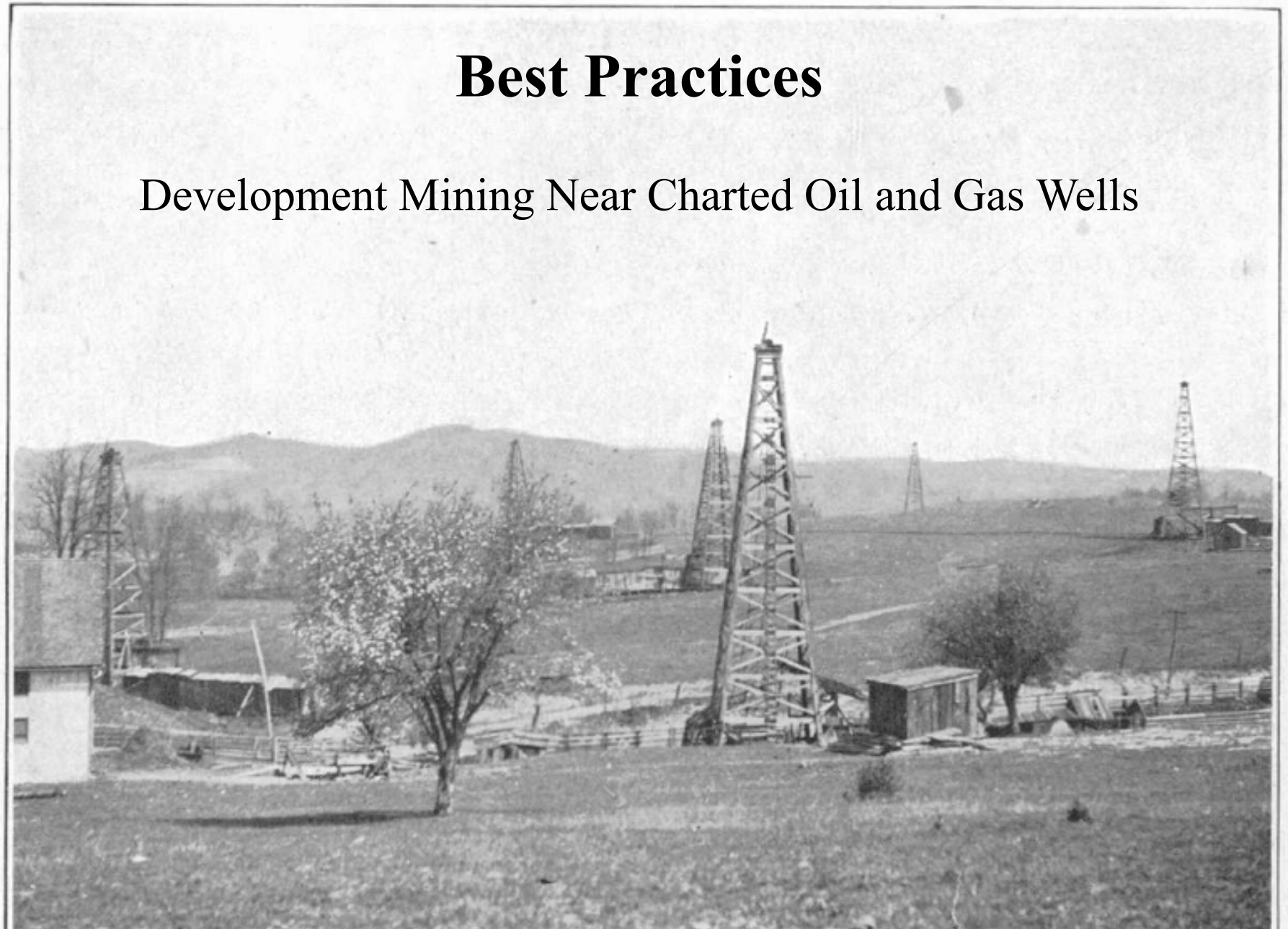
Best Practices

Development Mining Near Charted Oil and Gas Wells

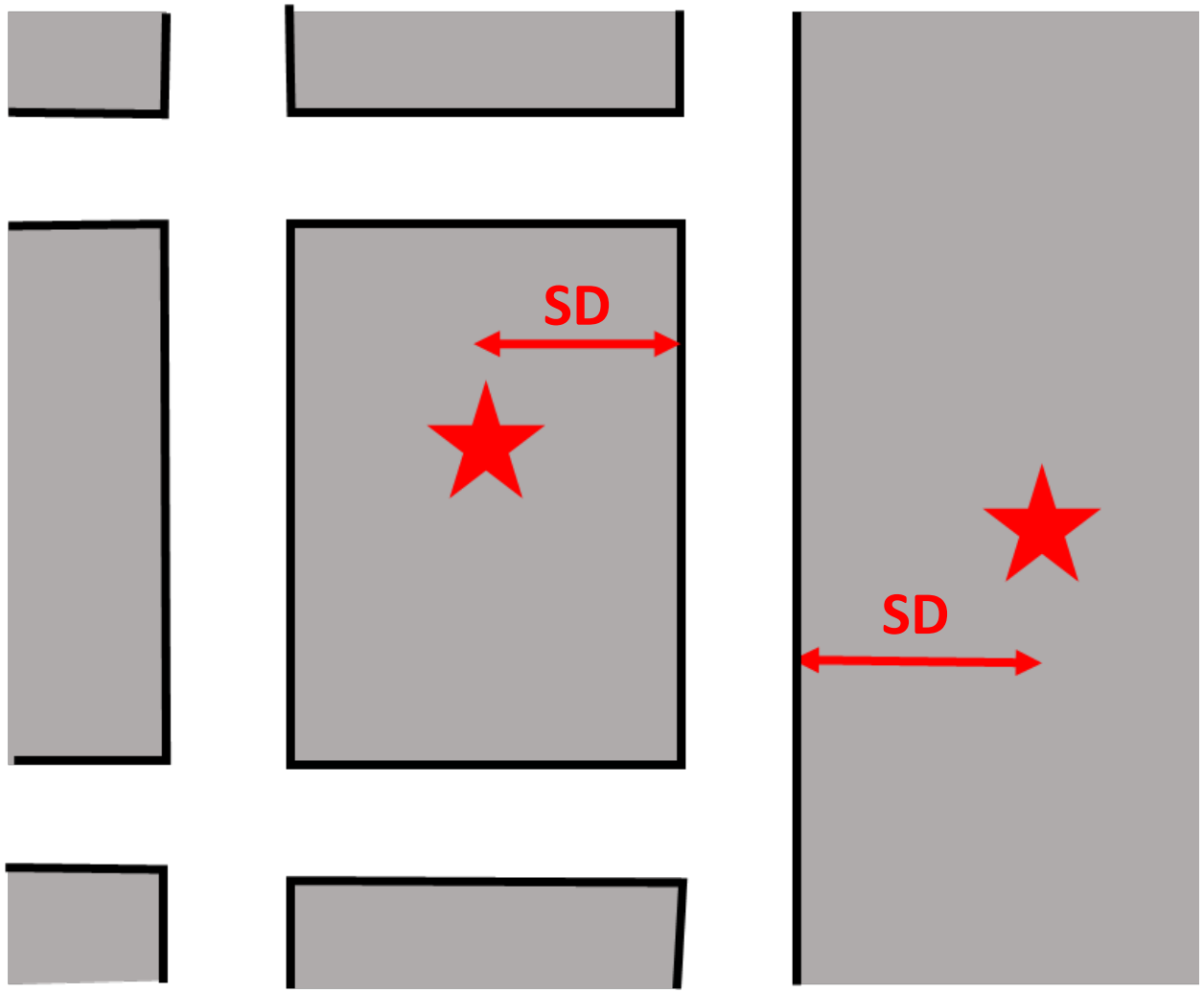


Background

- 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.

- Mine operators must establish and maintain a coal barrier of at least 300 feet in diameter around these wells unless they obtain approval from the District Manager for a lesser 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.



Background

The term “setback distance” is the distance between a well and the closest point of development mining (i.e., the rib-to-well distance).

Key

★ Gas Well

SD Setback Distance

Hazards Due to Gas Wells

- If a mine inadvertently intersects an active gas well, methane gas can inundate the mining section.
- Abandoned wells in depleted gas reservoirs can pose similar hazards because they may recharge with gas over time.
- Flooded and abandoned wells can cause injuries by forcibly ejecting material into the mine or by inundating the mining sections with water.

Plans, Citations, and Accidents Associated with Wells

- MSHA annually receives about 1,000 requests for mining near oil and gas wells,
- Approximately 40 percent are from the Northern Appalachian coalfields, and another 40 percent are from the Illinois Basin
- Guidelines for protective pillar plans vary by District, depending in large part on state regulations and guidelines.

30 CFR 75.1700 Citations between January 1, 2010, and January 1, 2020.

District	75.1700 Citations
Barbourville	4
Beckley	9
Lakewood	1
Madisonville	17
Morgantown	54
Mt. Pleasant	24
Norton	30
Pineville	5
Vincennes	8
Total	152

30 CFR Part 50 Reported Accidents Classified as Inundations, Ignitions or Explosions, and Associated with Wells between January 1, 2006, and January 1, 2020.

TYPE OF ACCIDENT	OCCURRENCES
UNDERGROUND MINING INTERSECTED WELL, WITH METHANE INUNDATION	9
UNDERGROUND MINING INTERSECTED WELL, WITH WATER INUNDATION	3
UNDERGROUND MINING INTERSECTED WELL, NO INUNDATION REPORTED	17
OTHER UNCHARTED HOLE INTERSECTED (I.E., WATER WELL OR POWER BOREHOLE)	3
TOTAL	32

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 (Commonwealth of Pennsylvania, 1957).

- Nearly all the case histories in the 1957 Study data set involved pillar recovery.

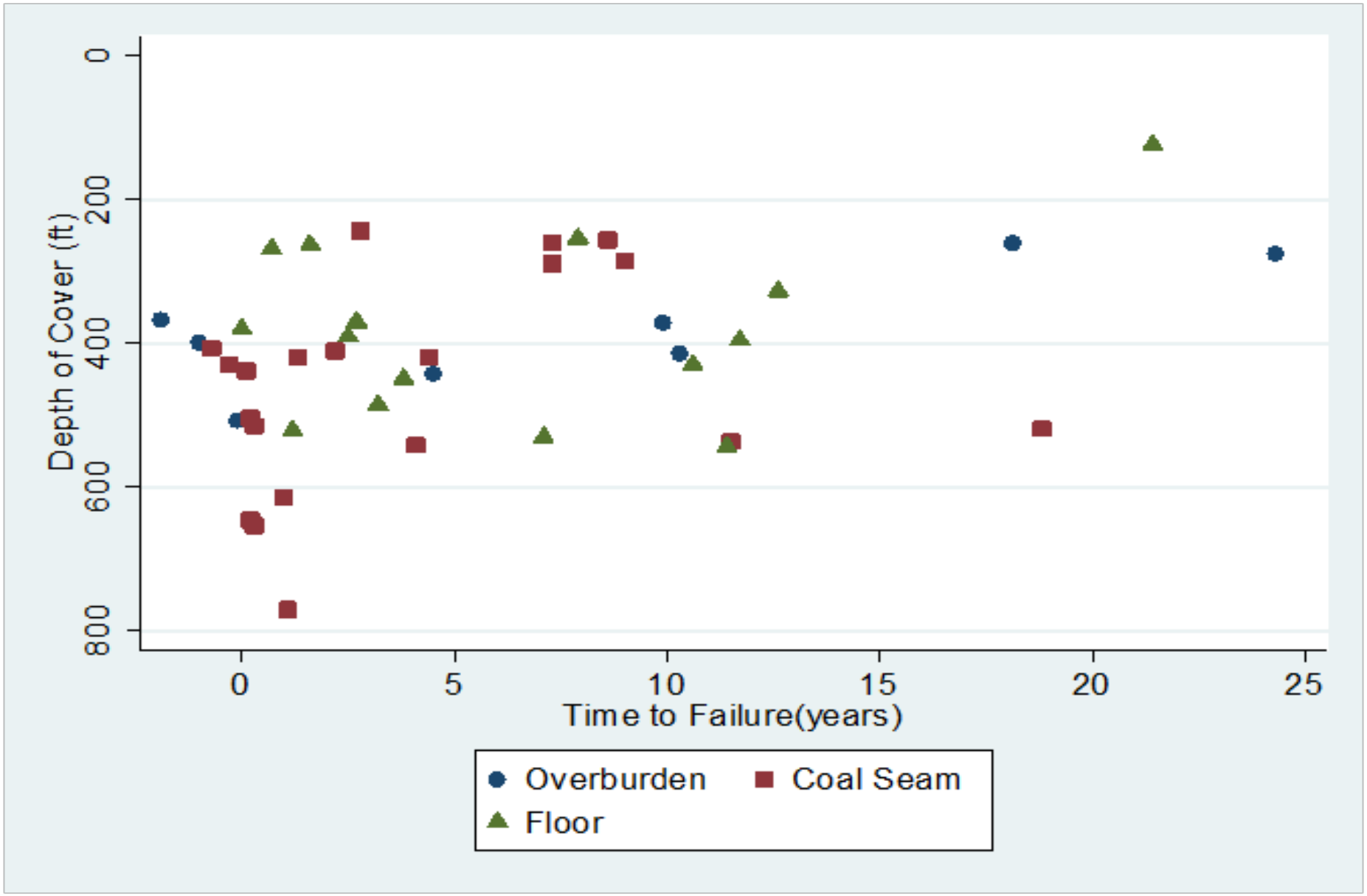
- The depth of cover (H) was less than 650 feet in all cases.

- The 1957 Study recommended that the setback distance should exceed 50 feet.

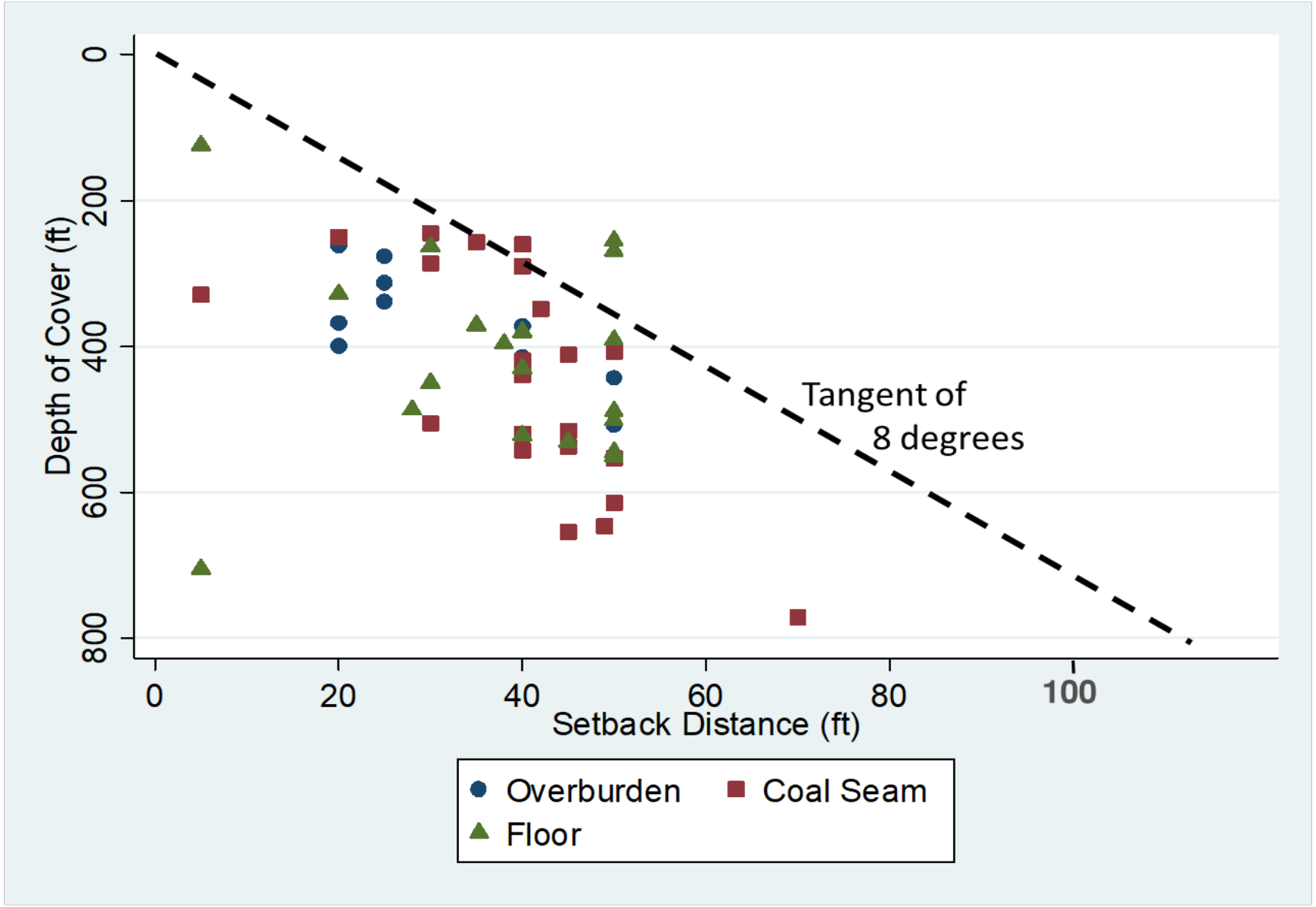
- Today many mines operate at depths of cover much greater than 650 feet.

- The 1957 Study did not consider downhole well deviation surveys that can accurately locate the well at the coal seam.


Gas Well

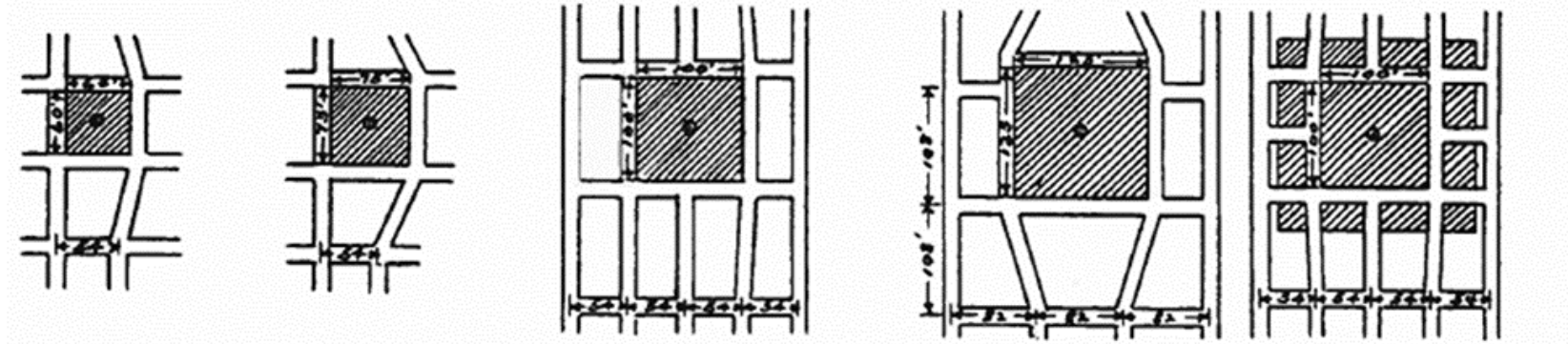


1957 Study Case Histories:
Depth of Cover vs. Time to Failure, by Location of failure.



1957 Study Case Histories:
Depth of Cover vs. Setback Distance, by Location of failure.

JOINT COAL AND GAS COMMITTEE
GAS WELL PILLAR STUDY
EXAMPLES OF PILLAR PLANS FOR VARIOUS DEPTHS OF COVER

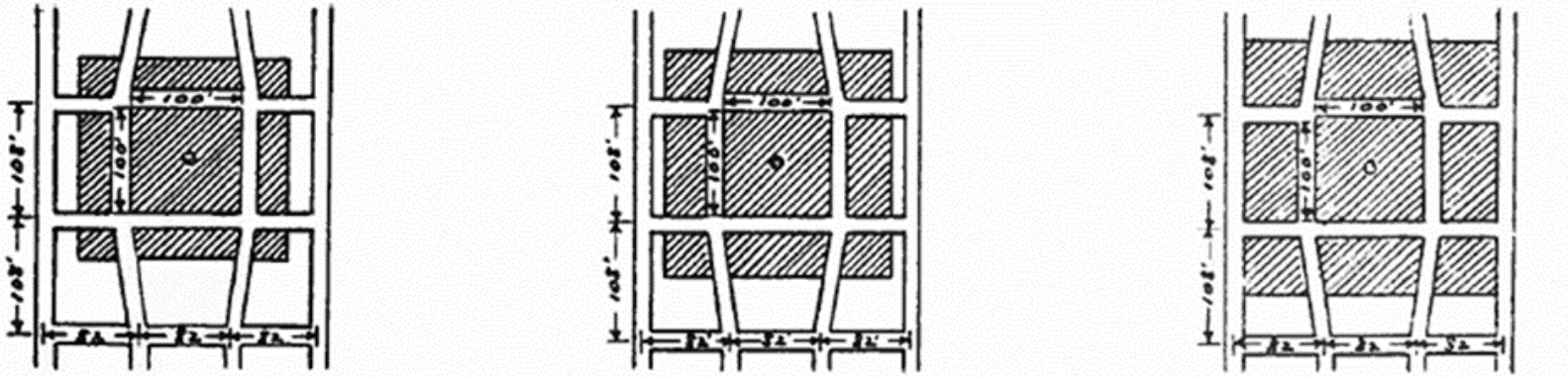


COVER 0' To 149'

COVER 150' To 249'

COVER 250' To 349'
(MIN. 10,000 SQ. FT. BEARING AREA)

COVER 350' To 449'
(MIN. 15,600 SQ. FT. BEARING AREA)(MIN. 22,000 SQ. FT. BEARING AREA)



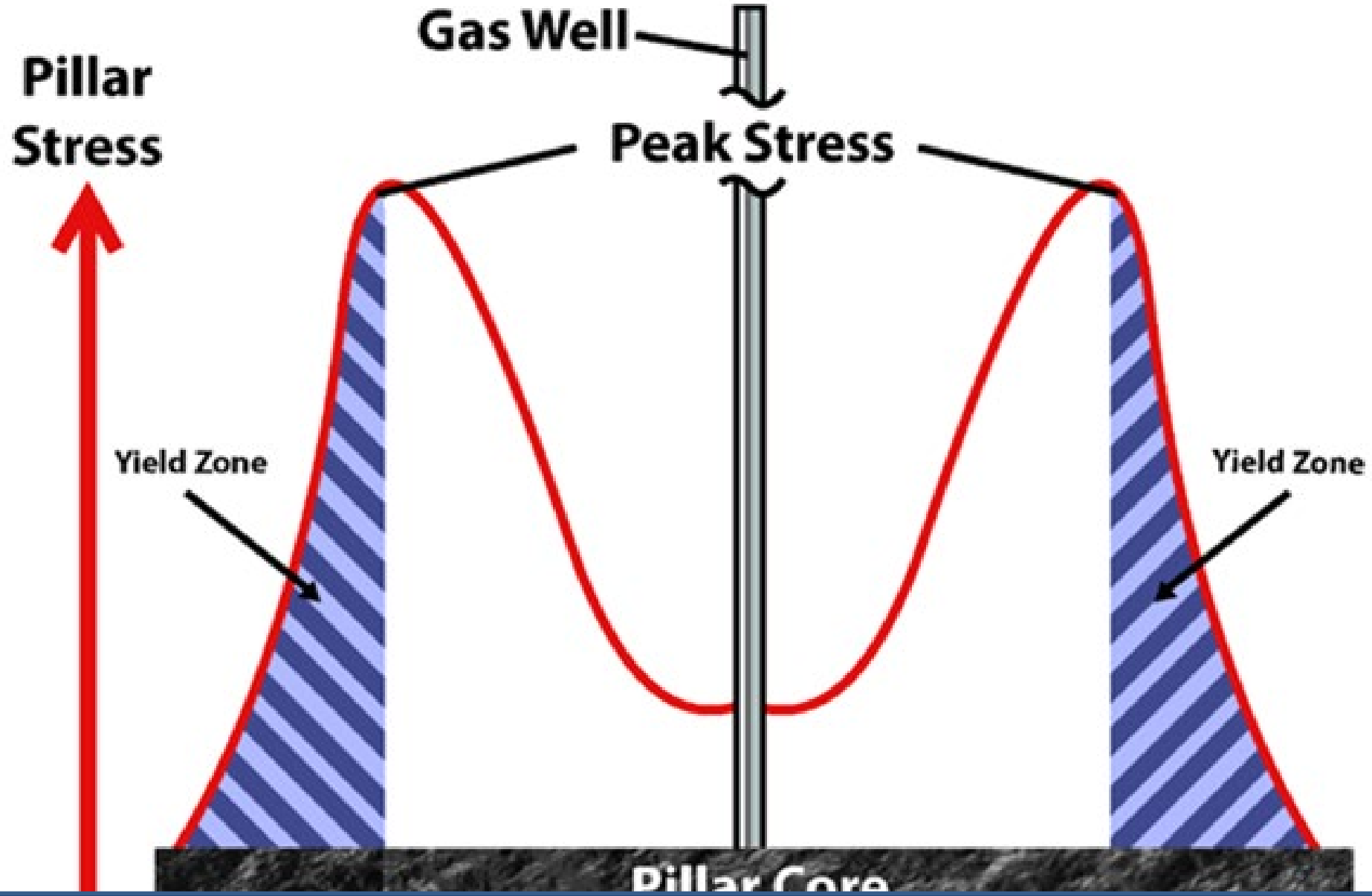
COVER 450' To 549
(MIN. 23,000 SQ. FT. BEARING AREA)

COVER 550' To 649'
(MIN. 32,000 SQ. FT. BEARING AREA)

COVER 650' To 700'+
(MIN. 40,000 SQ. FT. BEARING AREA)

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 (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.
- Greater Stability Factors (SF) and width-to-height ratios may be more appropriate for long-term and high-consequence applications.


Gas Well
Pillar Stress
Peak Stress
Yield Zone
Yield Zone
Pillar Core

Well Location Inaccuracies

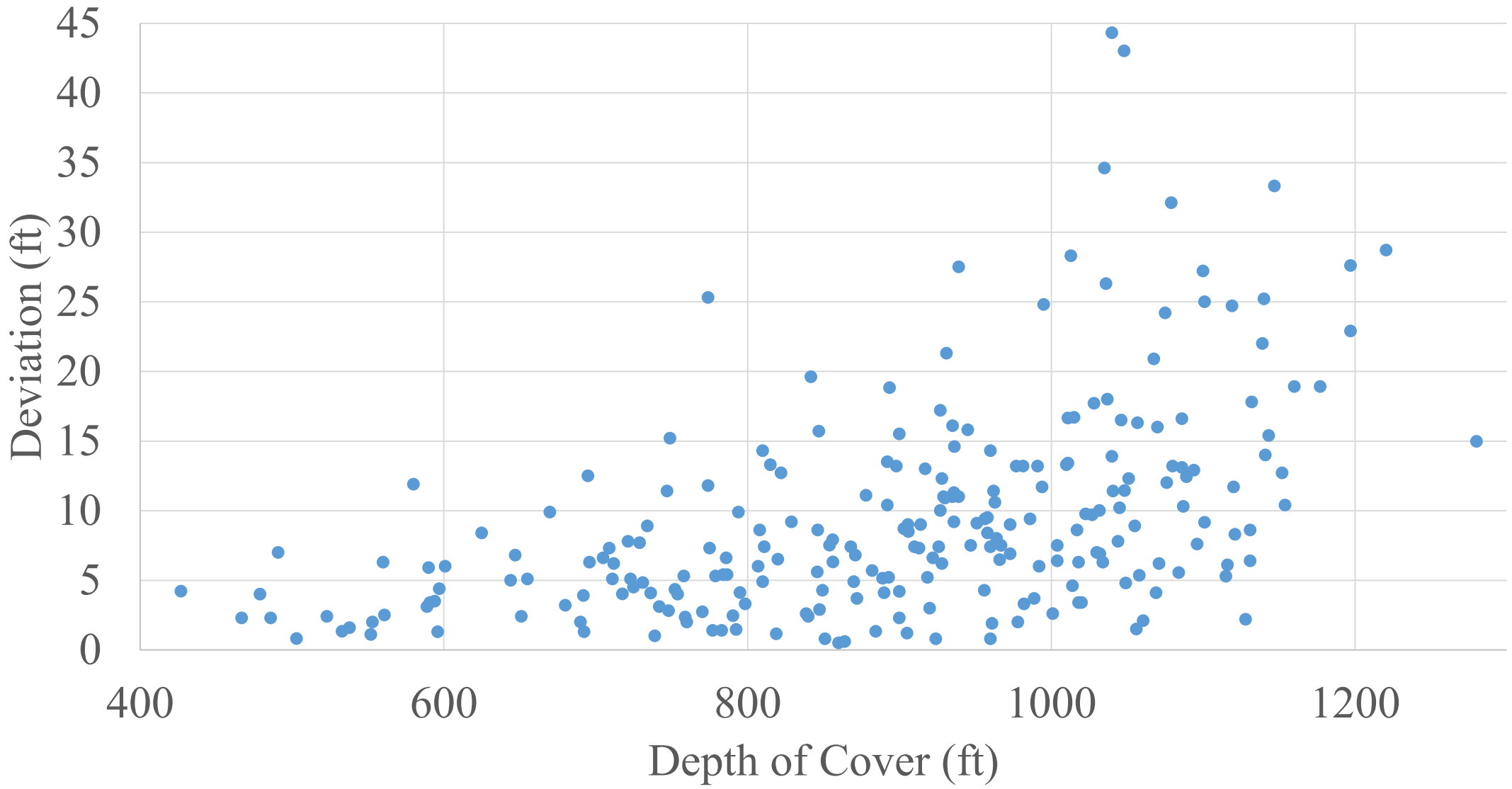
If the mine operator knows a well's surface location, the likelihood of an underground mine unintentionally intersecting it depends on the cumulative result of three kinds of errors: (1) well deviation, (2) surveying errors, and (3) mining errors.

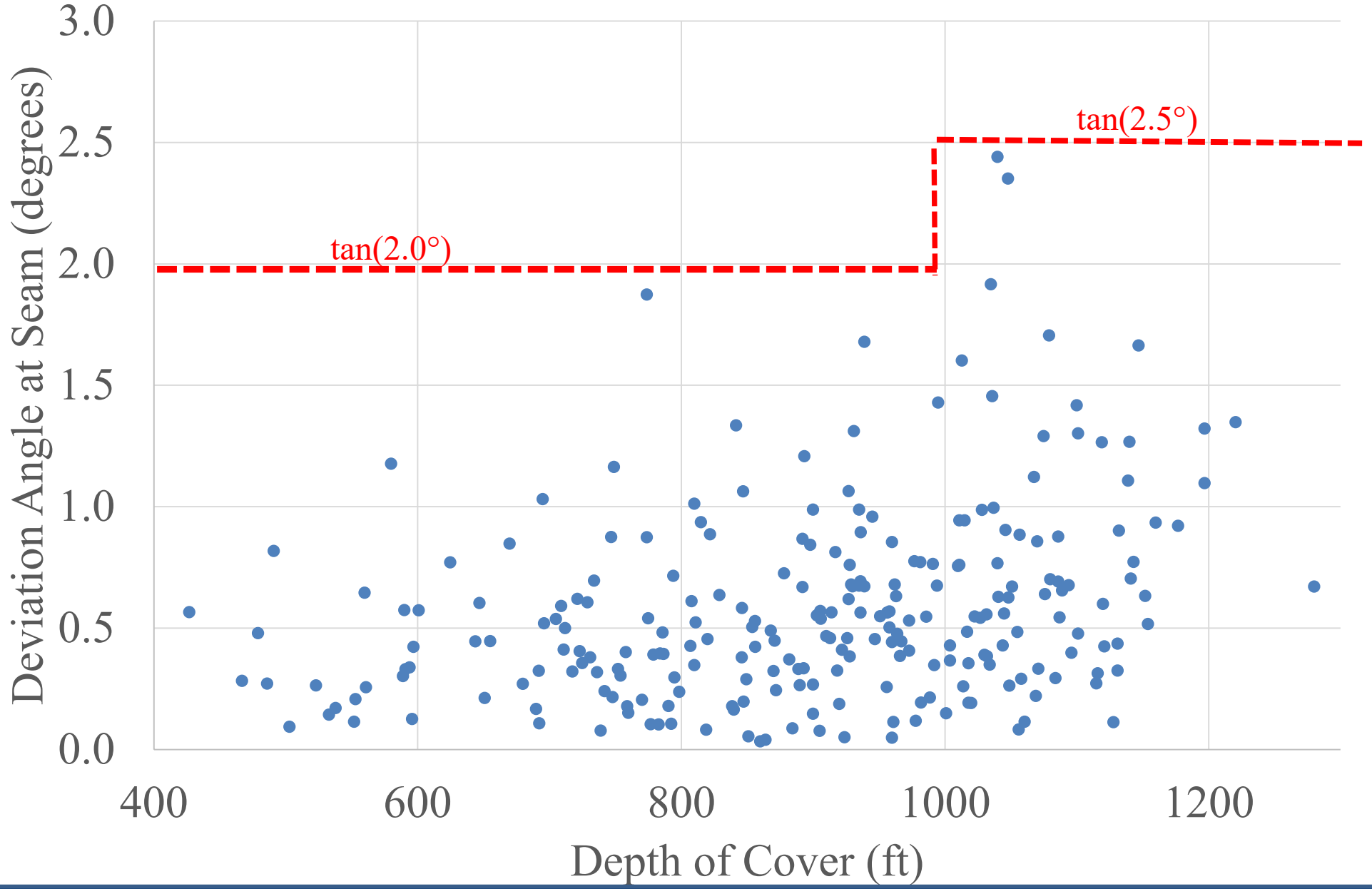
- ***Well deviation*** is the horizontal distance between the surface location of the well and where it penetrates the coal seam.

- Technical Support collected data from nearly 250 downhole well deviation surveys.

- 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°.

- Downhole gyro tool errors can affect the accuracy of the survey. They can be about H times the tangent of 0.2°.


45
40
35
30
25
20
15
10
5
0
Deviation (ft)
400
600
800
1000
1200
Depth of Cover (ft)


3.0
2.5
2.0
1.5
1.0
0.5
0.0
Deviation Angle at Seam (degrees)
tan(2.5°)
tan(2.0°)
400
600
800
1000
1200
Depth of Cover (ft)

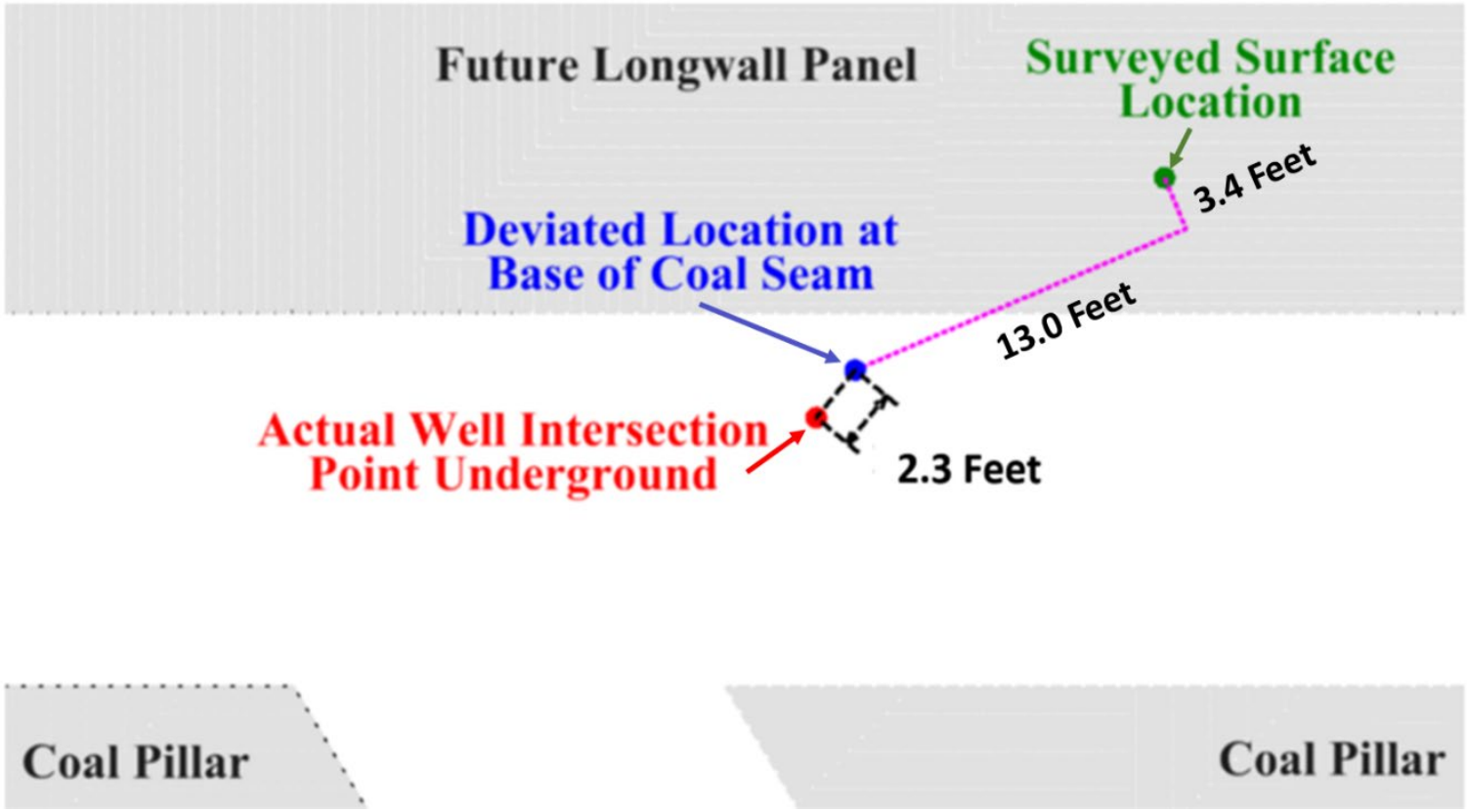
Surveying error: The surveyor can calculate the potential location error from the closure ratio.

- 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.


Future Longwall Panel
Surveyed Surface Location
3.4 Feet
Deviated Location at Base of Coal Seam
13.0 Feet
Actual Well Intersection Point Underground
2.3 Feet
Coal Pillar
Coal Pillar

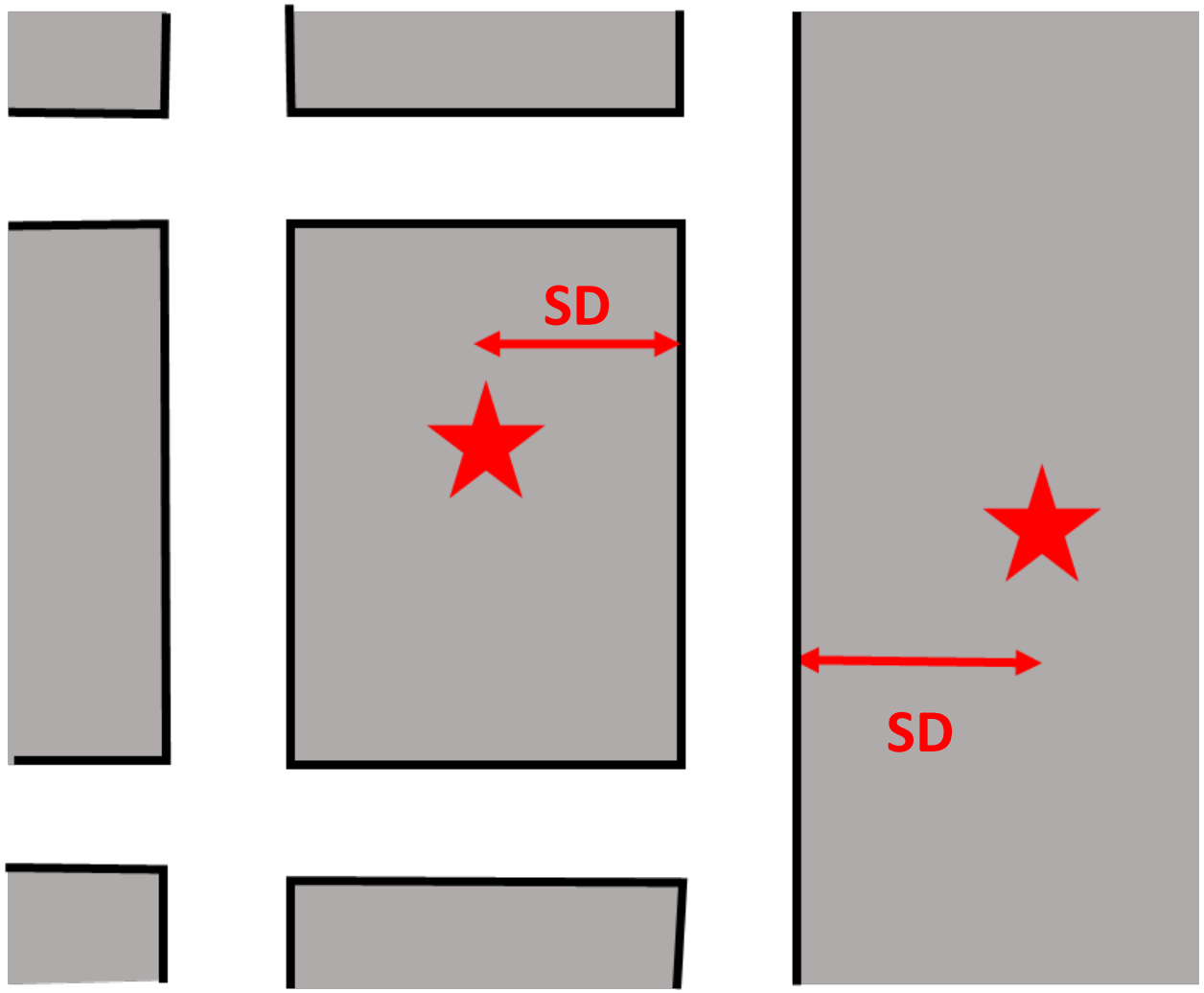
Best Practice Guidelines

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.

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.

Setback Distance



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 under deeper cover.

Key

★ Gas Well

SD Setback Distance

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*tan(2.2°) when H is less than 1,000 feet, and WD=H*tan(2.7°) when H is greater than 1,000 feet.
   b. When there is a deviation survey, WD=H*tan(0.2°) for all depths. (The mine operator may replace this value with a known, tool-specific error value.)

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, 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 Example 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 reduce the magnitude of mining errors. No deviation survey is available for the well. Therefore, the minimum setback distance SD_{MIN} is:

SD_{MIN} = 50' or (WD + SE + ME + SA), whichever is greater.
SD_{MIN} = 50' or (44' + 3' +5'+13'), whichever is greater.
SD_{MIN} = 50' or 65', whichever is greater.
SD_{MIN} = 65'

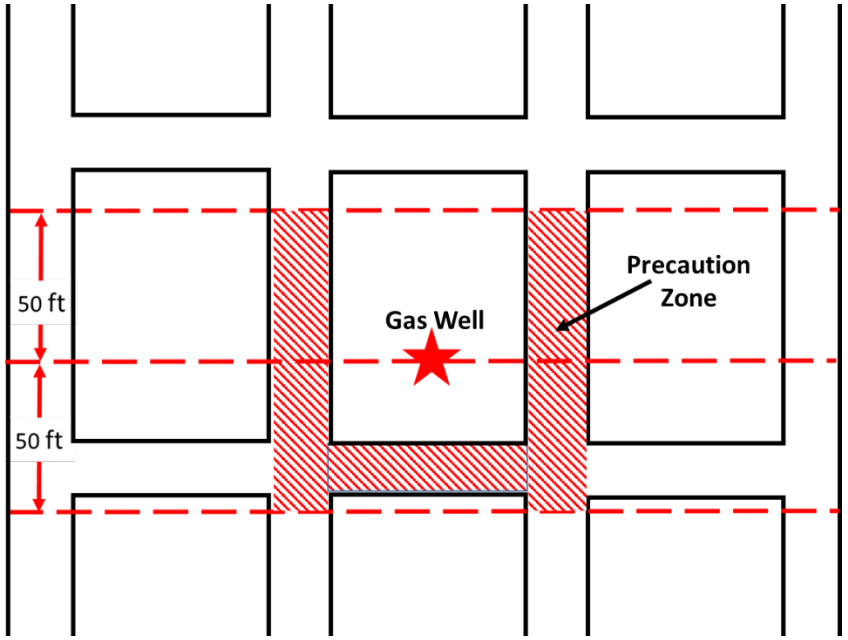
Calculation Example 2

A downhole deviation survey is available:

The location of a 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' or (WD + SE + ME + SA), whichever is greater.
SD_{MIN} = 40' or (3' + 3' + 5' + 13'), whichever is greater.
SD_{MIN} = 40' or 24', 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 the figure. 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.

Conclusions