Brief description of the source

The life cycle of an oil or gas well can be divided into several phases and events. Such phases can be briefly described as (1) Planning, (2) Drilling, (3) Completion, (4) Production and (5) Abandonment[1]. This TGD will mainly focus on the well life cycle that includes Well Testing, Well Intervention, Workover and Well Plug and Abandonment(P&A) activities that happen after the drilling phase is completed and are not included in other TGDs.

During the phases of well production and abandonment, several operations which can lead to emissions are present. Some of the well events or operations which are included in this TGD are emissions from (A) Well testing, (B) well interventions, (C) workovers, and (D) Plug and abandonment (P&A) which occur after the well is drilled and repeats throughout the lifetime of a well until its decommissioning.

(A) Well testing is performed throughout the life of oil and gas fields. During testing, operators measure formation pressure, characterize the formation fluids and reservoir, and determine permeability among other[2]. The objective of well testing is to forecast the reservoirs potential and plan the most efficient production methods. Some test methods include to perform a production well test in which well is flowed through a temporary completion to a test separator, or the use of a wireline formation tester to capture fluid samples and measure downhole pressure at the zone of interest. In cases where production well test is performed, the gas produced from the reservoir could lead to high levels of methane emissions if these are not properly captured or flared off.

During well testing, most of the gas is typically not vented but is instead directed for sale or sent to flare to minimize venting. If the gas is vented, it could lead to methane (CH_4) and possibly carbon dioxide (CO_2) emissions.[3]

(B) Well Interventions: These are a set of activities aimed at diagnosing, maintaining, or enhancing the performance of a well without resorting to major interventions or workovers These interventions are critical for optimizing production, addressing specific issues, and ensuring the continued functionality of the well. Examples of well interventions that involve methane emissions include, but are not limited to: lubricator bleed downs, well circulation during workover/well intervention and Christmas tree bleed downs. While methane emissions are typically low from these activities (if controlled with flare), large number of activities can cumulatively amount to high emissions.

(C) Workovers: These are heavy interventions that necessitate a halt in production at the formation, allowing the rig crew to implement significant equipment modifications[4]. Heavy interventions, or workovers, necessitate the removal of the surface equipment and other pressure barriers by the rig crew for unrestricted wellbore access. This process involves the dismantling and reinstallation of the Christmas tree and completion equipment.

(D) The process of plugging and abandoning a well is typically initiated for permanent closure under two circumstances: either when logs reveal insufficient hydrocarbon potential, making the completion of the well impractical, or after the reservoir has been exhausted through production operations[5].

[1] Well integrity lifecycle - PetroWiki (spe.org)
[2] The Defining Series: Well Testing Fundamentals | SLB
[3] 2021-api-ghg-compendium-110921.pdf
[4] Defining Well Intervention | SLB
[5] plug and abandon | Energy Glossary (slb.com)

System boundaries

Methane that is vented to atmosphere (continuously or periodically) from the process of well testing, workover and well interventions, and plugging and abandonment are covered by this TGD.

Periodic well interventions activities, such as well testing, workover, and other Coiled tubing/Eline/slickline jobs, among others are typically carried out as standalone activities and can result in bleed-off to be released directly to atmosphere. These are to be considered under this TGD, along with more regular or continuous well intervention activities.

Quantification of methane emissions from well completions is described in the *Well completions TGD.* The quantification methods linked to liquids unloading operations are described in the *Liquids unloading for gas wells TGD*.

Methane emissions from wells that have been Plugged and Abandoned (P&A'd) are not covered by this TGD(See paragraph D of section "Brief description of source"). These are to be considered as well integrity issues e.g., well leaks or, in case of larger quantities, well blow-outs. P&A'd wells are to be reported as a separate asset in the reporting template and the corresponding asset type is to be selected.

Methane routed to an existing VRU systems and routed to sales or for on-site use, i.e., not vented, are not to be reported. Hydrocarbons captured and routed to flare or thermal oxidation should be reported under Flaring (see *Flaring TGD*).

If methane is unintentionally released as part of the well testing, workover, intervention or plugging and abandonment, due to an unexpected event, it should be reported under Incidents (see *Incidents TGD*). Guidance on materiality is presented in the *General Principles TGD.*

Level 3 Quantification Methodologies

Emission Factors

Accepted source-level emission factors or those prescribed by local regulation are considered as providing Level 3 estimates. Partners are encouraged to use emission factors that best represent conditions and practices at their facilities and adjust the factors or units, where warranted, to more accurately estimate emissions given differences between the reference system on which the emission factor is based, and their systems. Whole gas emission factors can be used in combination with the methane content of the vented gas.

(A) Well testing

The following table provides an example of emission factors that can be used for well testing when gas is vented to the atmosphere.

Table 6-4. Well Testing Methane Emission Factors for Oil and Gas Exploration[6]

Source	Methane Emission Factor (t CH4/well test)	Whole Gas Emission Factor (scf gas/well)
Gas Well Testing – Vented to Atmosphere	0.7288	46,625
Oil Well Testing – Vented to Atmosphere	0.0565	3,613

[6] 2021-api-ghg-compendium-110921.pdf

(B) Well Interventions

Currently, in the literature, no specific emission factors are available for well interventions. If no satisfactory Level 3 quantification method is available for this emission source, Operators are encouraged to implement Level 4 methodologies in order to develop specific measurement-based emission factors.

Alternatively, operators can use emission factors used for other types of similar well activities such as, for example, workovers.

Depending on the type of Well Intervention activities, Engineering assumptions may be utilized to estimate the volume of gas released to quantity activity specific estimation factors with reduced uncertainty (Refer to Engineering Calculations below)

(C) Workovers

The following table provides an example of emission factors that can be used for Workovers.

Table 6-9. Production Segment Methane Emission Factors for Workovers without Hydraulic Fracturing[7]

Source	Methane Emission Factor (t CH4/workover)	Whole Gas Emission Factor (scf gas/workover)
Gas well workovers	0.047	3,114
Oil well workovers	0.0018	122

Engineering assumptions may be utilized to estimate the volume of gas released to quantity activity specific estimation factors with reduced uncertainty (Refer to Engineering Calculations below)

(D) Plug and abandonment (P&A)

Currently, in the literature, no specific emission factors are available for P&A. However, plug and abandonment of Wells involve Well cleanouts and other types of Well circulations that are similar to operations carried out during a Well workover. Therefore, quantification methods from workovers, including emission factors, may be used for P&A.

Engineering calculations

Accepted engineering calculations or those prescribed by local regulation are considered as providing Level 3 estimates.

[7] 2021-api-ghg-compendium-110921.pdf

Several input data might be required to accurately calculate methane emissions from well operations. For example, GOR, oil production, duration of testing, pressure, and temperature. Below is a non-exhaustive list of possible methods to calculate emissions from well operations.

(A) Well testing

EPA Subpart W (L) [8]

Section L covers calculation for "Well testing venting and flaring". In this, equations W-17A and B are used in which it is needed the GOR, average annual flow and the duration of the testing.

$$E_{a,n} = GOR * FR * D$$

$$E_{a,n} = PR * D$$

Where:

Ea,n = Annual volumetric natural gas emissions from well(s) testing in cubic feet under actual conditions.

GOR = Gas to oil ratio in cubic feet of gas per barrel of oil; oil here refers to hydrocarbon liquids produced of all API gravities.

FR = Average annual flow rate in barrels of oil per day for the oil well(s) being tested.

PR = Average annual production rate in actual cubic feet per day for the gas well(s) being tested.

D = Number of days during the calendar year that the well(s) is tested.

(B) Well interventions

EPA Subpart W (I)[9]

Section I covers calculation for "Blowdown vent stacks". In this, equations W-14A or W-14B are used to calculate the total annual natural gas emissions from each physical volume that is blown down.

Level 4 Quantification Methodologies

Methane emissions from well testing can be quantified using different methodologies: Direct measurement, measurement-based emission factors or engineering calculations/process simulation. Other quantification methodologies could also be considered under the conditions presented in the *General Principles TGD*.

Direct measurement and Measurement-based Emission factors

Measurements (including continuous and periodic monitoring) or emission factors developed based on representative measured emissions are considered Level 4 emissions quantification. Measurements must be taken that represent the total flow of each gas stream that is vented to the atmosphere.

Level 4 emission factors should be based on measurements conducted on a representative sample. For guidelines on the methodology to develop a statistically representative sample, please refer to the Uncertainty TGD.

[8] https://www.ecfr.gov/current/title-40/part-98/subpart-W#p-98.233(l) 40 CFR 98.233(l)
[9] https://www.ecfr.gov/current/title-40/part-98/subpart-W#p-98.233(i) 40 CFR 98.233(i)

The general principal to level 4 quantification of methane emissions from vents is to quantify:

- Gas flow or, for fixed volume emissions events, engineering calculations to determine the corresponding volume of gas released at atmospheric pressure and temperature
- Methane content
- Duration of the event (purge, vent, blowdown, flare…)

Methane emissions from gas venting is the multiplication of these three elements. These three elements can be quantified using the equipment and techniques described in the *Purging and venting TGD* for direct measurements and measurement-based emission factors.