

Best Practices Development Mining Near Chartered Oil and Gas Wells

Background

- Title 30 Code of Federal Regulations (30 CFR) 75.1700, requires coal mine operators to take reasonable measures to locate oil and gas wells penetrating coalbeds or any underground area of a coal mine.
- The term “setback distance” is the distance between a well and the closest point of development mining (i.e., the rib-to-well distance).
- Mine operators must establish and maintain a coal barrier of at least 300 feet in diameter (150-foot setback distance) around these wells unless they obtain approval from the District Manager for a lesser setback distance.
- The standard also allows the District Manager to require a greater barrier based on the depth of the mine, other geologic conditions, or other factors.

Hazards Due to Gas Wells

- If a mine inadvertently intersects an active gas well, methane gas can inundate the mining section.
- Inactive (i.e. non-producing, abandoned or inadequately plugged) wells in depleted gas reservoirs can pose similar hazards because they may contain pressurized fluids or gas. From 2006 to 2020, there were at least 12 inundations of water or gas in U.S. coal mines caused by intersecting inactive wells.
- Active or inactive wells have also caused injuries by forcibly ejecting material into the mine or by inundating the mining sections with water.

The Pennsylvania 1957 Study

- Historically, the primary technical document addressing interactions between gas wells and mining in the United States has been the “Pennsylvania Joint Oil and Gas Well Gas Well Pillar Study” published in 1957 (1957 Study).
- The 1957 Study’s recommendations were based on 72 case histories of wells which stopped producing gas because they were “sheared or pinched off,” with the well deformation attributed to nearby underground coal mining activity.
- Nearly all the case histories in the 1957 Study data set involved pillar recovery.
- The depth of cover (H) was less than 650 feet in all cases, which is less than most of today’s operating coal mines.
- The 1957 Study suggested a minimum setback distance from *development mining* of 50 feet (the center of a 100- by 100-foot pillar).
- The 1957 Study did not consider downhole well deviation surveys that can accurately locate the well at the coal seam.

Stability of Oil and Gas Well Protective Pillars

- Pillar and floor stability are two design considerations determining the size of oil and gas well protective pillars.
- Overburden movement (horizontal bedding plane slip) is not a significant concern for development mining.

- The ribs of a coal pillar can deteriorate over time due to exposure to the mine atmosphere.
- Floor failure can occur when thick, soft underclay is exposed to water.
- Today, engineers use methods like the “Analysis of Coal Pillar Stability” (ACPS) to evaluate pillar stability.
- More conservative design criteria (such as higher stability factors and width-to-height ratios (w/h)) may be more appropriate for gas well protective pillars in long-term and high-consequence applications.

Well Location Inaccuracies

If an underground mine operator locates a well on the surface, the likelihood unintentionally intersecting it depends on the cumulative result of three kinds of errors: (1) well deviation, (2) surveying errors, and (3) mining errors.

Well deviation is the horizontal distance between the surface location of the well and where it penetrates the coal seam.

- Technical Support collected data from nearly 250 downhole well deviation surveys where the wells penetrated the coal seam at depths ranging from 427 to 1,280 feet.
- The data shows that as wells penetrate deeper, their deviation potential increases.
- When $H < 1,000$ feet, no wells had deviations greater than H times the tangent of 2° .
- When $H > 1,000$ feet, the maximum deviation was less than H times the tangent of 2.5° .
- The well deviation is collected from downhole gyro instruments. The instruments can also have errors that can affect the accuracy of the survey. The errors can be about H times the tangent of 0.2° .

Surveying error: The mine surveyor can calculate the potential location error on the mine map from the closure ratio.

- For example, if the allowable closure ratio is 1:10,000, and the nearest known survey point (for example, a shaft bottom) is 22,000 feet away, the maximum potential surveying error is $((1/10,000) * (2) * (10,000 + 12,000))$, or 4.4 feet.
- The survey error is independent of the depth of cover.

Mining error: The setback distance should consider errors which occur due to mining off-sights due to inadequate survey control at the face, regardless of the depth of cover.

- Frequently establishing sight spads and conducting check surveys mitigates risk associated with mining off-sights.

Best Practice Guidelines

- Consider the following factors when evaluating the stability of the protective pillar:
 1. The pillar system stability factor should exceed 2.0, using programs such as the “Analysis of Coal Pillar Stability.”
 2. The minimum w/h for the protective pillar should exceed 12.
 3. In cases where extremely soft floor is present beneath the protective pillar and may be exposed to water, its stability should be assessed to determine whether the pillar design is adequate for the site conditions.

- The minimum setback distance should be 50 feet if no deviation survey is available, or 40 feet if a survey is available. Greater setback distances may be needed when the depth of cover exceeds 700 feet.
- The setback distance should be large enough to mitigate risks associated with the cumulative impact of the following four factors:
 1. **Well Deviation (WD):**
 - a. When no deviation survey is available, $WD = H \cdot \tan(2^\circ)$ when H is less than 1,000 feet, and $WD = H \cdot \tan(2.5^\circ)$ when H is greater than 1,000 feet.
 - b. When there is a deviation survey, $WD = H \cdot \tan(0.2^\circ)$ for all depths. (The mine operator may replace this value with the actual error value for the gyro instrument.)
 2. **Surveying Error (SE):** Site-specific criteria based on the operator's survey methods.
 3. **Mining Error (ME):** If the mine operator uses appropriate precautions, such as the "Best Practices" described below, then 5 feet may serve as a reasonable approximation of this error.
 4. **Pillar Rib Weathering and Peak Stress Avoidance Setback (SA):** Thirteen feet is adequate to prevent a well from encountering weathering or high-deformation zones near the pillar rib.

Calculation Examples

- **Case 1: The well's surface location is known, but no deviation survey has been conducted:**

A conventional gas well extends through a coal seam with 1,000 feet of cover. The surveying closure is within 3 feet, and safety precautions are in place to mitigate the risk of mining errors. No deviation survey is available for the well. Therefore, the minimum setback distance SD_{MIN} is:

$$SD_{MIN} = 50' \text{ or } (WD + SE + ME + SA), \text{ whichever is greater.}$$

$$SD_{MIN} = 50' \text{ or } (44' + 3' + 5' + 13'), \text{ whichever is greater.}$$

$$SD_{MIN} = 50' \text{ or } 65', \text{ whichever is greater.}$$

$$SD_{MIN} = 65'$$

- **Case 2: A downhole deviation survey is available:**

The location of an unconventional gas well at the mining horizon is known from a deviation survey. The depth of cover is 900 feet, the surveying closure is within 3 feet, and safety precautions are in place to reduce the magnitude of mining errors.

$$SD_{MIN} = 40' \text{ or } (WD + SE + ME + SA), \text{ whichever is greater.}$$

$$SD_{MIN} = 40' \text{ or } (3' + 3' + 5' + 13'), \text{ whichever is greater.}$$

$$SD_{MIN} = 40' \text{ or } 24', \text{ whichever is greater.}$$

$$SD_{MIN} = 40'$$

Best Practices for Mining in “Special Precaution Zones” Around Gas Wells

1. Prior to development, a “special precaution zone” should be defined around the gas or oil well as shown in Figure 1. When mining occurs within the precaution zone, miners should test for methane with a hand-held methane detector and a probe at least every 10 minutes. The precaution zone should also be free from accumulations of coal dust and coal spillage, and the mine operator should place rock dust on the roof, rib, and floor to within 20 feet of the face.
2. Firefighting equipment, including fire extinguishers, rock dust, and enough fire hose to reach the working face from the nearest fire tap should be available near the precaution zone while mining is conducted there.
3. Sufficient supplies of roof support and ventilation materials should be available near the precaution zone while mining is conducted there.
4. The mine operator should check the permissibility of and service equipment, including the section fan, on the shift prior to when mining begins in the precaution zone.
5. The mine operator should calibrate the methane monitor on the continuous mining machine on the shift prior to when mining begins in the precaution zone. The mine operator may check the calibration during the first half of the shift if they anticipate mining into the precaution zone during the second half of the shift.
6. The mine operator should advance check survey stations to within at least 300 feet of the precaution zone prior to development near the gas well.
7. The mine operator should install sight spads at the last open crosscut prior to development adjacent to the gas well. The mine operator should also use sight spads to establish crosscuts forming the protective pillar. Laser or additional sights should establish that the sight line for the entry or crosscut that they are mining is not more than 50 feet from the projected well location.
8. The mine operator should review safety precautions and a drawing of the area with all personnel involved in the mining operation near the well. They should do this prior to approaching the well and throughout all shifts while they are developing the protective gas well pillar.

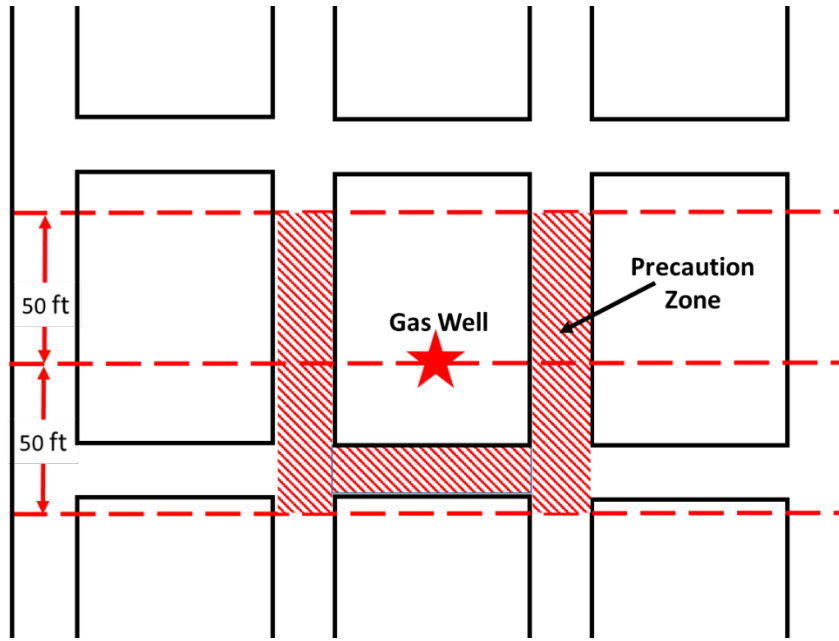


Figure 1. Special precaution zone around an oil or gas well.