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Title – Flare Regulatory Update

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Summary

The United States Environmental Protection Agency (USEPA) revised the regulations for the refinery through the Refinery Sector Rule (RSR) revisions to NESHAP CC and UUU (aka MACT CC and MACT UUU). The USEPA is expected to propose revisions to the Ethylene MACT and the Hazardous Organic NESHAP (HON) and the Miscellaneous Organics NESHAP (MON). These proposed changes have not been published as of July 2019 and the USEPA is expected to miss the March 2020 deadline to finalize the revisions to those rules. Based on conversations with the USEPA, the revisions to the regulations are expected to be very similar to the MACT CC requirements.

Regulatory Overview

Source categories within the RSR that utilize a flare as a control device are subject to the flare requirements found in the RSR, which require refineries with affected flares to meet specific operating limits related to:

1. Pilot flame presence,
2. Visible emissions,
3. Flare tip exit velocity (V_{tip}),
4. Net heating value in the combustion zone (NHV_{cz}), and
5. Net heating value dilution parameter (NHV_{dil}) for flares which receive perimeter assist air.

The requirements related to flare tip velocity, pilot lights, and smoking events were previously found in §63.11 of MACT Subpart A and §60.18 of New Source Performance Standard (NSPS) Subpart A. Compliance with the RSR operating limits requires monitoring of pilot flames, various flow rates, NHV/composition, and video recording of the combustion zone. In addition to the operating limits, the RSR requires facilities to maintain a Continuous Parameter Monitoring System (CPMS) Monitoring Plan, as well as a Flare Management Plan.

Pilot Flame Monitoring

The RSR includes the requirement to:

> *"operate each flare with a pilot flame present at all times when regulated material is routed to the flare. Each 15-minute block during which there is at least one minute where no pilot flame is present when regulated material is routed to the flare is a deviation of the standard. Deviations in different 15-minute blocks from the same event are considered separate deviations." [§63.670(b)]*

The monitoring requirements are to:

> *"continuously monitor the presence of the pilot flame(s) using a device (including, but not limited to, a thermocouple, ultraviolet beam sensor, or infrared sensor) capable of detecting that the pilot flame(s) is present." [§63.670(g)]*

Pilot flame monitors are not covered by the Quality Assurance (QA) requirements found in Table 13 of the rule; however, general QA requirements are found in §63.671.

Visible Emissions Monitoring

The RSR includes the requirement to:

> *"specify the smokeless design capacity of each flare and operate with no visible emissions, except for periods not to exceed a total of 5 minutes during any 2 consecutive hours, when regulated material is routed to the flare and the flare vent gas flow rate is less than the smokeless design capacity of the flare." [§63.670(c)]*

The monitoring requirements are to:

> *"monitor visible emissions while regulated materials are vented to the flare. An initial visible emissions demonstration must be conducted using an observation period of 2 hours using Method 22 at 40 CFR part 60, appendix A-7. The initial visible emissions demonstration should be conducted the first time regulated materials are routed to the flare. Subsequent visible emissions observations must be conducted using either the methods in paragraph (h)(1) of this section or, alternatively, the methods in paragraph (h)(2) of this section. The owner or operator must record and report any instances where visible emissions are observed for more than 5 minutes during any 2 consecutive hours as specified in §63.655(g)(11)(ii).*
>
> *(1) At least once per day for each day regulated material is routed to the flare, conduct visible emissions observations using an observation period of 5 minutes using Method 22 at 40 CFR part 60, appendix A-7. If at any time the owner or operator sees visible emissions while regulated material is routed to the flare, even if the minimum required daily visible emission monitoring has already been performed, the owner or operator*

shall immediately begin an observation period of 5 minutes using Method 22 at 40 CFR part 60, appendix A-7. If visible emissions are observed for more than one continuous minute during any 5-minute observation period, the observation period using Method 22 at 40 CFR part 60, appendix A-7 must be extended to 2 hours or until 5-minutes of visible emissions are observed. Daily Method 22 observations are not required to be conducted for days the flare does not receive regulated material.

(2) Use a video surveillance camera to continuously record (at least one frame every 15 seconds with time and date stamps) images of the flare flame and a reasonable distance above the flare flame at an angle suitable for visual emissions observations. The owner or operator must provide real-time video surveillance camera output to the control room or other continuously manned location where the camera images may be viewed at any time." [§63.670(h)]

Visible emissions monitoring via the surveillance camera does not have QA requirements listed in Table 13 of the rule.

Flow Rate Monitoring

The RSR includes the requirement to monitor the flow of vent gas, including supplemental gas addition, and assist gas (steam and/or air) to an affected flare [§63.670(i)]. Per §63.670(i)(1), "the flow monitoring systems must be able to correct for the temperature and pressure of the system and output parameters in standard conditions (i.e., a temperature of 20 °C [68 °F] and a pressure of 1 atmosphere)."

Per §63.670(i)(2), mass flow meters may be used for monitoring the flow of gas, but the measurements must be converted to volumetric flow using equation (1) shown below:

$$Q_{vol} = \frac{Q_{mass} \times 385.3}{MWt} \quad (1)$$

Where

Q_{vol} = Volumetric flow rate (standard cubic feet per second [scf/s])
Q_{mass} = Mass flow rate (pounds per second [lb/s])
385.3 = Conversion factor (standard cubic feet per pound-mole [scf/lb-mol])
MWt = Molecular weight of the gas at the flow monitoring (pounds per pound-mole [lb/lb-mol])

Additionally, according to §63.671(a)(8), "the [CPMS] must be capable of measuring the appropriate parameter over the range of values expected for that measurement location."

The flow rate monitors utilized for compliance will need to comply with the accuracy and QA requirements of Table 13 in the Rule.

Vent Gas Flow Monitoring

The RSR defines flare vent gas as "all gas found just prior to the flare tip." This gas includes all waste gas, sweep gas that is not recovered, purge gas, and supplemental gas but does not include pilot gas, total steam, or assist air. Table 13 of MACT CC specifies the accuracy requirements for vent gas flow meters.

Parameter	Minimum accuracy requirements
Flare Vent Gas Flow Rate	±20 percent of flow rate at velocities ranging from 0.03 to 0.3 meters per second (0.1 to 1 feet per second) ±5 percent of flow rate at velocities greater than 0.3 meters per second (1 feet per second)

Air Flow Monitoring

For air-assisted flares, the total volumetric flow of assist air must be monitored. Volumetric or mass flow meters can be used, provided they meet the accuracy requirements in Table 13.

Parameter	Minimum accuracy requirements
Flow Rate for All Flows Other Than Flare Vent Gas	±5 percent over the normal range of flow measured or 280 liters per minute (10 cubic feet per minute), whichever is greater, for gas flow ±5 percent over the normal range measured for mass flow

If Equation (1) is utilized to convert mass flow to volumetric flow, the RSR specifies using a molecular weight of 29 pounds per pound-mole (lb/lb-mol) for air.

As alternatives to flow monitoring for assist air, the RSR also allows for the use of engineering calculations with continuous temperature and pressure monitoring or continuous monitoring of fan speed/power in conjunction with fan curves. Utilizing the fan/power and fan curves could also require temperature and pressure monitoring to result in a value in standard conditions.

Steam Flow Monitoring

For flares that utilize assist steam, the total volumetric flow of steam, which includes, but is not limited to, center, lower, and upper steam, supplied to the flare must be monitored. Volumetric flow meters, mass flow meters, or engineering calculations with continuous temperature and pressure monitoring are allowed. Volumetric and mass steam flow meters must meet the same accuracy requirements as those described for air flow meters in Section 2.3.2.

If Equation (1) is utilized to convert mass flow to volumetric flow, the RSR specifies using a molecular weight of 18 lb/lb-mol for steam.

Supplemental Gas Flow Monitoring

Monitoring the flow of supplemental gas is dependent on the point of injection (whether introduced upstream or downstream of the vent gas flow meter) and the calculation method chosen for compliance. If the supplemental gas is introduced downstream of the vent gas flow meter or if the feed forward compliance calculation method is chosen, then a supplemental gas flow meter is required. If supplemental gas is added upstream of the flow meter, a supplemental gas flow meter is not required. However, while not required, a supplemental gas flow meter is recommended in order to accurately measure the amount of supplemental gas being supplied to the flare at a given time. Direct monitoring of supplemental gas flow allows for greater ease of control of the NHV_{cz} and NHV_{dil} and cost tracking.

Based on the definition of vent gas, supplemental gas is a part of flare vent gas. Therefore, if a separate supplemental gas flow meter is necessary to demonstrate compliance, the flow meter must meet the accuracy requirements for a vent gas flow meter. If a mass flow meter is used, the molecular weight of the supplied natural gas will need to be determined to assess if a constant value can be utilized in Equation (1).

Vent Gas Composition Monitoring

The RSR requires affected facilities to monitor either the vent gas composition or the net heating value in the vent gas (NHV_{vg}) for each affected flare [§63.670(j)]. The RSR allows several options for complying with this requirement.

1. Install a monitoring system capable of continuously (i.e., at least once every 15 minutes) monitoring the concentration of each individual component of the vent gas;
2. Install a grab sampling system capable of collecting a sample at least once every eight hours;
3. Install a monitoring system capable of directly measuring NHV_{vg} (with the option of additionally measuring the concentration of hydrogen [H_2]); or
4. Apply for an exemption using the results of sampling a gas stream and demonstrating a consistent or fixed minimum NHV_{vg}.

If the composition of the vent gas is monitored per option 1, the concentrations of each vent gas constituent will be used to calculate NHV_{vg} using Equation (2) below:

$$NHV_{vg} = \sum_{i=1}^{n} x_i NHV_i \qquad (2)$$

Where

i = Individual component in flare vent gas

n = Number of components in flare vent gas

x_i = Concentration of component i in flare vent gas (volume fraction)

NHV_i = Net heating value of component i as shown in Table 12 of the Rule (British thermal units per standard cubic foot [Btu/scf])

If an affected facility chooses to install a monitoring system capable of directly measuring NHV_{vg} (i.e., a calorimeter), the RSR also allows for the use of a second instrument to measure hydrogen. The RSR allows facilities to use the effective NHV of hydrogen of 1,212 Btu/scf, instead of its actual NHV of 274 Btu/scf, if the concentration of hydrogen is measured. If this option is used, the hydrogen concentration will need to be updated each time that the hydrogen instrument completes a cycle. That value will be used to correct the measured NHV_{vg} from the calorimeter until the next hydrogen measurement is reported. The measurement from the calorimeter can be adjusted, based on the concentration of hydrogen in the vent gas, as shown below in Equation (3).

$$NHV_{vg} = NHV_{measured} + 938x_{H_2} \quad (3)$$

Where

$NHV_{measured}$ = NHV_{vg} as measured by the calorimeter (Btu/scf)

x_{H_2} = Concentration of hydrogen in flare vent gas at the time the sample was input into the net heating value monitoring system (volume fraction)

938 = Net correction for the measured heating value of hydrogen (Btu/scf)

If the grab sample option is selected, the RSR [§63.670(l)(6)(i) and (ii)] specifies the following procedure for determining which grab sample is to be used for demonstrating compliance with the Rule.

i. Use the analytical results from the first grab sample collected for an event for all 15-minute periods from the start of the event through the 15-minute block prior to the 15-minute block in which a subsequent grab sample is collected.

ii. Use the results from subsequent grab sampling events for all 15-minute periods starting with the 15-minute block in which the sample was collected and ending with the 15-minute block prior to the 15-minute block in which the next grab sample is collected. For the purpose of this requirement, use the time the sample was collected rather than the time the analytical results become available.

During an event in which regulated material is being sent to the flare, an affected facility would be required to obtain a grab sample at least once every eight hours. More frequent samples can be taken by the facility if desired, however, no more than one grab sample every eight hours is required by the rule. The disadvantage of choosing the grab sampling option is that the affected facility will not be able to get timely results of the $NHV_{vg.}$ For example, if an event begins, and the grab sample is obtained at a time that low Btu material is being flared, the facility will not have the information concerning the amount of supplemental gas that needs to be added until the laboratory analysis is complete, which could be after the flaring event is concluded. This can result in extended periods of non-compliance compared to having an online analyzer.

Direct compositional or NHV monitoring is not required for flares with a consistent composition or a demonstrated minimum NHV_{vg}. In order to qualify for the exemption, affected facilities

would need to document the conditions which allow the flare to qualify for the exemption and obtain a minimum of 14 daily grab samples which support the assertion that the vent gas maintains a constant or minimum NHV_{vg}. The documentation that would need to be created would need to include:

> *"An explanation of the conditions that ensure that the flare gas net heating value is consistent and, if flare gas net heating value is expected to vary (e.g., due to product loading of different material), the conditions expected to produce the flare gas with the lowest net heating value" [63.670(j)(6)(C)]*

For infrequently operated flare gas streams/systems, seven grab samples must be collected unless other additional information would support reduced sampling.

Flare Tip Velocity

The RSR includes the requirement to:

> *"comply with either paragraph (d)(1) or (2) of this section, provided the appropriate monitoring systems are in-place, whenever regulated material is routed to the flare for at least 15-minutes and the flare vent gas flow rate is less than the smokeless design capacity of the flare.*
>
> *(1) Except as provided in paragraph (d)(2) of this section, the flare tip velocity (V_{tip}) must be less than 60 feet per second. The owner or operator shall monitor V_{tip} using the procedures specified in paragraphs (i) and (k) of this section.*
>
> *(2) V_{tip} must be less than 400 feet per second and also less than the maximum allowed flare tip velocity (V_{max}) as calculated according to the following equation. The owner or operator shall monitor V_{tip} using the procedures specified in paragraphs (i) and (k) of this section and monitor gas composition and determine NHV_{vg} using the procedures specified in paragraphs (j) and (l)..." [§63.670(d)]*

$$\log_{10}(V_{max}) = \frac{NHV_{vg} + 1{,}212}{850} \quad (4)$$

Where:

V_{max} = Maximum flare tip velocity (ft/s)

NHV_{vg} = Net heating value of the vent gas (Btu/scf)

Owners and operators of flares were required to comply with similar requirements under §60.18 and §63.11; however, the equation by which V_{max} is determined has been converted to English units.

In order to be able to calculate the tip velocity for a flare, the vent gas flow rate is required to be continuously monitored. The volumetric flow rate must be cumulative over each 15-minute block period and only needs to include flow during periods when regulated material is sent to the flare. Including all flows during the 15-minute block period is also allowed under the Rule.

Using the flow and unobstructed cross-sectional area of the flare tip, V_{tip} may be calculated using equation (5) below:

$$V_{tip} = \frac{Q_{cum}}{Area \times 900} \quad (5)$$

Where:

V_{tip} = Flare tip velocity (ft/s)
Q_{cum} = Cumulative volumetric flow over 15-minute block average period (standard cubic feet)
Area = Unobstructed area of the flare tip (square feet)
900 = Conversion factor (seconds per 15-minute block average)

Net Heating Value – Combustion Zone

The RSR establishes an operating limit of 270 Btu/scf for the NHV_{cz} [§63.670(e)]. This value is a calculated limitation and is not directly measured. NHV_{cz} incorporates the concept that excess assist gas in the combustion zone dilutes the combustible material and reduces combustion efficiency of the flare. The NHV_{cz} limit applies to all flares subject to the requirements of the RSR. Compliance is determined on a 15-minute block average basis when regulated material is sent to the flare for at least 15 minutes.

Previous flare regulations (§63.11 and §60.18) included minimum NHV_{vg} requirements. Under these regulations, unassisted flares are required to maintain 200 Btu/scf in the vent gas, while steam and air-assisted flares are required to maintain 300 Btu/scf. Per §63.640(s):

> *On January 30, 2019, flares that are subject to the provisions of 40 CFR 60.18 or 63.11 and subject to this subpart are required to comply only with the provisions specified in this subpart. Prior to January 30, 2019, flares that are subject to the provisions of 40 CFR 60.18 or 63.11 and elect to comply with the requirements in §§63.670 and 63.671 are required to comply only with the provisions specified in this subpart.*

Therefore, as long as the flare is in compliance with the requirements of the RSR, the flare does not need to comply with §63.11 and §60.18.

The RSR defines two different types of assist air which may be directed to a flare: perimeter and premix. Perimeter assist air does not factor into the calculation of NHV_{cz} and is described in more detail in Section 2.7. The RSR defines premix assist air as

"the portion of assist air that is introduced to the flare vent gas, whether injected or induced, prior to the flare tip. Premix assist air also includes any air intentionally entrained in center steam."

The definitions within the RSR do not always readily apply to all various flare configurations.

Net Heating Value – Dilution Parameter

In addition to the NHV_{cz}, flares actively receiving perimeter assist air are also subject to the NHV_{dil} limit [§63.670(f)], which must be greater than or equal to 22 British thermal units per square foot (Btu/ft^2) on a 15-minute block average basis when regulated material is sent to the flare for at least 15 minutes. This parameter primarily focuses on the time vent gas spends in the flammability region above the flare tip (i.e., the combustion zone).

The RSR defines assist air as

"all air that intentionally is introduced prior to or at a flare tip <u>through nozzles or other hardware conveyance</u> for the purposes including, but not limited to, protecting the design of the flare tip, promoting turbulence for mixing or inducing air into the flame. Assist air includes premix assist air and perimeter assist air. Assist air does not include the surrounding ambient air."

The RSR goes on to define perimeter assist air as

"the portion of assist air introduced at the perimeter of the flare tip or above the flare tip. Perimeter assist air includes air <u>intentionally entrained in lower and upper steam</u>. Perimeter assist air includes all assist air except premix assist air."

Multipoint Pressure Assisted Ground Flares

One area of difference between the current RSR and the expected EMACT is the USEPA has indicated that the proposed revisions may include an allowance for multipoint pressure assisted ground flares. This allowance would remove the requirements to obtain an Alternative Means of Emissions Limitation (AMEL). The allowance will have requirements similar to the AMELs that have been granted. For example, an alternative NHVvg is expected to be required.

Conclusions

Revisions to the EMACT, HON, and MON have been expected for some time and it appears that those revisions will be delayed again. Based on discussions with USEPA, it is expected that the flare requirements are expected to mirror the RSR flare requirements. However, there are expected to be some differences for multipoint pressure assisted ground flares.