not Assigned
Labels	:	2.1

IMDG-Code

UN number	:	UN 1010
Proper shipping name	:	BUTADIENES AND HYDROCARBON MIXTURE, STABILIZED
Class	:	2.1
Packing group	:	Not Assigned
Labels	:	2.1
Marine pollutant	:	no

Maritime transport in bulk according to IMO instruments

Pollution category	:	Data not available
Ship type	:	Data not available
Product name	:	Data not available

Special precautions for user

Remarks	:	Special Precautions: Refer to Section 7, Handling & Storage, for special precautions which a user needs to be aware of or needs to comply with in connection with transport.

SECTION 15. REGULATORY INFORMATION

EPCRA - Emergency Planning and Community Right-to-Know Act

CERCLA Reportable Quantity

Components	CAS-No.	Component RQ (lbs)	Calculated product RQ (lbs)
Benzene	**71-43-2**	**10**	**90**
propylene	**115-07-1**	**100**	**333**
butane	**106-97-8**	**100**	**2000**
propane	**74-98-6**	**100**	**2500**
Isoprene	**78-79-5**	**100**	*
Toluene	**108-88-3**	**1000**	*
1,3-butadiene	**106-99-0**	**10**	**10***

*: Calculated RQ exceeds reasonably attainable upper limit.
Calculated RQ exceeds reasonably attainable upper limit., The components with RQs are given for information.

SARA 304 Extremely Hazardous Substances Reportable Quantity

This material does not contain any components with a section 304 EHS RQ.

SARA 302 Extremely Hazardous Substances Threshold Planning Quantity

This material does not contain any components with a section 302 EHS TPQ.

SARA 311/312 Hazards : Flammable (gases, aerosols, liquids, or solids)
Gases under pressure
Aspiration hazard
Skin corrosion or irritation
Serious eye damage or eye irritation
Germ cell mutagenicity
Carcinogenicity
Specific target organ toxicity (single or repeated exposure)

SARA 313 : The following components are subject to reporting levels established by SARA Title III, Section 313:

1,3-butadiene	106-99-0	>= 90 - <= 100 %
propylene	115-07-1	>= 30 - < 50 %
Benzene	71-43-2	>= 10 - < 20 %
Isoprene	78-79-5	>= 0.1 - < 1 %

Clean Water Act

The following Hazardous Chemicals are listed under the U.S. CleanWater Act, Section 311, Table 117.3:

Toluene	108-88-3	0.2 %
Benzene	71-43-2	11 %
Isoprene	78-79-5	0.1 %

US State Regulations

Pennsylvania Right To Know

1,3-butadiene	106-99-0
propylene	115-07-1
Benzene	71-43-2
butane	106-97-8
cyclopentadiene	542-92-7
propane	74-98-6
but-1-ene	106-98-9
Cyclopentene	142-29-0
Toluene	108-88-3
Isoprene	78-79-5

California Prop. 65

WARNING: This product can expose you to chemicals including Isoprene, Benzene, 1,3-butadiene, which is/are known to the State of California to cause cancer, and Benzene, Toluene, 1,3-butadiene, which is/are known to the State of California to cause birth defects or other reproductive harm. For more information go to www.P65Warnings.ca.gov.

California List of Hazardous Substances

1,3-butadiene	106-99-0
propylene	115-07-1
Benzene	71-43-2
butane	106-97-8
cyclopentadiene	542-92-7

California Regulated Carcinogens

1,3-butadiene	106-99-0
Benzene	71-43-2

Other regulations:

The regulatory information is not intended to be comprehensive. Other regulations may apply to this material.

The components of this product are reported in the following inventories:

TSCA : Listed

DSL : Listed

ENCS : Listed

NZIoC : Listed

PICCS : Listed

TCSI : Listed

SECTION 16. OTHER INFORMATION

Further information

NFPA Rating (Health, Fire, Reactivity) 2, 4, 2

Full text of other abbreviations

ACGIH : USA. ACGIH Threshold Limit Values (TLV)
ACGIH BEI : ACGIH - Biological Exposure Indices (BEI)
OSHA CARC : OSHA Specifically Regulated Chemicals/Carcinogens
OSHA Z-1 : USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
OSHA Z-2 : USA. Occupational Exposure Limits (OSHA) - Table Z-2
ACGIH / TWA : 8-hour, time-weighted average
ACGIH / STEL : Short-term exposure limit
OSHA CARC / PEL : Permissible exposure limit (PEL)
OSHA CARC / STEL : Excursion limit
OSHA Z-1 / TWA : 8-hour time weighted average
OSHA Z-1 / STEL : Short Term Exposure Limit
OSHA Z-2 / TWA : 8-hour time weighted average
OSHA Z-2 / CEIL : Acceptable ceiling concentration
OSHA Z-2 / Peak : Acceptable maximum peak above the acceptable ceiling concentration for an 8-hr shift
Abbreviations and Acronyms : The standard abbreviations and acronyms used in this document can be looked up in reference literature (e.g. scientific dictionaries) and/or websites.

ACGIH = American Conference of Governmental Industrial Hygienists
ADR = European Agreement concerning the International Carriage of Dangerous Goods by Road
AICS = Australian Inventory of Chemical Substances
ASTM = American Society for Testing and Materials
BEL = Biological exposure limits
BTEX = Benzene, Toluene, Ethylbenzene, Xylenes
CAS = Chemical Abstracts Service
CEFIC = European Chemical Industry Council
CLP = Classification Packaging and Labelling
COC = Cleveland Open-Cup
DIN = Deutsches Institut fur Normung
DMEL = Derived Minimal Effect Level
DNEL = Derived No Effect Level
DSL = Canada Domestic Substance List
EC = European Commission
EC50 = Effective Concentration fifty
ECETOC = European Center on Ecotoxicology and Toxicology Of Chemicals
ECHA = European Chemicals Agency
EINECS = The European Inventory of Existing Commercial Chemical Substances
EL50 = Effective Loading fifty
ENCS = Japanese Existing and New Chemical Substances Inventory
EWC = European Waste Code
GHS = Globally Harmonised System of Classification and Labelling of Chemicals
IARC = International Agency for Research on Cancer

IATA = International Air Transport Association
IC50 = Inhibitory Concentration fifty
IL50 = Inhibitory Level fifty
IMDG = International Maritime Dangerous Goods
INV = Chinese Chemicals Inventory
IP346 = Institute of Petroleum test method N° 346 for the determination of polycyclic aromatics DMSO-extractables
KECI = Korea Existing Chemicals Inventory
LC50 = Lethal Concentration fifty
LD50 = Lethal Dose fifty per cent.
LL/EL/IL = Lethal Loading/Effective Loading/Inhibitory loading
LL50 = Lethal Loading fifty
MARPOL = International Convention for the Prevention of Pollution From Ships
NOEC/NOEL = No Observed Effect Concentration / No Observed Effect Level
OE_HPV = Occupational Exposure - High Production Volume
PBT = Persistent, Bioaccumulative and Toxic
PICCS = Philippine Inventory of Chemicals and Chemical Substances
PNEC = Predicted No Effect Concentration
REACH = Registration Evaluation And Authorisation Of Chemicals
RID = Regulations Relating to International Carriage of Dangerous Goods by Rail
SKIN_DES = Skin Designation
STEL = Short term exposure limit
TRA = Targeted Risk Assessment
TSCA = US Toxic Substances Control Act
TWA = Time-Weighted Average
vPvB = very Persistent and very Bioaccumulative

A vertical bar (|) in the left margin indicates an amendment from the previous version.
|| There has been a significant change in transport classification in section 14.

Sources of key data used to compile the Safety Data Sheet : The quoted data are from, but not limited to, one or more sources of information (e.g. toxicological data from Shell Health Services, material suppliers' data, CONCAWE, EU IUCLID date base, EC 1272 regulation, etc).

Revision Date : 03/06/2025

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

US / EN

Attachment 5: Confidential Business Information Log

Document Title	Submittal Date	Page and Line Numbers	Information Description	Basis for Confidential Treatment as Identified in the Pennsylvania Air Pollution Control Ace, 35 P.S. § 4013.
Shell Polymers Monaca, Flare Gas Recovery Additional Information	12/08/25	Pages 14-16 Table 3 Entire	PE vent gas streams labels, flow rates, duration, and # events per year	Shell operates PE Units 1 and 2 under license from Univation Technologies ("Univation"), which covers the "core plant" of these units, including process vents. Similarly, Shell operates PE Unit 3 under license from Ineos Commercial Services UK Ltd. ("Ineos"), which covers the "core plant" of the unit, including process vents. The combination of specific individual vent identifications with flow rate and compositional data are claimed as confidential proprietary information as defined by the Pennsylvania Right to Know Law and pursuant to Section 13.2 of the Air Pollution Control Act, 35 P.S. 4013.2.
Shell Polymers Monaca, Flare Gas Recovery Additional Information	12/08/25	Page 17 Table 4 Entire	PE vent gas streams labels, flow rates, duration, and # events per year	Shell operates PE Units 1 and 2 under license from Univation Technologies ("Univation"), which covers the "core plant" of these units, including process vents. Design process vent flow rates and compositions are provided by the referenced licensors and are unique to each technology. The combination of specific individual vent identifications with flow rate and compositional data are claimed as confidential proprietary information as defined by the Pennsylvania Right to Know Law and pursuant to Section 13.2 of the Air Pollution Control Act, 35 P.S. 4013.2.
Shell Polymers Monaca, Flare Gas Recovery Additional Information	12/08/25	Page 18 Table 5 Entire	ECU startup, shutdown, and maintenance vent gas flow rates, duration, and # events per year	This data is operational and process data which are inherent to Shell's design and licensor agreements. The combination of specific individual vent identifications with flow rate and compositional data are claimed as confidential proprietary information as defined by the Pennsylvania Right to Know Law and pursuant to Section 13.2 of the Air Pollution Control Act, 35 P.S. 4013.2.

Document Title	Submittal Date	Page and Line Numbers	Information Description	Basis for Confidential Treatment as Identified in the Pennsylvania Air Pollution Control Ace, 35 P.S. § 4013.
Shell Polymers Monaca, Flare Gas Recovery Additional Information	12/08/25	Page 20 Table 7 Entire	ECU startup, shutdown, and maintenance vent gas flow rates, duration, and # events per year	This data is operational and process data which are inherent to Shell's design and licensor agreements. The combination of specific individual vent identifications with flow rate and compositional data are claimed as confidential proprietary information as defined by the Pennsylvania Right to Know Law and pursuant to Section 13.2 of the Air Pollution Control Act, 35 P.S. 4013.2.
Shell Polymers Monaca, Flare Gas Recovery Additional Information	12/08/25	Attachment 1	ECU furnace burner data sheet	This is a vendor document provided to Shell and contains specific design information which is protected by Shell's licensor agreements with the vendor. The design data is confidential proprietary information as defined by the Pennsylvania Right to Know Law and pursuant to Section 13.2 of the Air Pollution Control Act, 35 P.S. 4013.2.
Shell Polymers Monaca, Flare Gas Recovery Additional Information	12/08/25	Attachment 2	Cogen HRSG duct burner data sheet	This is a vendor document provided to Shell and contains specific design information which is protected by Shell's licensor agreements with the vendor. The design data is confidential proprietary information as defined by the Pennsylvania Right to Know Law and pursuant to Section 13.2 of the Air Pollution Control Act, 35 P.S. 4013.2.
Shell Polymers Monaca, Flare Gas Recovery Additional Information	12/08/25	Attachment 3	GTG performance guarantee	This document reflects specific design data between Shell and its vendor and includes specific design and engineering data which is confidential proprietary information as defined by the Pennsylvania Right to Know Law and pursuant to Section 13.2 of the Air Pollution Control Act, 35 P.S. 4013.2.