

Notice to Operators
Reporting Hydrogen Sulfide (H₂S)
Clarifications for Implementation of COGCC Rule 607
and BLM Onshore Order No. 6

April 13, 2012

The purpose of this Notice to Operators (NTO) is to clarify the Colorado Oil and Gas Conservation Commission's (COGCC's) hydrogen sulfide (H₂S) reporting requirements as per Rule 607 and the supporting referenced document BLM Onshore Order No. 6. COGCC will apply this NTO to oil and gas operations in Colorado as defined in the 100 Series of COGCC's rules. BLM Onshore Order No. 6 applies to all onshore Federal and Indian oil and gas leases when drilling, completing, testing, reworking, producing, injecting, gathering, storing, or treating operations are being conducted in geologic zones which are known or could reasonably be expected to contain H₂S or which, when flared, could produce sulfur dioxide (SO₂), in such concentrations that upon release could constitute a hazard to human life. BLM Onshore Order No. 6 also establishes reporting thresholds for H₂S concentrations for gas streams encountered in geologic zones and production facilities which are referenced in this Order. The requirements and minimum standards set in BLM Onshore Order No. 6 do not relieve an operator from compliance with any applicable Federal, State, or local requirement(s) regarding H₂S or (SO₂) which are more stringent. The NACE MR0175 referenced within the BLM Onshore Order No. 6 shall refer to the most current standard.

Per COGCC Rule 607.a. (well servicing) and 607.b. (well drilling) and consistent with BLM Onshore Order No. 6, operators are required to report to COGCC and file a H₂S drilling operations plan when working in geologic zones known or reasonable expected to encounter H₂S in the gas stream at concentrations at or above 100 ppm. In addition, Rule 607.c.states "***any gas analysis indicating the presence of hydrogen sulfide.***" Through this NTO, "***gas analysis***" shall mean any detection of H₂S, measured in a representative sample of the sources gas submitted for laboratory analysis. Any field measurement of H₂S during oil and gas operations detected by using colorimetric tubes, hand-held personal monitors, fixed gas monitors or other field instrumentation at a concentration equal to or greater than 20 ppm shall be verified by a subsequent sampling of the source gas by laboratory gas analysis for H₂S concentration. All subsequent Gas Analysis which report concentrations above non-detect at a subject location shall be reported to COGCC and the Local Governmental Designee (LGD).

It is important that all reported measurements be representative of the condition(s) and location of the source gas whether in the gas stream or at a production facility. In this NTO, "Gas Stream" is defined as gas flowing from the well head, in a gathering line or other pressurized equipment, in which gas flows at a steady rate past the collection point. Production equipment with "Static Conditions" is defined as equipment in which gas is not pressurized or does not readily flow past the collection point, except by dispersion within the system as in the headspace of a storage tank.

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ACTION LEVELS AND REQUIRED SUBMITTALS

Sundry Notice of any gas analysis containing H₂S concentrations shall be submitted

Operators shall provide verbal or electronic notice to COGCC and the LGD for any gas analyses (as defined by this NTO) indicating the presence of H₂S within 48-hours of receipt of the gas analysis results. In addition to verbal or electronic notices, the operator shall submit a Sundry Notice, Form 4 to COGCC within forty five (45) calendar days of receipt of gas analysis results. Representative measurements are required for calculating the Radius of Exposure, as described in Attachment B.

As part of the documenting the Representative Measurement, the operator shall attach a copy of the laboratory analytical report to the Sundry Notice. Sundry Notices shall include the following minimum information:

1. Well or Facility name
2. API Number or COGCC Facility Number
3. H₂S concentration in ppm
4. Date sample or measurement was collected
5. Type of measurement or analysis (e.g., gas analysis, meter measurement, or colorimetric tube)
6. Description of sample point
7. Absolute Open Flow Potential in cubic feet per day (CFPD) at the H₂S source(s): 4-point flow test or an alternate method approved by the Director.
8. If flow is not open to the atmosphere, then state that the source is not flowing and include a description of the potential for atmospheric release and duration in which the container or gathering line would likely be opened for servicing operations.
9. Distance to the nearest occupied residence, school, church, park, school bus stop, place of business, or other areas where the public could reasonably be expected to frequent.
10. Distance to the nearest Federal, State, County, or municipal road or highway owned and principally maintained for public use.

If the H₂S concentration in the gas stream is reasonable expected to be encountered, or is detected from the laboratory gas analysis, at a concentration of 100 ppm or higher, the operator shall calculate the Radius of Exposure to determine whether or not a Public Protection Plan is required, as described in Attachment B.

Sundry Notice of any gas analysis containing H₂S concentrations at or above 500 ppm a production facility or storage tank with Static Conditions.

Operators shall provide verbal and electronic notice to COGCC and the LGD, for any gas analyses with H₂S concentrations equal to or exceeding a concentration of 500 ppm in a production facility or storage tank at static conditions (see III.D.2.c of BLM Onshore

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Order #6) or excess 10 ppm at 50 feet where the sustained ambient H₂S concentration is detected in excess of 10 ppm at 50 feet from the facility or tank as measured at ground level under calm conditions (see III.D.1 of BLM Onshore Order #6). In addition to verbal and electronic notices, the operator shall submit a Sundry Notice, Form 4 to COGCC within forty five (45) calendar days of detection.

Operators may utilize field measurements of H₂S concentrations in gas samples collected from a production tank and in ambient air near a production tank, or by appropriate EPA reference methods for laboratory analysis, to represent H₂S concentrations for “static conditions” as defined in this NTO. In addition, operators may consider collecting a pressurized gas sample upstream of the production tank for laboratory analysis to better understand the source of the H₂S from the subject well, especially if the production tank is connected to more than one well. Representative measurements are required for calculating the Radius of Exposure, as described in Attachment B.

Reporting Questionnaire, Operations Plan, and Public Protection Plans

The reporting requirements described above, COGCC Rule 607.a. and Rule 607.b. require operators to comply with U.S. Department of the Interior, Bureau of Land Management (BLM) Onshore Order No. 6 when H₂S gas is reasonably expected to be encountered during drilling, well servicing or production servicing operations at concentrations greater than or equal to 100 ppm. Refer to Attachments C, D and E for guidance on which report to submit to COGCC.

In the event an Operational Plan and Public Protection Plan is necessary and prior to or shortly after placement of H₂S warning signage viewable at the entrance to the oil and gas location by the subject surface owner and/or adjacent landowners, operators will conduct educational outreach to these subject landowners to provide information on the conditions and concentrations for which H₂S is being encountered, safety measures taken, signage and any other appropriate information.

H₂S Mitigation and Treatment Concerns

As appropriate, based on local field conditions, operators should treat all water or recycled fluids, intended for use downhole, to minimize the potential for the introduction of conditions conducive for growth of sulfate reducing bacteria in downhole formations. Surface equipment should be treated as soon as practicable if H₂S is observed and its source is isolated to surface equipment to reduce the potential for continued growth of sulfate reducing bacteria.

Separate from this NTO and pursuant to Rule 912.b. for certain situations when a Sundry Notice is required for gas venting; COGCC may require flaring of gas containing H₂S pursuant to Rule 912.b. Situations may also arise when an operator may consider flaring gas when prior COGCC approval is not required (an upset condition, well

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maintenance, well stimulation flowback, purging operations, or a productivity test). H₂S produces sulfur dioxide (SO₂) when burned, which either remains in gaseous form (through atmospheric dispersion from the flare stack); or, it may combine with water to form sulfurous acid in gas phase or sulfuric acid in liquid phase. While SO₂ is not as toxic as H₂S, both forms of SO₂ can result in negative health effects. SO₂ gas is heavier than air and therefore appropriate precautions should be taken.

H₂S is sometimes removed from gas streams using iron sulfide, which generates spent iron sponge. Spent iron sponge is flammable and subject to spontaneous combustion in dry conditions. Therefore, appropriate precautions should be taken.

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Attachment A

Representative Measurement

Representative measurements are required for calculating the Radius of Exposure, when the H₂S are equal to or greater than 100 ppm. Representative measurements include a laboratory analysis of a sample taken from a fitting that is attached directly to the wellhead, gathering line, or separator and has been under steady-state flow (dynamic) with sufficient volumes that represent concentrations found in the reservoir (in situ). Non-flowing samples (static) are considered approximate or estimated values and *are not* representative. Because of the density differences between gas components, H₂S settling & separation can occur under static conditions, and the sample may not be representative of the composition of the flowing gas stream (see specific gravity table below). Atmospheric measurements are also considered approximate or estimated values because of wind, thermal gradients, and density differences of the gas components. Mixing, settling, and separation can result in dilution or concentration of H₂S in the gas sample.

Component	Specific Gravity	Molecular Weight
Air	1.0000	28.964
H ₂ S	1.1765	34.076
CH ₄	0.5539	16.043
C ₂ H ₆	1.0382	30.070

All approximate or estimated concentrations should be verified for accuracy by collecting representative samples for laboratory analysis as soon as practicable. Gas meters or colorimetric tubes could be used to collect representative measurements if they are integrally attached to the drilling or production system using a sealed sampling port, which facilitates sampling of the gas stream under steady-state flowing conditions. However, if the gas meter or colorimetric tube measures atmospheric conditions near but not within the gas stream (a non-sealed port), then the measured concentration would be considered approximate or estimated because of potential mixing with atmospheric gases.

If and when practicable, H₂S gas sampling and measurements in liquid storage vessels shall be performed with the vessel at least three quarters (3/4) full and taken at approximately one (1) foot above the liquid surface or liquid/gas interface. The sample or measurement should be collected as soon as practicable after opening the hatch or sample port for the vessel.

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Attachment B

Radius of Exposure

Representative measurements are required for calculating the Radius of Exposure. A Radius of Exposure shall be calculated for situations in which H₂S concentrations of 100 ppm or higher may be present in the gas stream to determine whether or not a Public Protection Plan is required. The Radius of Exposure calculation determines the distance from the source (e.g., the wellhead or other production equipment) at which an exposure to 100 ppm or 500 ppm H₂S could be encountered during a loss of well control or servicing operation. Potential exposure to H₂S in such an event would diminish with greater distance to the source as H₂S is dispersed in the atmosphere.

RADIUS OF EXPOSURE – Pasquill-Gifford Equation

Note: the following equations are only valid for H₂S concentrations less than 10% (100,000 ppm). Refer to BLM Onshore Order No. 6 if H₂S concentrations are equal to or exceed 10%.

100 ppm Radius of Exposure

$$R = ((1.589) \cdot (\text{H}_2\text{S mole fraction}) \cdot (Q))^{0.6258}$$

Where:

R = radius of exposure in feet

H₂S mole fraction = concentration in ppm divided by 1 million

Q = cubic feet per day gas flow rate against atmospheric pressure
or Absolute Open Flow Potential taken from a conventional
four point back pressure test

Assumptions:

Pressure = 14.7 psig

Temperature = 60 °F

500 ppm Radius of Exposure

$$R = ((0.4546) \cdot (\text{H}_2\text{S mole fraction}) \cdot (Q))^{0.6258}$$

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RADIUS OF EXPOSURE – Example Calculations

100 ppm Radius of Exposure
H₂S concentration = 3,900 ppm
Flow Rate = 500 MCFD

$$R = \left((1.589) \cdot \left(\frac{3,900}{1 \times 10^6} \right) \cdot (500 \cdot 1,000) \right)^{0.6258}$$

$$R = 153 \text{ feet}$$

500 ppm Radius of Exposure
H₂S concentration = 3,900 ppm
Flow Rate = 500 MCFD

$$R = \left((0.4546) \cdot \left(\frac{3,900}{1 \times 10^6} \right) \cdot (500 \cdot 1,000) \right)^{0.6258}$$

$$R = 70 \text{ feet}$$

Percent Hydrogen Sulfide Conversions

Percent H₂S is taken from either the mole or volume fraction of H₂S in the total mixture of gases.

Example assuming 10% H₂S:

- 10 % H₂S = 0.10 volume or mole fraction of total gas mixture
- 0.10 = 100,000 ppm H₂S in a 1,000,000 ppm total mixture of gases
- 0.10 = 100 ml in 1,000 ml (1 liter) mixture of gases
- 0.10 = 100 cu ft in 1,000 cu ft mixture of gases

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**Hydrogen Sulfide (H₂S) Notice to Operators
Attachment C
Reporting Guidance Questionnaire**

Operators shall complete and submit Attachment C (Reporting Questionnaire) of this NTO to COGCC concurrent with submittal of an Operations Plan, and if required, a Public Protection Plan pursuant to BLM Onshore Order No. 6.

Operator Name: _____
Well Name: _____
API Number: _____
Legal Location: _____
Field Name: _____
County: _____
Operator Contact: _____
 Title: _____
 Phone: _____
 Email: _____

Description of operation underway or circumstances:

Distance to closest normally occupied building or structure (feet): _____

Number of buildings or structures within 3,000 feet: _____

Distance to closest public road (feet): _____

Name of public road: _____

Prevailing wind direction: _____

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Notifications

COGCC: Verbal **Written (attach documentation)**

If Yes:

Name of Contact(s): _____

Contact Date(s): _____

Local Governmental Designee: Verbal **Written (attach documentation)**

If Yes:

Name of Contact(s): _____

Contact Date(s): _____

Gas Sampling & Analysis

Reservoir Name/Completed Zone: _____

Description of Sample Location: _____

Is the sample "representative" of reservoir concentrations (see NTO narrative for a definition of a "representative" sample): **Yes** **No**

Well casing or drill pipe volume from surface to TMD (cubic feet): _____

Estimated continuous cumulative flow volume at time of sample (cubic feet): _____

Flow rate at time of sample (cubic feet per day): _____

Absolute Open Flow of well (cubic feet per day): _____

Reservoir pressure (psig): _____

Reservoir temperature (°F): _____

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Radius of Exposure

Equations Assume:

Pressure = 14.7 psig

Temperature = 60 °F

100 ppm Radius of Exposure:

H₂S (ppm) = _____

H₂S mole fraction (ppm divided by 1 million) = _____

Q (CFD) = _____ at atmospheric pressure

$$R = ((1.589) \cdot (\text{H}_2\text{S mole fraction}) \cdot (Q))^{0.6258}$$

R = Radius of Exposure (feet) _____

500 ppm Radius of Exposure:

H₂S (ppm) = _____

H₂S mole fraction (ppm divided by 1 million) = _____

Q (CFD) = _____ at atmospheric pressure

$$R = ((0.4546) \cdot (\text{H}_2\text{S mole fraction}) \cdot (Q))^{0.6258}$$

R = Radius of Exposure (feet) _____

Tanks, Pressure and Storage Vessels Sampling/Measurement

___ # Tank(s) ___ # Free Water Knockouts (FWKO) ___ # Pressurized Vessels

Largest Tank: _____ bbls Free water knockout: _____ bbls

Largest Tank: _____ height (feet) Free water knockout: _____ height (feet)

Liquid level: _____ feet to liquid from thief hatch in top

Sample point: _____ feet above liquid level

Liquid level: _____ feet of liquid in pressure vessel

Working Pressure: _____ psi in pressure vessel

Tank: _____ H₂S ppm FWKO: _____ H₂S ppm Pressurized Vessels: _____ H₂S ppm

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Additional Required Information

Description of Well Control Equipment:

Description of H₂S mitigation and management:

Has the need for compliance with the most current NACE MR0175 standard been determined and what is the H₂S partial pressure of the system with a description of equipment metallurgy to be used.

Check and report on flow lines and gathering line(s) leaving well pad:

- Water: Outside Diameter: ___ in Rate: ___ bbls/day H₂S: ___ ppm Working pressure: ___ psi
- Gas: Outside Diameter: ___ in Rate: ___ bbls/day H₂S: ___ ppm Working pressure: ___ psi
- Oil: Outside Diameter: ___ in Rate: ___ bbls/day H₂S: ___ ppm Working pressure: ___ psi

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Operations Plan

An Operation Plan is required for all drilling and well servicing operations in which H₂S gas is reasonably expected to be encountered during drilling or well servicing operations at concentrations greater than or equal to 100 ppm. An Operations Plan should also be in place when servicing production equipment or gathering equipment, including flow lines, if H₂S gas is reasonably expected to be encountered during the servicing operations at concentrations greater than or equal to 100 ppm. Copies of the Operation Plan should be submitted to COGCC, the LGD, prior to commencing the operation.

An Operation Plan checklist is included as Attachment D to this NTO. The checklist should be submitted to COGCC concurrent with submittal of the Operation Plan.

When drilling, the Operation Plan shall be implemented prior to drilling within 500 feet of the H₂S-bearing formation or at least three (3) days prior to encountering the formation, based on average drilling rates for the production hole, whichever occurs first. Notify COGCC, the LGD, and local emergency dispatch of operator's intent to implement the Operation Plan prior to commencing drilling, workover, completion, or servicing operations on production or gathering equipment.

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Hydrogen Sulfide (H₂S) Notice to Operators Attachment D Operations Plan Checklist

An Operations Plan per COGCC Rules 607.a. and 607.b. along with BLM Onshore Order No. 6 shall be available at well site during drilling, workover, completion, and servicing operations; at the operator's local field office; and on file with COGCC, the local emergency dispatch office, and the Local Government Designee's office.

A Public Protection Plan may also be required in certain situations.

Plan Contents

Personnel Training

- Description of training plan

Site Identification

- Operator Name
- Well Name or Facility Name
- Latitude-Longitude
- Legal Location
- API Number

Operator's Key Personnel

- Names
- Titles
- Responsibilities, duties, and jobs
- Telephone numbers

Rescue & Management Personnel

(include jurisdictional law enforcement, fire, hospital, COGCC, BLM)

- Organization
- Phone numbers
- Address

Well Site Diagram

- Rig orientation
- Pits
- All other equipment
- Gathering lines
- Prevailing wind direction
- Surrounding terrain
- Briefing areas
- Primary briefing area, based on prevailing wind direction
- Access/Egress roads

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- Flare line
- Caution & danger signs
- Wind socks

Access, Egress and Roads

- At least one access road
- At least one egress (exit) road
- Security
- Traffic control
- Attendance Roster
- Fencing where public access is likely

Protective Equipment for Essential Personnel

- Location; type; storage and maintenance of all working monitors and escape packs
- Means of communication when using breathing equipment
- Testing, calibration, & maintenance records

H₂S Detection and Monitoring Equipment

- Location of H₂S sensors
- Location of audible alarms
- Location of visual alarms
- Portable H₂S monitors
- Portable SO₂ monitors
- Testing, calibration, & maintenance records

Visual Warning Systems

- Wind direction indicators
- Caution signs
- Danger signs (easily seen within 50' of storage vessel or potential point of exposure)

Metallurgy

- Metallurgical properties of all temporary and fixed tubular goods
- Metallurgical properties of well control equipment potentially exposed to H₂S (Drilling Operations)
- Metallurgical properties of production and gathering equipment
- Inspection and maintenance schedules to check for corrosion, cracks or leaks; records should be maintained by the operator for COGCC inspection upon request

Well Control (Drilling Operations)

- Flare line and means of ignition
- Remote controlled choke
- Flare guns/flares
- Mud-gas separator
- BOP & Flow Control

Mud Program (Drilling Operations)

- Mud system and additives
- Mud degassing system
- H₂S scavengers

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Public Protection Plan

A Public Protection Plan per COGCC Rules 607.a. and 607.b. along with BLM Onshore Order No. 6 is required for drilling, workover, completion, and production operations when any of the following conditions apply:

1. The 100 ppm Radius of Exposure is greater than 50 feet **and** includes any occupied residence, school, church, park, school bus stop, place of business, playground, or other areas where the public could reasonably be expected to frequent.
2. The 500 ppm Radius of Exposure is greater than 50 feet **and** includes any part of a Federal, State, County, or municipal road or highway owned and principally maintained for public use.
3. The 100 ppm Radius of Exposure is equal to or greater than 3,000 feet where facilities or roads are principally maintained for public use.

A Public Protection Plan checklist is included as Attachment E to this NTO. The checklist should be submitted to COGCC concurrent with submittal of the Public Protection Plan.

When drilling, the Public Protection Plan shall be implemented prior to drilling within 500 feet of the H₂S-bearing formation or at least three (3) days prior to encountering the formation, based on average drilling rates for the production hole, whichever occurs first. Notify COGCC, the LGD, and local emergency dispatch of operator's intent to implement the Public Protection Plan prior to commencing drilling, workover, completion, or servicing operations on production or gathering equipment.

If H₂S gas is reasonably expected to be encountered during drilling, workover, completion, production or any servicing operations at concentrations greater than or equal to 100 ppm, and an operator determines that a Public Protection Plan is not required, then the operator shall submit a Form 4, Sundry Notice to the COGCC for Director approval with calculations and/or other supporting documentation that demonstrate why a Public Protection Plan should not be submitted prior to performing the operations.

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Hydrogen Sulfide (H₂S) Notice to Operators Attachment E Public Protection Plan Checklist

Copies of the Public Protection Plan shall be available at well site during drilling, workover, completion, and servicing operations; at the operator's local field office; and on file with COGCC, the local emergency dispatch office, and the Local Government Designee's office.

Public Outreach and Communication

Items to be discussed with COGCC personnel and considered as an integral part of the plan include:

- Public education
- Seminars
- Mass alert systems
- Use of sirens
- Telephones on site
- Radio on site

Minimum items required to present and discuss in public education, meetings, & seminars:

- Hazards of H₂S and SO₂
- Necessity for a plan
- Possible sources of H₂S and SO₂
- Instructions for reporting a leak to the operator and/or rescue and safety personnel
- Manner of public notification
- Steps to be taken in an emergency
- Evacuation plan and drills

Plan Contents

Site Identification

- Operator Name
- Well Name or Facility Name
- Latitude-Longitude
- Legal Location
- API Number

Operator's Key Personnel

- Names
- Titles
- Responsibilities, duties, and jobs
- Telephone numbers

Rescue & Management Personnel

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(include jurisdictional law enforcement, fire, hospital, COGCC, BLM)

- Organization
- Phone numbers
- Address

Public Potentially Present within the Radii of Exposure

- Names
- Phone numbers
- Addresses

Area Maps, including:

- Radius of Exposure where 100 ppm could potentially be encountered (if any variables are uncertain, then use 3,000 feet, per BLM Onshore Order No. 6)
- Radius of Exposure where 500 ppm could potentially be encountered
- Likely locations that public may be present within the Radii of Exposure

Description of Warning Systems and Administrative Controls

- Monitors (activated)
- Site security
- Access control