Shell Chemical Appalachia LLC
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BY ELECTRONIC MAIL

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Environmental Protection/Southwest Regional Office
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RE: Emission Exceedance Report and Mitigation Plan for Shell Chemical Appalachia LLC

Dear Anna:

Shell Chemical Appalachia LLC (Shell) submits this Emission Exceedance Report and Mitigation Plan (Technical Report) as requested by the Pennsylvania Department of Environmental Protection (PADEP) on December 14, 2022. PADEP's request was sent concurrently with a Notice of Violation (NOV) for Plan Approval PA-04-00740C, issued February 18, 2021. The NOV alleges that Shell exceeded its 12-month rolling emission limits for Volatile Organic compounds (VOCs) as contained in Section C, Condition #005, of Plan Approval PA-04-00740C. This information was proactively communicated to PADEP as required by the Plan Approval. This Technical Report incorporates the specific information requested by PADEP and is organized accordingly.

One important consideration which requires emphasis by Shell, in connection with the NOV, is that the Plan Approval did not include short-term limits which would have been appropriate for the start-up process and that would have accounted for malfunctions that typically occur with the commissioning of a major chemical production facility. The emissions which occurred during the "shakedown period" were not explicitly included in the Facility's potential-to-emit (PTE), which provided the basis for the emission limitations set forth in the Plan Approval. This concern was discussed with PADEP during the permitting process although short term or alternative limits were not incorporated into the permit. Shell requests that PADEP consider the fact that start-up emissions have been traditionally viewed by industry and regulators as beyond an operator's control in regard to the NOV. As relevant here, Shell is approaching a more normal operation each day as it completes commissioning of the Facility and makes the necessary adjustments to the equipment and control logic. This result is evident with the flaring emissions and the monthly actual emissions improving in November and December 2022.

1. **Evaluation of the Commissioning Process**

Shell's Polymers Monaca site is a world scale polyethylene (PE) production facility ("Facility") which is a first for the Northeast United States, and a first to be constructed in many years. The Facility includes utilities, electrical and steam or cogeneration, flares, the ethane cracking unit (ECU), polyethylene (PE), and logistics (rail and truck transport). The design and construction of the Facility required many years of planning and coordination with PADEP and the Environmental Protection Agency (EPA), along with local governments such as Potter and Center Townships. Numerous meetings and public hearings were held prior to permit issuance and construction, which involved millions of hours of work, and which have contributed economic benefits to the region.

The commissioning process entailed more than two years of work and detailed planning and teamwork. Following construction of the Facility, Shell implemented a 28-block handover which included five systems (a block is designated part of the Facility and associated equipment) to Shell's Integrated Commissioning and Startup (iCSU) Team. The five systems included: outside the battery limits; PE 1, 2, and 3; ECU; and Cogen. After each block was handed over to the iCSU team, equipment readiness, walkdowns and more than 100 pre-start-up safety (PSSR) reviews were completed. Punch lists were developed to track completion of items required for commissioning. Once PSSRs were completed, the equipment was ready for commissioning.

Commissioning included chemical cleaning and steam blowing using smart torque technology to ensure the equipment was properly tightened. Various tanks and miles of piping and process equipment were pressure tested to ensure tightness at start-up. This process was accomplished from the initial torquing program during installation in the construction phase and pneumatic and hydrostatic testing during the commissioning phase. The means for assuring tightness depended on the type of equipment service and varied across the different units. The objective of the tightness testing program was to find and repair leaks. The objective of other quality programs was to ensure the systems were cleaned to prevent operational issues with debris prior to the start-up and to prevent safety and environmental incidents. Each system was also "walked down" by a team of subject matter experts prior to commissioning.

Importantly, Shell's Operations team were comprehensively trained within their assigned units. Training included the development of procedures and a virtual program which is a three-dimensional model and dynamic process simulator that replicates operating conditions and operational response. The virtual program allowed operators to train and gain experience on operating their units and making changes to the equipment and responding to alarms under different operating scenarios. Once construction activities were completed, Shell's Operations team led the commissioning and plant operations as each piece of equipment was energized.

Initial start-up began in November 2019 with the energization of the Cogeneration's high voltage switchgear followed by water treatment in 2021. Consistent with all business delays in the U.S., the Covid pandemic caused Shell's plant to pause operations while new testing and health protocols were implemented. Once the Covid protocols were implemented, Shell was able to slowly ramp up personnel and activities were able to resume. The Covid pandemic resulted in a delay in the completion of the Facility and overall start-up.

Cogeneration began in June 2021 which provided steam and electricity used for commissioning and start-up activities. The first fire of each gas turbine generator (GTG) occurred in June/July 2021, which provided the steam for Cogeneration steam blows. Catalyst was loaded during the steam blow restoration period, and the units restarted in October 2021 to provide the steam and electricity for the Facility. This steam and electricity also form the basis for utilities in normal operations. Wastewater treatment was started in phases to support the various wastewater streams. The biotreaters were seeded with bacteria and placed into service prior to the introduction of hydrocarbon into the process units in mid-2022.

As commissioning progressed to start-up, some important steps were taken in 2022 to begin full commissioning and start-up of the ECU and PE units. In May 2022, Shell began filling vessels, tanks and equipment with nitrogen and propane. The ECU ethane clean-up process began in August 2022, followed by ECU feed into Furnace Number 1 on September 5, 2022. As the ECU was started up, equipment downstream of the furnaces was energized with the goal of making on-specification ethylene for storage in the onsite ethylene storage tank. Until confirmed progress could be made, ethylene and other hydrocarbons were combusted onsite by the high pressure (HP) and low pressure (LP) flares (additional explanation is set forth herein). Cool down of the Ethylene storage tank began in September 2022 and storage began in late September to early October once various equipment malfunctions were resolved. The first PE pellets were created from Shell- manufactured ethylene in early October 2022.

2. **<u>Identify the Causes of Excess Emissions and Sources Where the Excess Emissions Occurred</u>**

The timeline set forth below describes the causes of excess emissions associated with malfunctions which occurred during commissioning and start-up. These malfunctions resulted in more time to bring ethylene on specification before feed and commissioning could move forward, allowing flaring to be reduced. As a result, excess emissions occurred in September 2022 into mid-October.

From September to December 2022, the ECU experienced several unforeseen malfunctions during the initial start-up and shakedown period of the ECU unit. These malfunctions prevented the progress of fully commissioning the ECU and producing on specification ethylene to continue the commissioning cooldown filling step, utilization of the ethylene storage tank and providing ethylene to the available PE units to produce PE pellets. The result of the incidents was additional emissions resulting from directing the feed to the high pressure (HP) flare system and not forward into ethylene storage and PE production. As noted above, despite the preventative measures detailed throughout this Report, excess emissions during cold equipment start-up are not atypical, and are extremely difficult to avoid when starting up a brand-new facility. Shell's Plan Approval permit application reasonably accounted for how long and how many emissions would be anticipated during start-up and into normal operations. Shell's Plan Approval permit application did not, however, include unanticipated malfunctions that may be experienced during initial start-up. At present, normal operations have not been achieved and Shell is still in the process of shaking down the emission sources to bring them to normal operations. In short, Shell's emissions from September to October 2022 are not typical of normal operations, and resulted from the initial vessel, pipe and tank filling, and setbacks occurring with starting the units for the first time after construction was complete. A summary of the unanticipated malfunctions is provided below:

- Starting on September 8, 2022, the initial startup of the ECU experienced a series of flange leaks and instrumentation trips of ECU process equipment. Unit startup was progressing and the Deethanizer and Acetylene Converter (AC) were online and on specification when a leak was discovered on the manway of Low Temp Drum 3 on the Demethanizer Feed Train on September 8. The operators made the appropriate moves to minimize the leak, so the insulation could be safely removed, and an attempt to make and complete online repair. The leaks were likely caused by the thermal stresses that resulted when the equipment was brought to normal operating temperatures (which were not achieved during tightness testing).

- On the evening of September 8, the Ethylene Refrigeration Compressor (ERC) reached a low-temperature trip on the 4th Stage when the Demethanizer bottoms were on specification and feed was introduced into the C2 Splitter. When the ERC trips, the C2 Splitter and Demethanizer Systems cannot be operated due to insufficient pressures required for the operation and flaring of the cracked gas must occur upstream of these systems. During this time, a leak was also discovered on the Cold Flare Drum inlet line flange. Operations made moves to enable safe access by Maintenance for an online repair attempt. The leak was repaired on September 10, and Operations were in the process of restarting the ERC when it tripped on high vibration, which is designed to protect the machine from mechanical damage. When the ERC tripped, the Cracked Gas Compressor (CGC) also tripped due to loss of control oil. With the CGC down and a need for troubleshooting and repairing the issues that caused the trip, ethane feed was removed from the unit to minimize flaring. Once the issues were understood and mitigated, feed was later introduced that day and restart continued. Over the next few days, the CGC, ERC, Deethanizer, AC, Demethanizer, and C2 Splitter systems were all restarted, and Ethylene Product was being produced with sufficient quality to begin cooling down the Ethylene Storage system on September 15.

- On September 15, the Ethylene Splitter (C2 Splitter) reached on specification milestone with ethane < 1000 ppm for the first time, allowing for the initial ECU startup to progress and start sending ethylene to the ethylene tank to start cooling down the tank. Cool down of the ethylene storage tank is an important step to safely commission this storage tank for the first time that it is put into service. During this step, some ethylene is going into the storage tank for the initial storage tank cool down, but the majority of the ethylene was sent to the HP Flare System until the tank was cooled down sufficiently. Once this initial commissioning step is completed, all ethylene goes to the storage tank or into the Polyethylene Units rather than to the HP flares. The cooldown step of the ethylene storage tank with on spec ethylene was interrupted by a trip of the CGC that same day.

- On the night of September 15, the CGC tripped on high 4th Stage Suction Drum Level. Troubleshooting to understand cause started immediately, and on the morning of the following day, an issue was found in the calibration settings on the level instruments on that drum and several other applications across the unit. These were corrected and the unit restart commenced again on September 16.

- On September 18, the Propane Refrigeration Compressor (PRC) tripped on low 1st stage suction pressure due to swings in the unit controls. A trip of the PRC results in the inability to operate the entire cold side of the ECU, from the discharge of the CGC forward. Once the trip was understood and corrections were put in place to prevent recurrence, the PRC was restarted, and the Cold Side restart commenced.

- On the morning of September 21, the AC Reactor tripped due to swings in the methanol levels caused by inadequate removal of non-condensable gases in the system. Once this was understood and actions taken to prevent recurrence, the AC Reactor was restarted, and the remaining Cold Side restart commenced.

- On September 23, the startup was progressing with the C2 Splitter system and the column was not achieving design conditions. Troubleshooting continued into the following day and a plugged C2 Splitter Reboiler strainer was identified as the likely cause. An online backflush of the strainer was performed, and it temporarily enabled the system to perform as designed, but unfortunately there was no ability to remove the material that was plugging the system without a complete shutdown of the C2 Splitter system and thus the entire ECU unit. By September 24, on specification ethylene was being produced in the ECU, and on specification pellets were produced in PE2 on October 1, 2022.

- On October 2, the C2 Splitter Reboiler strainer was showing signs of plugging again. The AC Reactor was off specification for several hours. During that time, Operators took the opportunity to backflush the strainer and, while that provided marginal benefit, the conditions deteriorated again across the next couple days.

- On October 5, the strainer plugged, and Operators could no longer operate the C2 Splitter system and continue producing ethylene that was on specification. A decision was made to perform a controlled shutdown on the ECU to enable intrusive maintenance work on the strainer to remove the material that caused the plugging. The ECU was brought down safely, and flaring was minimized to the Totally Enclosed Ground Flare (TEGF) (Source 205) to allow access to the C2 splitter vessels requiring the direct inspection and repair. In addition, the temporary maintenance outage allowed the maintenance team to repair missing refractory material on TEGF A enclosure and inspect both TEGFs during the outage.

- On October 17, the redundant ethylene storage tank boil off gas (BOG) compressor failed resulting in additional emissions being sent to Multi-Point Ground Flare (MPGF) (Source 204A) to control the boil off gas from the tank instead of recovering the ethylene.

- On October 24, there was an upset during an ethane feed dryer swap that resulted in off-spec acetylene on the AC Reactor outlet. This resulted in flaring during the resulting restart of the Demethanizer and C2 Splitter Systems along with getting the tail gas on specification and routed back to fuel, which all occurred by October 26.

- On November 15, excess carbon monoxide was present in the AC Reactor system that resulted in off-spec acetylene on the AC Reactor outlet. This was much shorter in duration than the previous AC Reactor event and resulted in all streams back to normal routing by the next day, November 16.

- On November 18, ethylene was sent to PE3 Unit for the first time, and PE pellets were produced on that unit for the first time on November 21, 2022.

- On November 20, a small amount of ethylene was flared during a C2 Splitter system upset until the ethylene returned back to specification.

- On November 28, the ECU lost Super High Pressure (SHP) steam supply from Utilities Cogen Plant. This resulted in a slowdown of the CGC and eventual trip of the AC Reactor system on low feed flow, per design. The AC Reactor, Demethanizer, and C2 Splitter were restarted, and all streams were routed away from the flare by the end of the day on November 29.

- On December 23, the ECU began experiencing operability issues due to the extremely cold ambient temperatures. On the morning of December 24, the Cogen Unit lost all Boiler Feed Water (BFW) flow to the site, which by design results in a complete ECU shutdown. Operations worked to controllably shutdown the ECU and park the unit in a safe operating mode until BFW and steam were restored. The unit remained down for approximately 2 weeks while the site worked through recovery efforts to repair equipment that was damaged from the freezing conditions and initial restart activities commenced. On the evening of January 6, ethane feed was reintroduced into the ECU to restart the unit and ethylene was on specification on January 8.

3. **Confirmation for Source ID 205 /High-Pressure Flare, and Root Cause Analyses for Flaring Events**

PADEP has requested confirmation that the HP flare has operated in accordance with the FMP. PADEP has also requested information required by the Plan Approval for flaring events (defined as an event that exceeds the baseline by 500,000 scf within a 24-hour period) in connection with the Plan Approval requirements for Sources 204 and 205 (Section D, Source ID 204, Condition No. 14, and Source ID 205, Condition Nos. 10 and 11).

Flare Minimization Plan (FMP)

Shell received approval from PADEP for the FMP in September 2020. The FMP incorporates procedures for operating and maintaining the flare systems, discusses mechanisms to minimize flaring emissions, identifies continuous monitoring conducted on flare equipment, documents expected flare baseline flows, and includes root cause analysis (RCA) and corrective action analysis (CAA) procedures. It is important to note that design criteria were used to establish flare baseline flow data which is, respectively, 6,400 thousand standard cubic feet per day (MSCD) and 4,500 MSCD for the HP and LP flaring systems to represent continuous flow during normal operation of the Facility.

Rates during the initial commissioning and start-up were often above these values and were part of the planned start-up from September through October 2022. Accordingly, a single cause for these emissions is known and multiple root cause-analyses were not warranted for planned activities associated with the initial commissioning and start-up. However, when individual equipment failed, or upset conditions occurred during start-up, which caused unplanned flaring, Shell complied with its Plan Approval and provided immediate verbal notification to PADEP and followed-up with written correspondence in the form of a Malfunction Report which included a root cause analysis and a discussion of the corrective actions undertaken to immediately mitigate the emissions and prevent re-occurrence.

HP Flare System

Shell’s HP flare system includes two TEGFs and an elevated flare for vent gas overflow when the capacity of the TEGFs is exceeded. When the elevated flare is used, steam is added at the tip to minimize the formation of smoke (i.e., visible emissions), which can be very difficult, due to the varying on rate and volume of flare during flaring incidents. Flaring at the site is continuous per design and as permitted in the Plan Approval. Since the ECU began to make product in late September 2022, there have been approximately 2,784 hours of flaring (September to December 2022). During that time, the elevated flare has only been used for a total of 134 minutes (discontinuously), which equates to approximately <0.08% of total flaring time. Moreover, smoking from the flare tip has occurred for a total 46 minutes (discontinuously), which is approximately <0.03%

The HP Flare has been operated in accordance with the FMP. The HP Flare is operated using steam-assist to support sufficient combustion air and mixing in the combustion zone. Visible emissions from the HP Flare have been observed and reported during commissioning, and improvements have been made to the steam control system. Improvements were made to further control steam addition based upon the flare gas valve position (as the indicator of flow to the HP Fare) and maintaining the steam to vent gas ratio using valve position-to-flow correlations. The original design was determined to rely on low pressures below the capability of pressure transmitters. Improvements have also been made to the steam supply control system using standard Proportional Integral Derivative controller tuning methods to increase performance and stability of the steam supply system.

Description of the Corrective Actions Undertaken by Shell in Accordance with the FMP

Operation and Maintenance Procedures - Included as part of the original FMP submittal, Shell attached a list of the relevant site procedures associated with operating and maintaining equipment associated with its flare system. As part of Shell's review of flaring incidents, Shell reviewed relevant procedures to identify opportunities to modify the operation of equipment to prevent reoccurring incidents. For example, Shell revised a butene unloading procedure used to commission its butene vessel to prevent overflow vapors to the flare.

Mechanisms to Minimize Furnace Upsets - Prevention measures related to process equipment and hardware at the Facility include monitoring and controlling net heating value (NHV) and specific gravity of tailgas/natural gas blends used as fuel in the cracking furnaces. This monitoring helps maintain the stability of the cracking furnaces and allows operators to anticipate changes in raw fuel composition that are required for stable operation of the ECU. The ability to pressure-control the tailgas system with purchased natural gas reduces flaring which may otherwise result from dynamic variations of fuel gas contributors. Proper fuel gas system supply pressure is important for the reliable operation of the ECU. Having a range of streams available to provide pressure control minimizes the risk of fuel system pressure disturbances which would otherwise lead to process upsets and result in flaring.

Use of Off-Specification Sphere – To minimize flaring emissions, Shell installed an Off-Specification Sphere that can function to re-use an ethane and ethylene mixture which are off-specification and generated during initial start-up. The Sphere serves to hold clean ethane in case of a process upset during the initial start-up before the ethylene product is being made and provides additional storage capacity for the purged off-specification ethylene product as the unit begins to produce its product. Throughout the commissioning and start-up of the ECU, the Sphere was used to reduce start-up flaring emissions by capturing the off-specification product rather than routing it to the flare. Once the ECU unit was online and exporting on-specification ethylene product to downstream units, the Sphere's contents were routed to the cracked gas compressor and furnaces when we commissioned the ethylene storage tank, as designed.

Designed for Minimum Turndown – During the initial commissioning and start-up of the ECU, Shell used fewer than seven furnaces and operated them at their minimum feed rates. Because flaring is required when the unit is inventoried, stabilized, and brought online, operating the furnaces at minimum turndown rates during commissioning involved a fraction of the flaring that would have occurred if the furnaces were operated at maximum rates. Also, Shell designed recycle loops from the back end to the front-end of process to supplement fresh feed and meet minimum flow through equipment especially during start-up conditions. A combination of furnace turndown rates and recycling ECU process gas from the back end to the front-end of the unit during start-up served to further reduce flaring during commissioning. The combined process minimized flaring during start-up and was executed according to plan.

On-site Ethylene Storage and Surge Capacity - Shell's design of its ECU includes specialized equipment to liquefy a portion of its ethylene product so that it can be stored in an atmospheric storage tank. The ability to use ethylene, rather than another hydrocarbon to purge nitrogen from the system prior to introducing ethylene to the tank for cooling and product storage provides a means of reducing the total amount of flaring during start-up. Also, this on-site storage mitigates flaring by providing spare capacity to provide ethylene feed to the PE units when the ECU experiences an upset that requires immediate shutdown or slowdown. Rather than immediately shutting down and flaring, the PE units can remain online while using the ethylene in the storage tank as feed. Conversely, when the PE units execute both planned and emergency shutdowns, the ability to condense ethylene into an atmospheric storage tank while the ECU is ramping down to minimum rates or idle production greatly reduces the threat of excess flaring emissions upon PE outages. The ECU experienced a shutdown while one or more PE Units were online. Although use of the atmospheric ethylene tank could not prevent a PE Unit going off-line on all occasions, the atmospheric storage tank provides the ability to supply feed to the PE units promptly to reduce flaring from PE Units. Also, the PE Units experienced an unplanned shutdown while the ECU was in operation. In these cases, the functionality of the atmospheric storage tank served to minimize flaring as the tank-maintained capacity to receive feed during a PE malfunction. Additionally, the ability to surge ethylene product was critical to minimize flaring when the ECU was forced to operate at or near-minimum rates when none of PE Units were able to remain online. The ability to balance ethylene production and ethylene storage to match feed rates associated with minimum polyethylene production of the PE Units has proven to be critical in minimizing flaring during the shakedown period of the PE Units.

Continuous Monitoring - Shell installed several monitoring devices and developed control strategies to eliminate and minimize excess emissions from flares when necessary. Pilot flame detection at the flare tip(s) is conducted using retractable thermocouples. These thermocouples can be withdrawn from the flare tip while the flare is in service to be repaired, thus eliminating downtime of the control device. Visible emissions from flares are monitored continuously via video cameras and the footage is saved on a dedicated server for a minimum of five years. The video surveillance camera(s) are placed at a reasonable distance and at an angle suitable for such observations, and real-time output is provided continuously at the control room console for operators' immediate response if necessary. Also, flare header volumetric flow rate monitors have been installed to measure flare vent gas, steam assist and air assist flows. Finally, the flare header lines are equipped with a gas chromatograph, which monitors the composition of vent gas combusted in each flare. Together, all monitoring variables provide Shell with the ability to proactively monitor flare vent gas to ensure vent gas has adequate heating value for efficient combustion, and to facilitate a prompt response to flaring incidents.
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Turnaround Review – Shell's FMP includes the evaluation of past turnarounds to improve on current procedures to further reduce flaring. The initial commissioning and start-up of the Facility does not fall under the definition of turnaround, so this activity has not been implemented yet. That said, a retrospective review has been conducted to evaluate threats to operation (i.e., events that can cause unplanned shutdowns or slowdowns that result in flaring).

Root Cause Analysis and Corrective Actions **-** Although work processes and systems are in place to minimize flaring to a best engineering extent, some flaring events still occur. Console operators have the authority and are trained to take the appropriate corrective actions when responding to incidents (i.e., equipment failure, process swing, etc.) to protect human life, minimize environmental impact, and secure plant equipment. Such responses can include actions to stabilize operation of affected equipment, and, when necessary, the slowdown of the production unit or shutdown of any affected equipment/unit. For implementation of the FMP, flaring events are those events that exceed applicable permit or regulatory limits. These flaring events are investigated to determine root cause, followed by corrective actions which are taken to prevent recurrence. Flaring events which do not exceed permit limits are reported to management staff and may be reviewed, as appropriate, to understand the failure modes and access recurrent failures.

Since the Facility's initial start-up, 15 unplanned flaring events required verbal notification to PADEP. However, only three of the 15 events exceeded applicable short-term limits, specifically visible emissions for more than five minutes in two consecutive hours and were subject to the requirement to conduct a root cause analysis. For these flaring events, Shell notified PADEP and followed up with a written incident report that summarized its analysis to identify the root cause and any associated corrective actions. Examples of corrective actions implemented at the Facility to date have included: installation of O-rings on pumps not installed by manufacturer, re-torquing flange bolts, adjustments to compressor oil accumulator bladder, re-calibration levels gauges for multi-phase liquids, tuning of controller gain function, adjustments to nitrogen ejector system, pump seal replacement, control logic revisions, review and revise procedures, conduct instrument simulation study for ensuring fit-for-purpose, and adding alarms to console.

<u>Flare Operational Assurance and Improvements</u>: The TEGFs are currently operated at a lower capacity than during the initial start-up as flaring rates have been reduced since ethylene can now be stored in the tank and sent to the PE Units. Shell's experts on heat transfer performed visual inspections of the TEGF burners and flame pattern under low flow conditions to ensure a stable and uplifted tip with zero smoke to establish a minimum flow and ensure proper air and fuel mixing is achieved. At this time, TEGF stages 1 through 3 have temporarily been taken out of service due to observed damage at the burner tips until repair outages for each TEGF can be scheduled when the risk of a flaring event is minimized. Closing stages 1 through 3 has been completed in consultation with the flare manufacturer, and the manufacturer's confirmation that destruction efficiency will not be affected by this closure. TEGFs are designed to open stages in sequence based on system pressure to maintain flow and velocity at the burners; that is, opening new stages when pressure increases and capacity is needed, and closing them when it is not. The only effect of this staged closure is that the overall capacity of the TEGFs is reduced by approximately five percent when the start-up flaring has been significantly reduced.

The low pressure (LP) MPGF is operated using perimeter air-assist to support sufficient combustion air and mixing in the combustion zone. Visible emissions from the MPGF have been observed and reported during commissioning and improvements were made to the control system. MPGF blower speed control has been updated with smooth ramping from minimum speed to maximum speed. The speed setpoint is still based on flare flow and NHV and follows the curve provided by the flare vendor. However, the discrete steps have been removed and replaced with continuous speed control. Two additional tools have been added - gain and bias. The speed setpoint is referenced from the curve and then calculated as (referenced speed) * (gain) + (bias). These long-term improvements have increased the blower responsiveness and reduced the likelihood of future visible emissions. Shell continues to monitor for visible emissions and tune the blower speed and adjust setpoints for improved performance.

4. <u>**Measures That Were Employed and Measures That Could Have Been Employed to Reduced or Prevent Excess Emissions**</u>

Multiple measures were employed by the Facility to reduce or prevent excess emissions from occurring.

- During construction, installation of equipment and components followed a program for recommended torque values. The construction contractors used the SMART Torque program to assure and document tightness of equipment during this stage of construction. Piping and equipment were pressure tested by various means to assure tightness and integrity to prevent leakage and allow for a safe startup of the facility. Prior to the startup, the various units and associated operational systems were reviewed and inspected by a team of discipline subject matter experts. The formalized review and system walk (PSSR) is documented and is a key component of Shell's process safety program.

- Prior to startup of the ECU and PE units, Shell discovered that multiple (approximately 40) heat exchangers had out-of-specification head gaskets installed for the equipment service. The correct gaskets were sourced and installed prior to starting up the units because of the Process Safety risk, avoiding the likelihood of excess emissions from leakage and shutdowns of impacted units where these heat exchangers were installed.

- Shell's leak detection and repair (LDAR) program monitoring was implemented in parallel with the start-up of the process units and other applicable equipment.

- As discussed in Section 3, Shell followed its approved FMP and implemented flare minimization measures as available during start-up. Mitigation measures also included the turndown capacity of the furnaces utilizing the minimum number of furnaces / feed rates for safe operation of the ECU and to progress commissioning operations.

- Following startup of the process / utility units, each equipment malfunction was evaluated by operations / technical support, and a plan was developed for any repairs to be made as quickly as possible to limit emissions and to safely continue with the overall commissioning plan.

- Two flange leaks were encountered during the ECU commissioning when equipment encountered very cold process fluids for the first time. A team of technical support staff reviewed the details around these leaks, and increased flange, manway, and connection torques were applied within safe ranges to accommodate new or sudden temperature operating conditions to prevent any further leakage of the equipment.

- If malfunctions indicated the potential for a similar failure in other equipment/controllers with the same manufacturer or similar use, a comprehensive review of similar equipment which was repaired, and/or recalibrated was undertaken based on lessons learned from the malfunction to minimize any additional malfunction events. An example of applying lessons learned is the comprehensive review of all 163 guided wave radar level instruments that was completed, with 29 of those instruments requiring an adjustment of calibration settings. These actions avoided additional malfunctions with similar equipment and the associated excess emissions that would have occurred.

- Blowdown of vessels to repair vapor leaks from pump seals was completed in a controlled manner to avoid use of the elevated flare with the hydrocarbon vapors. The maintenance pause in the beginning of October 2022 to repair the plugged C2 Splitter strainer is another example of minimizing the emissions from malfunctioning equipment. The ECU was brought down and restarted safely without use of the elevated flare. Only equipment necessary to facilitate the plugged strainer repairs was de-inventoried and sent to the TEGF instead of the entire hydrocarbon inventory of the ECU. These types of actions avoided flaring at the highly visible elevated flare and, in the case of this specific activity, minimized emissions by following the plan for isolating and venting only the necessary equipment to facilitate the repairs.

- In October 2022, both BOG compressors experienced similar coupling failures preventing recycling of vent gas from the ethylene storage tank and requiring control of the vented gas at the MPGF until repairs could be completed with replacement couplings. A mitigation plan was developed to minimize/eliminate flaring at the MPGF. Measures were implemented to minimize the flaring by proactively reducing the ethylene storage tank levels and use of the ethylene feed in the PE units that were available. The balance between ethylene production and PE demand was communicated daily to support the emission mitigation plan.

- As discussed above in the review of the FMP, Shell identified and used flaring mitigation measures throughout the commissioning phase of the process units. These methods included using only the minimum number of furnaces and at a minimum feed rate to facilitate initial start-up of the ECU unit, use of the off-specification sphere and ethylene storage tank, and recycling ethylene / tail gas back to the furnaces for fuel which avoided unnecessary flaring and emissions.

- The additional operational knowledge acquired from the start-up of the new equipment were used to update the ECU operating start-up procedures as necessary based on that new knowledge. The gained operational knowledge was realized with additional restarts of the ECU months following September and the maintenance pause in the beginning of October 2022, with improvements in how quickly on specification ethylene was achieved. On specification ethylene can now be achieved more quickly, within two days, allowing feed forward into the ethylene storage tank and into the available PE units, thereby minimizing flaring and excess emissions.

- Another method that was considered to minimize or prevent excess emissions included a complete shutdown and de-inventory of the facility during the initial start-up. This method is always an option and is considered during malfunction incidents or during operational issues if the units cannot operate safely or if the Facility determines that it cannot recover from these issues. The complete shutdown of the Facility would not have resulted in less overall flaring and flare emission. A Facility wide shutdown was not implemented during this time, but Shell did complete a partial shutdown of the ECU to repair the plugged inlet strainer on the C2 Splitter which was causing operational issues in the ECU and excess emission to the HP Header System and preventing the unit to be fully commissioned. The outage lasted approximately 12 days, and since that time, operational performance has improved with the result of less malfunctions and excess emission in ECU.

- Shell engaged an environmental contractor to update the lowest achievable emission rate (LAER) analyses to determine if additional emission controls, work practices or more stringent emission limits are appropriate to be applied at the facility. Much of the material review applied to normal operations and a cold start-up of a new facility. Based on the contractor’s review to date, no additional controls or new work practices were determined to be necessary, and the original analysis is still relevant to the sources and controls that are operating today.

5. **Projections of Emission Exceedances That Are Anticipated to Occur in the Future**

The Facility calculates actual emissions from the stationary emission sources on an at least monthly basis. To document how the emissions are calculated, the Facility has assembled an “Air Emissions Protocol for PADEP’s Inventory Program – 2022 Air Emissions.” Shell’s emission calculation protocol lists the emission sources and activities, details the emissions calculation approach and methodology used to calculate air emissions for each source and activity, and the data inputs and assumptions that are required to perform the emissions calculations. The Protocol will be updated as needed when refined calculation approaches/methods arise from stack testing, monitoring, sampling, manufacturer data, research, etc. to provide the highest accuracy of the emission estimates.

PADEP has requested that Shell forecast future emissions to evaluate potential future exceedances with the Facility-wide 12-month rolling permit limits. To project emissions, Shell evaluated current monitoring data, flare volumes, and various operational parameters and trends.

The projections are based on obtaining normal operations and does not address additional unanticipated malfunctions. The Facility is evaluating the compliance status with the Facility-wide 12-month rolling summation emission limits and has evaluated two separate cases for actual compliance status and projected compliance status.

- Case 1: Includes the initial cold startup/shakedown emissions from the manufacturing processing units that occurred from May through October 2022.

- Case 2: Excludes the initial cold start-up/shakedown emissions from the manufacturing processing units that occurred from May through October 2022.[1]

Compliance Status

For preliminary actual emissions though December 2022, the compliance status with the 12-month rolling total emission limits is as follows:

- Case 1: The emissions are below the Facility-wide 12-month rolling summation emission limits for all the pollutants, except the following:

    - Shell initially reported that VOC emissions, were above the limits for the 12-month rolling period ending October 2022 and continuing through the 12-month rolling period ending December 2022. Recent flare destruction efficiency testing described in the next section suggests that Shell could have over reported VOC emissions in prior submissions. Shell no longer believes the VOC emissions exceed the limits as specified in the Plan Approval.

    - NOx emissions, in which the emissions are above the limits for the 12-month rolling period ending December 2022.

- Case 2: The emissions are below the Facility-wide 12-month rolling total emission limits for all the pollutants considering adjusted emissions for malfunctions during commissioning.

January 2023 Flare Destruction Efficiency Testing

Additional information which Shell can provide in connection with an evaluation of actual and projected compliance status is available based upon a Flare Destruction Efficiency Testing which occurred in

[1] As noted herein, Shell believes that initial cold startup/shakedown emissions detailed above should not be included when determining compliance with the above emission limits. These emissions are part of the shakedown period and were not explicitly included in the facility's PTE, which provided the basis for the emission limitations above. Shell is approaching a more normal operation each day as it finishes commissioning of the PE Unit and making the necessary adjustments to the equipment and control logic. This is evident with the flaring emissions and the monthly actual emissions improving in November and December 2022.

January 2023. Briefly, Shell contracted with its flare vendor to perform a test using a flare camera (Flare Guardian) which was mounted to perform a test at the top of the TEGF B for destruction efficiency. Three tests were performed:

- January 13, 2023, was used to calibrate the equipment and establish the test parameters.
- January 19, 2023 was the actual flare test where an average destruction efficiency of 99.55% was measured with a standard deviation of 0.34. Three discoloration events occurred during the test, and the result was 99.55%.
- January 20, 2023 was not a planned test; however, a malfunction occurred and a flaring event resulted. The average destruction efficiency was measured at 99.62% with a standard deviation of 0.26. No discoloration occurred.

The conclusions reached from the "Flare Destruction Efficiency Testing" are as follows and relevant to PADEP's request for emissions data.

- Using the average destruction efficiency of 99.55 percent, the Facility is not in violation of its 12-month rolling total emission limitations for VOCs and the Facility is no longer in violation of Section C, Condition #005 of PA-04-00740C and 25 Pa. Code § 127.25.
- The Facility will reevaluate its glide paths and submit additional information to PADEP on February 21, 2023.
- Given this new information, the malfunction emission ("adjusted") data submitted with the Facility's Malfunction Reports will need to be recalculated and will be provided with the February 21 letter to PADEP.
- Aside from malfunction emissions occurring mostly in September and October, the Facility is below its 12-month rolling total PTE for VOCs as calculated by the Flare Guardian Test results using an average destruction efficiency of 99.55 percent.

Projected Compliance Status

The projected compliance status with the 12-month rolling total emission limits is estimated as follows:

- Shell does not anticipate any exceedance of the Facility-wide 12-month rolling total permit limits for the following air contaminants, regardless of the inclusion of initial cold startup/shakedown emissions: Total HAPs, PM-Filterable, PM 10, PM 2.5, SOx, and Ammonia.

- Case 1: Projected emissions may be above the 12-month rolling total emission limits as detailed below:

  - Indicate the possibility of VOC emissions being above the limit starting on the 12-month rolling period ending June 2023 and below the limit starting with the 12-month rolling starting August 2023.
  - NOx emissions are currently above the limit starting on the 12-month rolling period ending December 2022, as stated above. The projected emissions indicate the possibility of the emissions above the limit until the 12-month rolling period ending April 2024.
  - CO emissions are currently below the limit but projected to possibly be above the limit starting with the 12-month rolling period ending February 2023, then below the limit starting with the 12-month rolling period ending September 2023.

- CO2e emissions are currently below the limit but project to possibly be above the limit starting with the 12-month rolling period ending June 2023, then below the limit starting with the 12-month rolling period ending September 2023.

Case 2: Projected emissions considering adjustments for malfunctions are anticipated to be below the limit for VOC, CO and CO2e. Only NOx is projected to be over the 12-month rolling total limit starting with the 12-month rolling period ending May 2023, then below the limit starting with the 12-month rolling period ending April 2024.

Note that the projected emissions are estimated and subject to change. The projected emissions do not address additional unanticipated malfunction emissions.

6. **Description of and Schedule for Implementing Additional Emission Mitigating Measures**

The Facility is implementing several additional measures to mitigate emissions. The most important measure is maintaining the operating units in a safe and stable mode of operation as the Facility approaches normal operations and moves from the shakedown period of initial start-up. These emission mitigation measures include full implementation of key monitoring programs that use conservative default factors that significantly impact the current emission inventory estimates. By way of example, the Facility plans to enhance its LDAR program to fully monitor all of the approximately 64,000 components ahead of required regulatory schedules. In addition, Shell is completing the testing of several sources which include the cracking furnaces, Cogeneration, and thermal oxidizers that currently use conservative default factors for estimating emissions from these sources. Both the enhanced LDAR program and completion of stack testing will result in a more accurate emission inventory, including VOC and HAPs, based on field- determined emission factors. The emission inventory calculations, inputs, assumptions, and factors are also being reviewed to determine areas of improvement for accuracy and less conservatism in our reported emission inventory estimates.

One area for mitigating Facility emissions is the review of the use of supplemental natural gas in the flare systems, both HP Header (Source 205) and LP Heater Systems (Source 204). The supplemental natural gas is added to maintain the NHV in the flare systems above 500 Btu/scf. This is especially important when the header systems are receiving non-combustible gases (nitrogen). By reducing the set points in the control logic of the flare systems to a lower value, less supplemental gas is used resulting in lower emissions. Work is currently underway to review and reduce the NHV Set points in the control logic of the flare systems.

Set forth below is a brief description and schedule for implementing additional emission mitigating measures:

- Enhanced Leak Detection and Repair (LDAR) Program

  Although the LDAR monitoring has started in all process units including approximately 64,000 components, the enhanced LDAR program will prioritize and accelerate initial monitoring of high HAP / VOC containing lines / equipment components. In addition, we will focus monitoring on equipment components with the highest leak default factors (compressors, relief valves, pumps, valves) to improve the emission inventory accuracy for fugitive emissions.

Shell will increase the monitoring of any repeated leakers as well as evaluate monitoring equipment that is not normally required to be monitored (compressors and dual seal pumps). Operations and maintenance will use forward looking infrared (FLIR) cameras to find and fix leakers thus minimizing fugitive emissions beyond the already stringent LDAR program requirements.

Schedule: Ongoing

- Complete RATA / Stack Testing of Remaining Sources

Shell is finishing emission testing of the applicable sources as identified in the Plan Approval. The RATA testing for the furnaces is currently in process along with stack testing. Cogeneration follow-up testing of the HAPs is completed and we are currently waiting to receive and review the results from the testing contractor. Both the Spent Caustic and Continuous Vent Thermal Oxidizers are yet to be tested as well as the PE Pellet Dryer and PE Catalyst Activator Vents once normal operations are established with these units.

Once complete, the new emission factors from testing will be incorporated into the emission calculations updating the emission inventory. These updates will likely impact NOx, VOC and HAPs emission estimates that currently utilize conservation default factors in calculating emissions.

Schedule: Ongoing and anticipated completion of testing is in the second quarter 2023

- Review of Flaring Activity and Approved FMP

Shell will review the approved FMP and update as needed based on actual utilization of the FMP based on the initial start-up beginning in 2022 into normal operations. Updates to the flaring baselines, flare minimization methods and procedures will be incorporated into the FMP as necessary and provided to PADEP for review and approval for the operating permit application process.

Schedule: Ongoing

- Reduce Supplemental Gas to Flares for NHV Reduction

Shell has reduced the NHV setpoint for the TEGFs down to 700 Btu/scf following initial commissioning flaring and as flaring rates achieve a normal stable baseline flow and composition. Control logic on the NHV setpoint for the MPGF CVTO Header has been updated to only activate when vent gas is being routed to the MPGF (this MPGF header functions as backup to the CVTO). Control logic and operational improvements are under evaluation to remove or limit supplemental gas to the MPGF PE1/2 Header when regulated material is not present. These changes and improvements are intended to reduce supplemental gas to the minimum necessary for proper flare operation and minimize emissions. Effective NHV setpoints which maintain compliance with permit limits while providing sufficient margin to adjust supplement gas flow and absorb fluctuations of flow and composition will continue to be evaluated.

Shell is also developing an installation plan for calorimeters on all flare headers to improve response time and calculation of NHV. Calorimeters will achieve a significantly faster response time to measure and output NHV of the vent gas compared to the existing gas chromatographs which rely on extracting a sample and performing a delayed analysis. This allows for tighter margins on the NHV setpoint as supplemental gas additions will be faster and react quicker to real time changes.

Schedule: Ongoing

- <u>WWTP Emission Calculations and Operational Improvement</u>

  Sample wastewater at least monthly for VOC and Semi-Volatile Organic Compounds for improved emission calculations based on additional data. Use periodic TOC sampling data from wastewater as a quality check. Research / develop alternative calculation procedures for Water9 Program used to estimate emissions from this source.

  Schedule: Ongoing

- <u>Review of Air Emission Inventory Protocols and Accuracy Improvements</u>

  Review protocols to ensure they align with actual emission calculations and data collection. Review calculation methodologies, emission factors, manufacturer data and data inputs to determine if there are new/updated methods for improved accuracy of emission inventory. Update protocol and calculations to align with emissions factors developed from on-site stack testing results.

  Schedule: Ongoing

- <u>Continued Review of Operations Procedures / Instrumentation QA/QC / Calibrations</u>

  As additional runtime is gained from the initial start-up of the process equipment as operations move to stable conditions, capture learnings, update operations start-up procedures, provide additional training and adjust instrument calibrations. These activities support improved operations and result in normal operating emissions and avoid / minimize excess emissions from additional malfunction events.

  Schedule: Ongoing

Summary

September and October 2022 were associated with the cold start and commissioning of a major and unique polyethylene production facility, and the first of its kind in the Northeast United States. The timing was related to the ECU taking longer to commission than planned, and unanticipated malfunctions occurred which is not atypical for the commissioning of a complex chemical production facility. As the Facility continues to operate, this type of cold start commissioning will not occur, and currently, Shell is well into normal operations, and will continue to make improvements as operations continue.

Shell implemented the FMP as required, and flare minimization is built into the design of the plant. Emissions at start-up have been associated with the time and duration of commissioning. Shell has implemented measures proactively, taking pause for maintenance, or pursuing corrective actions as operational issues were identified. The Facility will continue to identify and resolve any operational issues to ensure that emissions are stabilized before ramping up production. Operating the flares at a rate of more than 500 Btu/scf has assured a higher destruction efficiency and reduced the VOC emissions to atmosphere.

Shell appreciates PADEP's review, and consideration of information contained in this Report. We request the opportunity to meet in person to further present detailed technical information relevant to the responses set forth herein, which will allow PADEP to have a more comprehensive understanding of the Facility's operations to-date, and the efforts undertaken by Shell to comply with its Plan Approval.

Sincerely,

Kimberly Kaal

Kimberly Kaal
Environmental Manager, Attorney-in-Fact

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