# Natural Gas Pipeline Safety Setback Standards

## 49 CFR Part 192 - TRANSPORTATION OF NATURAL AND OTHER GAS BY PIPELINE: MINIMUM FEDERAL SAFETY STANDARDS

## 49 CFR § 192.903
## ASME B31.8S - 2018
## **Rhodes** & **Stephens** Equations

Prepared by
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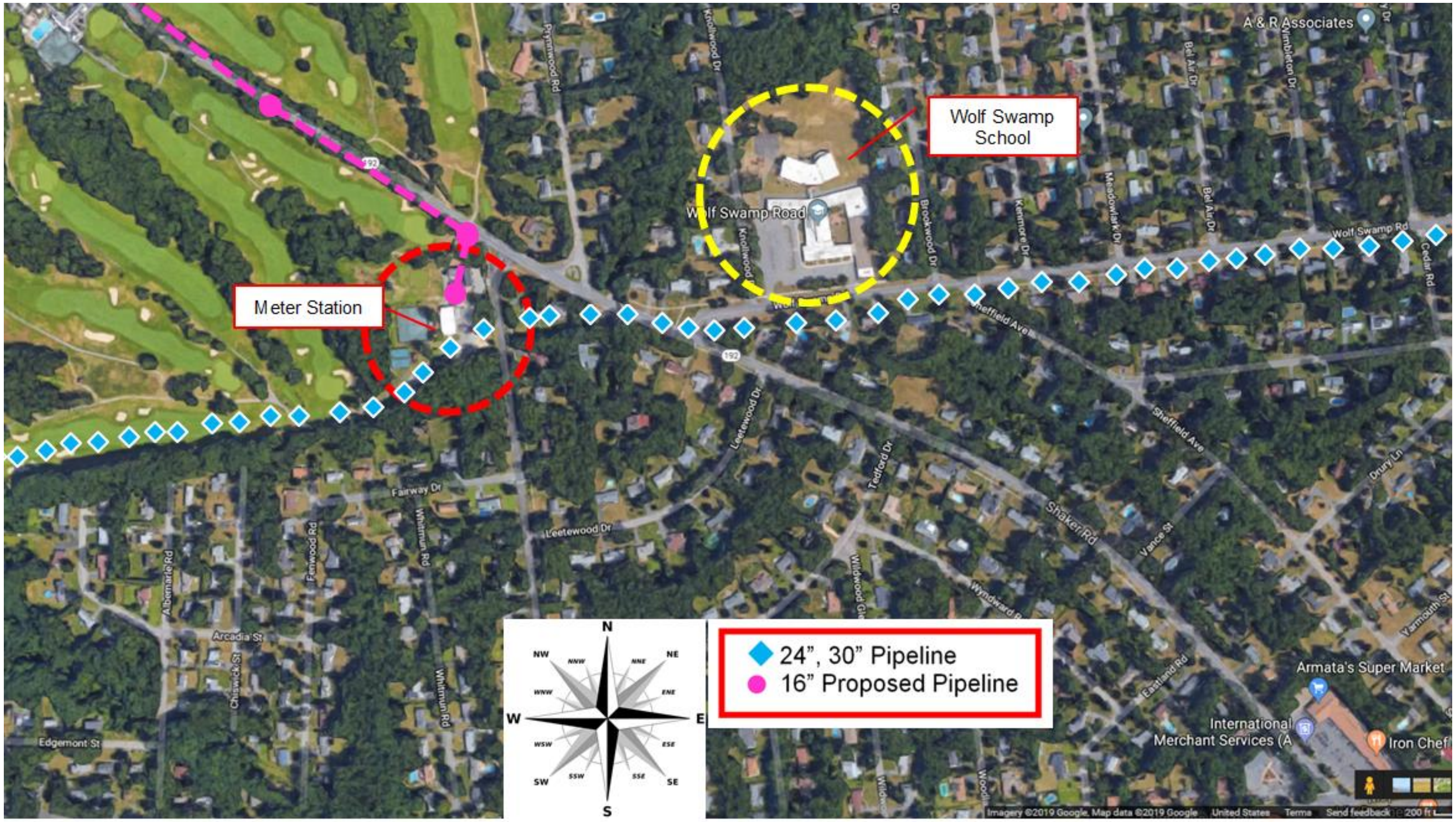
May 7, 2019

# Acknowledgment

The following summary explicitly credits the work of

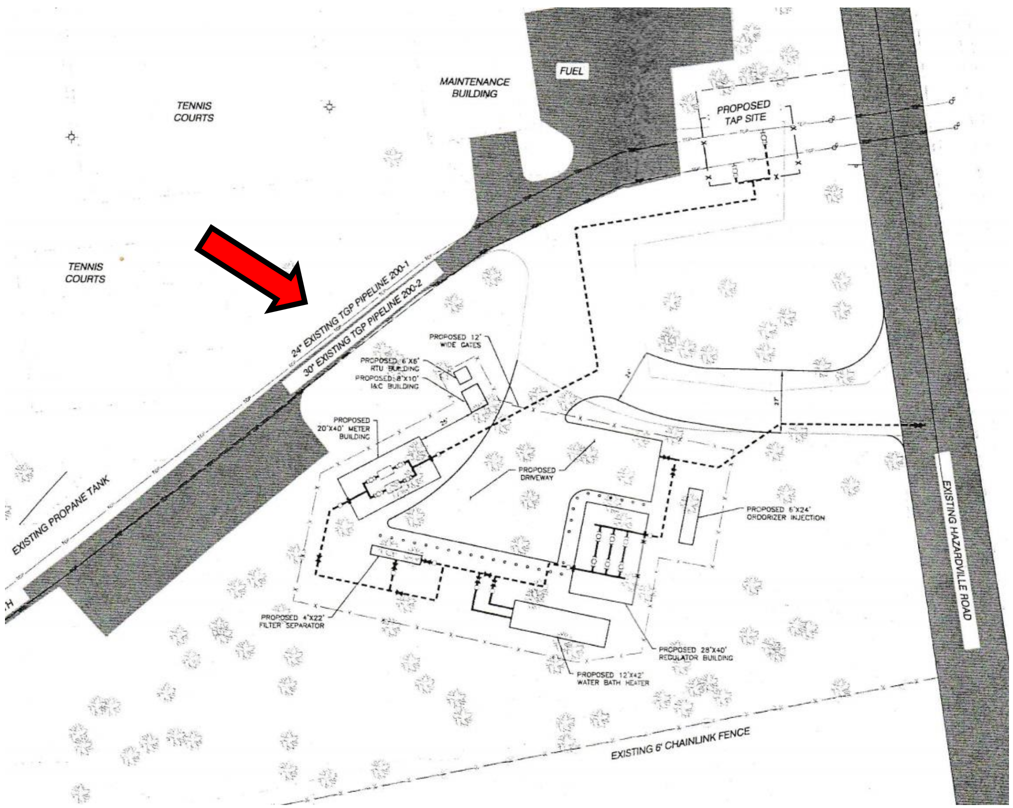
**Dr. Charles Rhodes, PE, Mark Stephens,** and the ***American Society of Mechanical Engineers (ASME)*** for their contribution to establishing standards for natural gas high pressure transmission pipeline safety set-backs.

# Proposed Gas Meter Station



# Subject Proposed Metering Station

(Note 24” and 30” Existing Gas Pipelines)



# Title 49 Subtitle A Part 1 Subpart A §1.2 U.S. Department of Transportation

§1.2 Organization of the Department.

(a) The Secretary of Transportation is the head of the Department.

(b) The Department comprises the Office of the Secretary of Transportation (OST), the Office of the Inspector General (OIG), and the following Operating Administrations, each headed by an Administrator who reports directly to the Secretary:

(1) The Federal Aviation Administration (FAA).
(2) The Federal Highway Administration (FHWA).
(3) The Federal Motor Carrier Administration (FMCSA).
(4) The Federal Railroad Administration (FRA).
(5) The Federal Transit Administration (FTA).
(6) The Maritime Administration (MARAD).
(7) The National Highway Traffic Safety Administration (NHTSA).
(8) The Pipeline and Hazardous Materials Safety Administration (PHMSA).
(9) The Research and Innovative Technology Administration (RITA).
(10) The Saint Lawrence Seaway Development Corporation (SLSDC).

# Title 49: Transportation
## Part 1 – Organization and Delegation of Powers and Duties

(h) "Pipeline and Hazardous Materials Safety Administrator" is synonymous with "Administrator of the Pipeline and Hazardous Materials Safety Administration."

49 CFR Part 192 - TRANSPORTATION OF NATURAL
AND OTHER GAS BY PIPELINE: MINIMUM FEDERAL SAFETY STANDARDS

# § 192.903

- The following definitions apply to this subpart:
- *Assessment* is the use of testing techniques as allowed in this subpart to ascertain the condition of a covered pipeline segment.
- *Confirmatory direct assessment* is an integrity assessment method using more focused application of the principles and techniques of direct assessment to identify internal and external corrosion in a covered transmission pipeline segment.
- *Covered segment or covered pipeline segment* means a segment of gas transmission pipeline located in a high consequence area. The terms gas and transmission line are defined in § 192.3.
- *Direct assessment* is an integrity assessment method that utilizes a process to evaluate certain threats (*i.e.,* external corrosion, internal corrosion and stress corrosion cracking) to a covered pipeline segment's integrity. The process includes the gathering and integration of risk factor data, indirect examination or analysis to identify areas of suspected corrosion, direct examination of the pipeline in these areas, and post assessment evaluation.
- *High consequence area* means an area established by one of the methods described in paragraphs (1) or (2) as follows:

# § 192.903

- **(1)** An area defined as -
  - **(i)** A Class 3 location under § 192.5; or
  - **(ii)** A Class 4 location under § 192.5; or
  - **(iii)** Any area in a Class 1 or Class 2 location where the potential impact radius is greater than 660 feet (200 meters), and the area within a potential impact circle contains 20 or more buildings intended for human occupancy; or
  - **(iv)** Any area in a Class 1 or Class 2 location where the potential impact circle contains an identified site.
- **(2)** The area within a potential impact circle containing -
  - **(i)** 20 or more buildings intended for human occupancy, unless the exception in paragraph (4) applies; or
  - **(ii)** An identified site.

# § 192.903

- **(3)** Where a potential impact circle is calculated under either method (1) or (2) to establish a high consequence area, the length of the high consequence area extends axially along the length of the pipeline from the outermost edge of the first potential impact circle that contains either an identified site or 20 or more buildings intended for human occupancy to the outermost edge of the last contiguous potential impact circle that contains either an identified site or 20 or more buildings intended for human occupancy. (See figure E.I.A. in appendix E.)

- **(4)** If in identifying a high consequence area under paragraph (1)(iii) of this definition or paragraph (2)(i) of this definition, the radius of the potential impact circle **is greater than 660 feet** (200 meters), the operator may identify a high consequence area based on a prorated number of buildings intended for human occupancy with a distance of 660 feet (200 meters) from the centerline of the pipeline until December 17, 2006. If an operator chooses this approach, the operator must prorate the number of buildings intended for human occupancy based on the ratio of an area with a radius of 660 feet (200 meters) to the area of the **potential impact circle** (*i.e.*, the prorated number of buildings intended for human occupancy is equal to 20 × (660 feet) [or 200 meters]/potential impact radius in feet [or meters] 2).
- *Identified site* means each of the following areas:

# § 192.903 Note Reference to ASME B31.8S

*Potential impact circle* is a circle of radius equal to the potential impact radius (PIR).

*Potential impact radius* (PIR) means the radius of a circle within which the potential failure of a pipeline could have significant impact on people or property. PIR is determined by the formula $r = 0.69 * (\text{square root of } (p * d^2))$, where 'r' is the radius of a circular area in feet surrounding the point of failure, 'p' is the maximum allowable operating pressure (MAOP) in the pipeline segment in pounds per square inch and 'd' is the nominal diameter of the pipeline in inches.

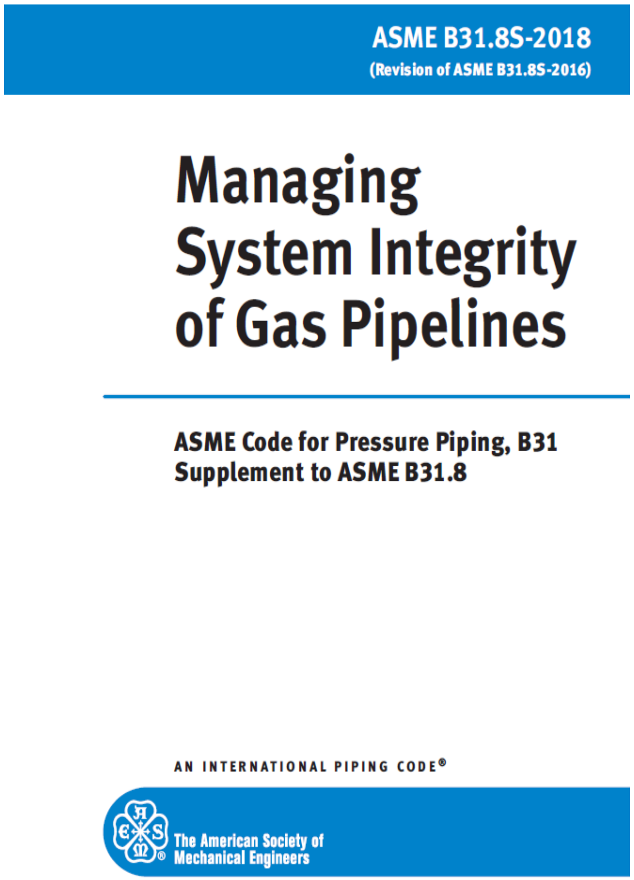
**NOTE:**

0.69 is the factor for natural gas. This number will vary for other gases depending upon their heat of combustion. An operator transporting gas other than natural gas must use section 3.2 of **ASME/ANSI B31.8S** (incorporated by reference, *see* § 192.7) to calculate the impact radius formula.

*Remediation* is a repair or mitigation activity an operator takes on a covered segment to limit or reduce the probability of an undesired event occurring or the expected consequences from the event.

[68 FR 69817, Dec. 15, 2003, as amended by Amdt. 192-95, 69 FR 18231, Apr. 6, 2004; Amdt. 192-95, 69 FR 29904, May 26, 2004; Amdt. 192-103, 72 FR 4657, Feb. 1, 2007; Amdt. 192-119, 80 FR 181, Jan. 5, 2015]

# ASME B31.8S-2018
# (Stephens Equation)






specific risk analysis model, only that the risk model used can be shown to be effective. The detailed risk analyses will provide a better understanding of integrity, which will enable an operator to have a greater degree of flexibility in the timing and methods for the implementation of a performance-based integrity management plan. Section 8 provides details on plan development.

The plan shall be periodically updated to reflect new information and the current understanding of integrity threats. As new risks or new manifestations of previously known risks are identified, additional mitigative actions to address these risks shall be performed, as appropriate. Furthermore, the updated risk assessment results shall also be used to support scheduling of future integrity assessments.

**2.4.2 Performance Plan.** The operator shall collect performance information and periodically evaluate the success of its integrity assessment techniques, pipeline repair activities, and the mitigative risk control activities. The operator shall also evaluate the effectiveness of its management systems and processes in supporting sound integrity management decisions. Section 9 provides the information required for developing performance measures to evaluate program effectiveness.

The application of new technologies into the integrity management program shall be evaluated for further use in the program.

**2.4.3 Communications Plan.** The operator shall develop and implement a plan for effective communications with employees, the public, emergency responders, local officials, and jurisdictional authorities in order to keep the public informed about their integrity management efforts. This plan shall provide information to be communicated to each stakeholder about the integrity plan and the results achieved. Section 10 provides further information about communications plans.

**2.4.4 Management of Change Plan.** Pipeline systems and the environment in which they operate are seldom static. A systematic process shall be used to ensure that, prior to implementation, changes to the pipeline system design, operation, or maintenance are evaluated for their potential risk impacts, and to ensure that changes to the environment in which the pipeline operates are evaluated. After these changes are made, they shall be incorporated, as appropriate, into future risk assessments to ensure that the risk assessment process addresses the systems as currently configured, operated, and maintained. The results of the plan's mitigative activities should be used as a feedback for systems and facilities design and operation. Section 11 discusses the important aspects of managing changes as they relate to integrity management.

**2.4.5 Quality Control Plan.** Section 12 discusses the evaluation of the integrity management program for quality control purposes. That section outlines the necessary documentation for the integrity management program. The section also discusses auditing of the program, including the processes, inspections, mitigation activities, and prevention activities.

## 3 CONSEQUENCES

### 3.1 General

Risk is the mathematical product of the likelihood (probability) and the consequences of events that result from a failure. Risk may be decreased by reducing either the likelihood or the consequences of a failure, or both. This section specifically addresses the consequence portion of the risk equation. The operator shall consider consequences of a potential failure when prioritizing inspections and mitigation activities.

The ASME B31.8 Code manages risk to pipeline integrity by adjusting design and safety factors, and inspection and maintenance frequencies as the potential consequences of a failure increase. This has been done on an empirical basis without quantifying the consequences of a failure.

Paragraph 3.2 describes how to determine the area that is affected by a pipeline failure (potential impact area) in order to evaluate the potential consequences of such an event. The area impacted is a function of the pipeline diameter and pressure.

### 3.2 Potential Impact Area

**3.2.1 Typical Natural Gas.** The radius of impact for natural gas whose methane + inert constituents content is not less than 93%, whose initial pressure does not exceed 1,450 psig (10 MPa), and whose temperature is at least 32°F (0°C) is calculated using the following formula:

*(U.S. Customary Units)*

$$r = 0.69 \cdot d\sqrt{p} \qquad (1)$$

*(SI Units)*

$$r = 0.00315 \cdot d\sqrt{p}$$

where

$d$ = outside diameter of the pipeline, in. (mm)
$p$ = pipeline segment's maximum allowable operating pressure (MAOP), psig (kPa)
$r$ = radius of impact, ft (m)

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EXAMPLES:

(1) A 30-in. diameter pipe with a maximum allowable operating pressure of 1,000 psig has a radius of impact of approximately 660 ft.

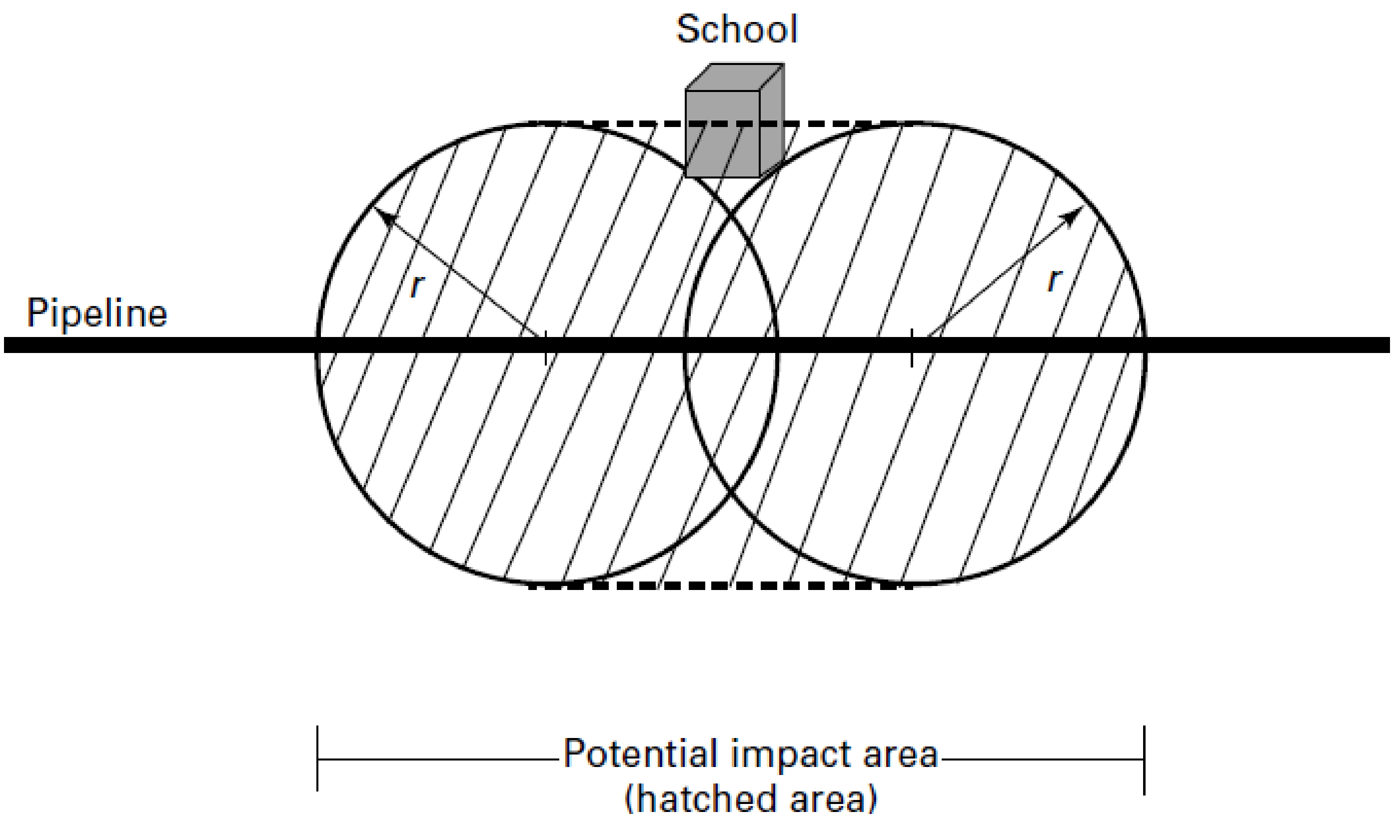
$$r = 0.69 \cdot d\sqrt{p} = 0.69(30 \text{ in.})(1{,}000 \text{ lb/in.}^2)^{1/2}$$
$$= 654.6 \text{ ft} \approx 660 \text{ ft}$$

(2) A 762-mm diameter pipe with a maximum allowable operating pressure of 6 900 kPa has a radius of impact of approximately 200 m.

$$r = 0.00315 \cdot d\sqrt{p} = 0.00315\,(762 \text{ mm})(6\,900 \text{ kPa})^{1/2}$$
$$= 199.4 \text{ m} \approx 200 \text{ m}$$

# ASME B31.8S-2018

**Figure 3.2.4-1 Potential Impact Area**



# ASME B31.8S-2018

**3.2.4 Ranking of Potential Impact Areas.** The operator shall count the number of houses and individual units in buildings within the potential impact area. The potential impact area extends from the extremity of the first affected circle to the extremity of the last affected circle (see Figure 3.2.4-1). This housing unit count can then be used to help determine the relative consequences of a rupture of the pipeline segment.

The ranking of these areas is an important element of risk assessment. Determining the likelihood of failure is the other important element of risk assessment (see sections 4 and 5).

## 3.3 Consequence Factors to Consider (18)

When evaluating the consequences of a failure within the impact zone, the operator shall consider at least the following:

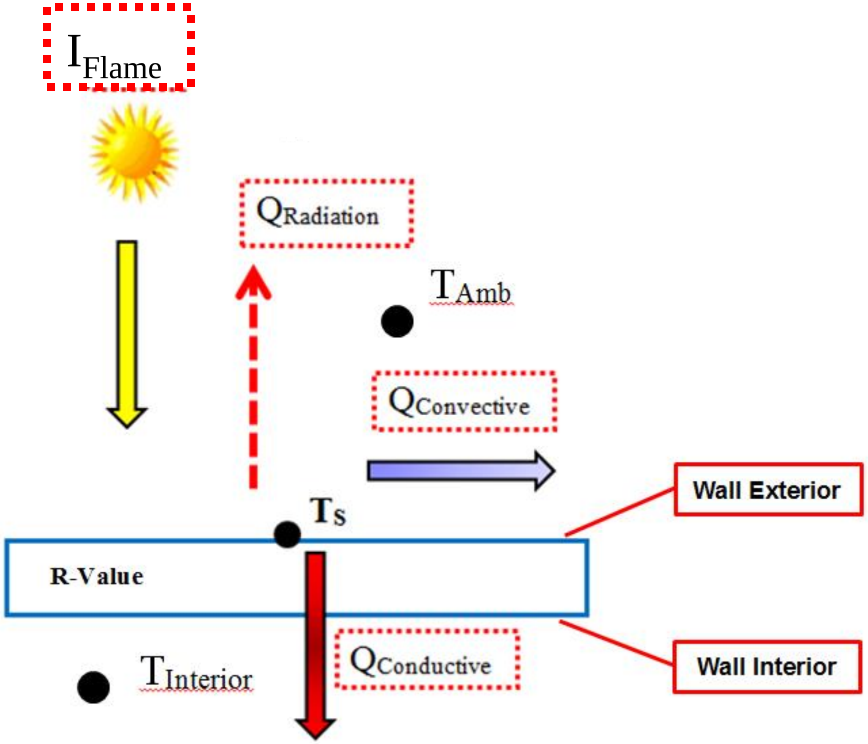
*(a)* number and location of inhabited structures
*(b)* proximity of the population to the pipeline (including consideration of man-made or natural barriers that may provide some level of protection)
*(c)* proximity of populations with limited or impaired mobility (e.g., hospitals, schools, child-care centers, retirement facilities, prisons, recreation areas), particularly in unprotected outside areas
*(d)* property damage
*(e)* environmental damage
*(f)* effects of unignited gas releases
*(g)* security or reliability of gas supply (e.g., impacts resulting from interruption of service)

*(h)* public convenience and necessity
*(i)* potential for secondary failures
*(j)* duration of a failure event, including product depressurization and potential fire

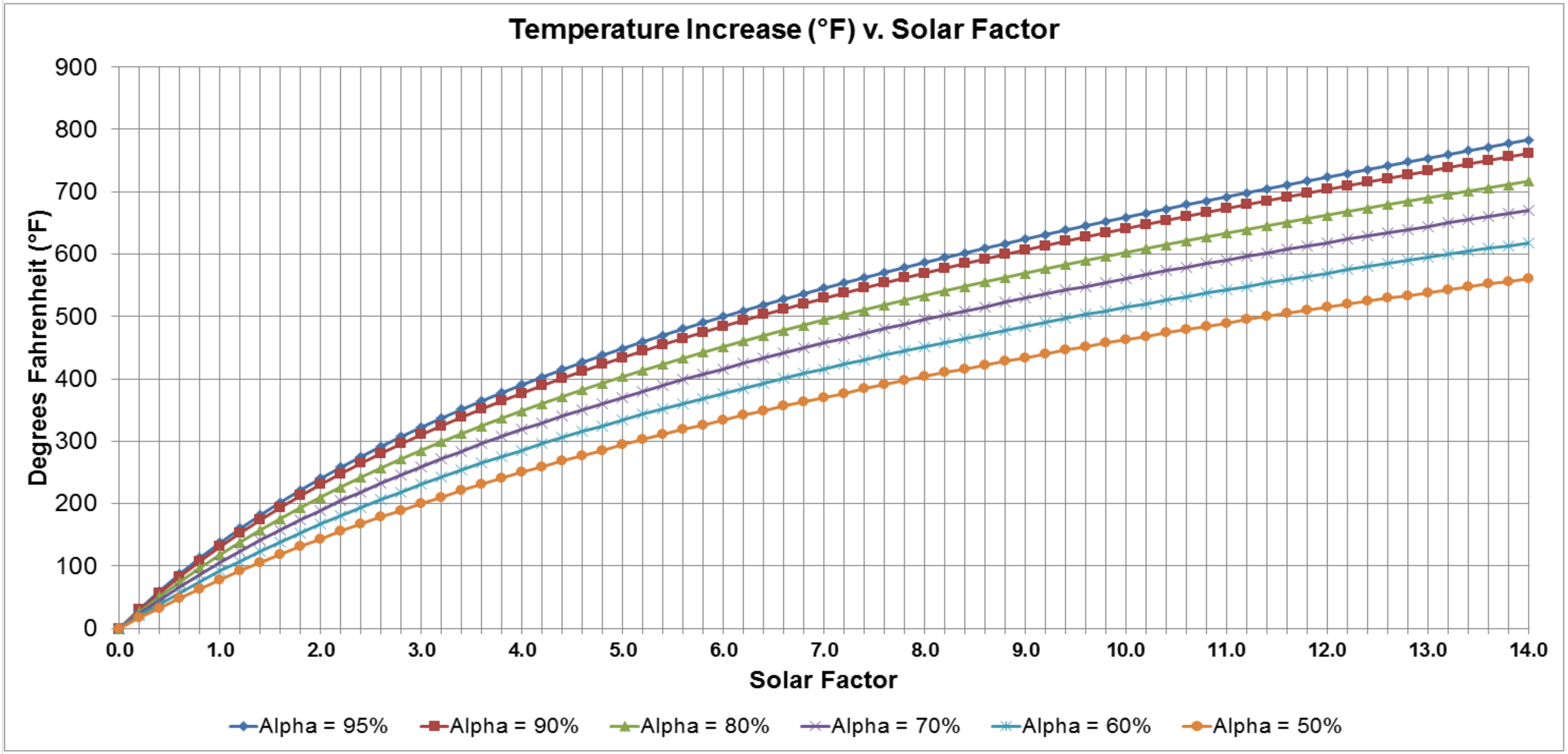
Note that the consequences may vary based on the richness of the gas transported and as a result of how the gas decompresses. The richer the gas, the more important defects and material properties are in modeling the characteristics of the failure.

# Surface Energy Balance

0= Qsolar gain – Qradiation - Qconvective - Qconductive



| Solar Factor: | 1.0 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 | 11.0 | 12.0 | 13.0 | 14.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rs | | | Rs/2 | | | | | (2/3)Rs/2 | | | Stephens | | |
| Btu/(hr-sf): | 433 | 865 | 1,298 | 1,731 | 2,163 | 2,596 | 3,029 | 3,462 | 3,894 | 4,327 | 4,760 | 5,192 | 5,625 | 6,058 |
| W/m$^2$ | 1,365 | 2,730 | 4,095 | 5,460 | 6,825 | 8,190 | 9,555 | 10,920 | 12,285 | 13,650 | 15,015 | 16,380 | 17,745 | 19,110 |

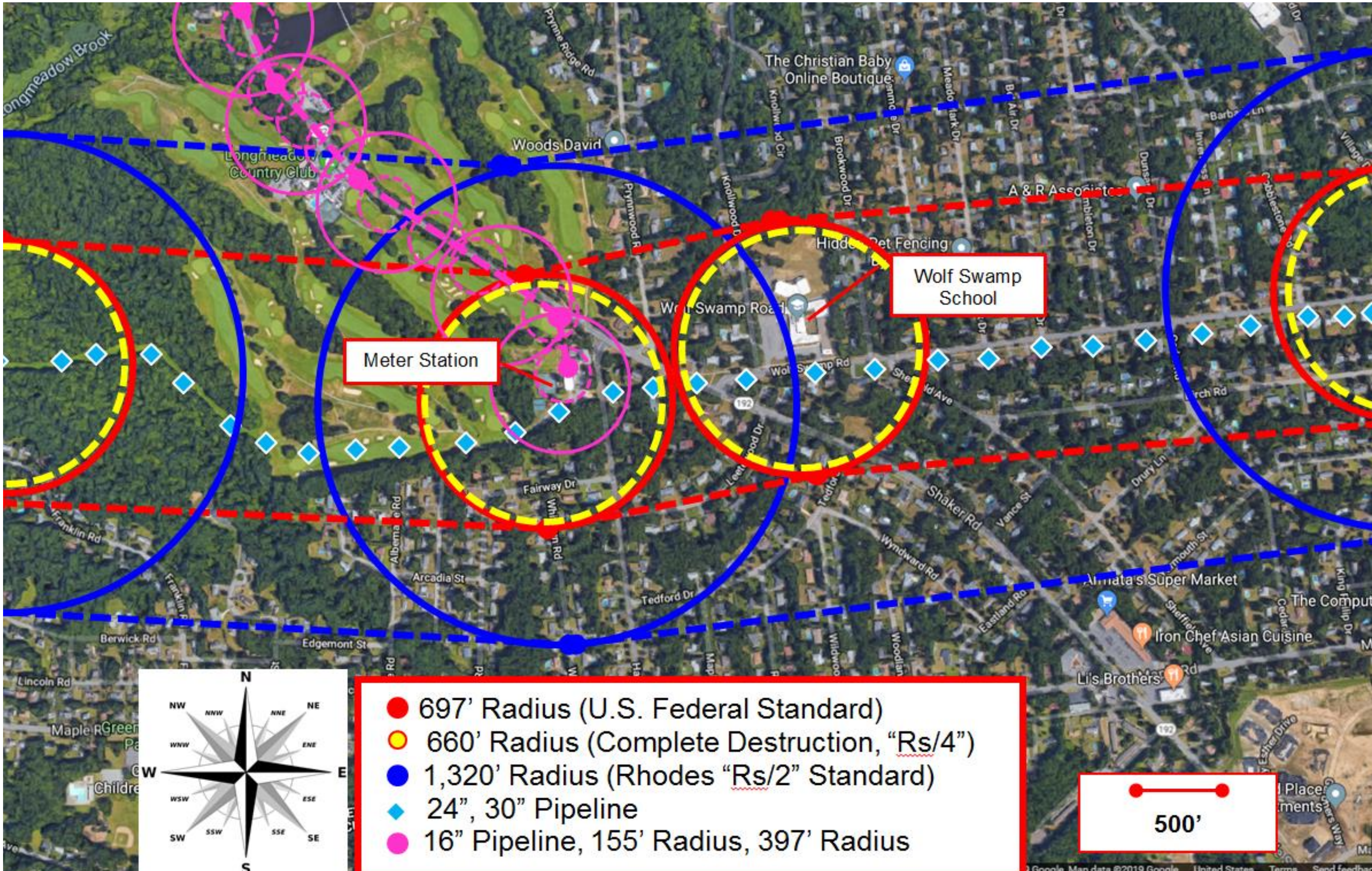


# ASME B31.8S
## (Stephens Equation)

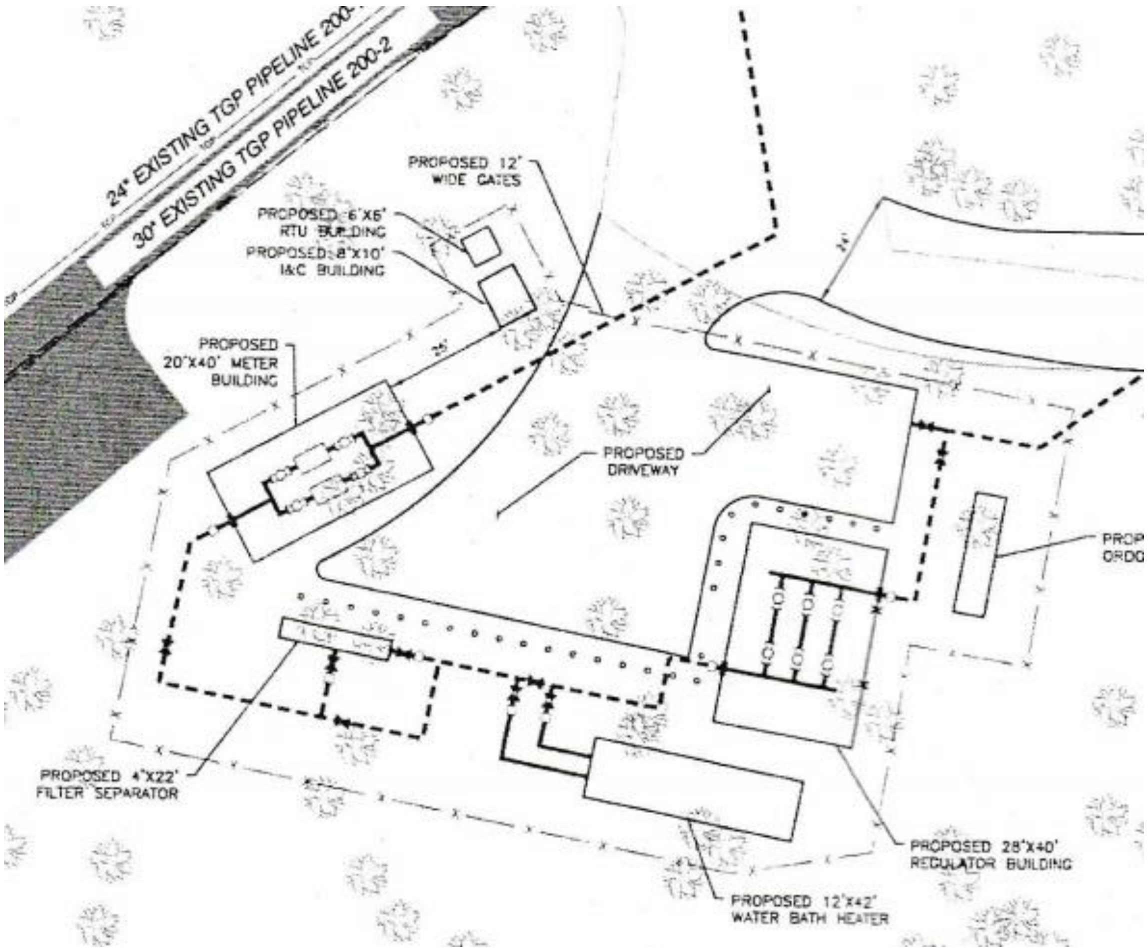
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Stephens Equation, Radiation level of I= | | | | 5,000 | Btu/(hr-sf) | |
| | | | | | | | |
| Pressure (psig): | 200 | 300 | 400 | 500 | 600 | 700 | 800 |
| | | | | | | | |
| Pipe Diam (in) | (ft) | (ft) | (ft) | (ft) | (ft) | (ft) | (ft) |
| 12 | 116 | 142 | 164 | 184 | 201 | 218 | 233 |
| 16 | 155 | 190 | 219 | 245 | 269 | 290 | 310 |
| 18 | 174 | 214 | 247 | 276 | 302 | 326 | 349 |
| 24 | 233 | 285 | 329 | 368 | 403 | 435 | 465 |
| 30 | 291 | 356 | 411 | 460 | 504 | 544 | 581 |
| 36 | 349 | 427 | 493 | 552 | 604 | 653 | 698 |
| 38.4 | 372 | 456 | 526 | 588 | 645 | 696 | 744 |
| 42 | 407 | 499 | 576 | 644 | 705 | 761 | 814 |

# Rhodes Equation

| | (2/3)Rs/2 Distance (ft) for Pipe Diameter and Pipeline Pressure | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | Pressure (psig): | **200** | **300** | **400** | **500** | **600** | **700** | **800** |
| | | | | | | | | |
| | Setback Radius: | **(ft)** | **(ft)** | **(ft)** | **(ft)** | **(ft)** | **(ft)** | **(ft)** |
| Diameter | | | | | | | | |
| **12** | " | 198 | 221 | 238 | 252 | 264 | 275 | 285 |
| **16** | " | 264 | 295 | 317 | 336 | 352 | 367 | 379 |
| **18** | " | 297 | 331 | 357 | 378 | 397 | 412 | 427 |
| **24** | " | 397 | 442 | 476 | 505 | 529 | 550 | 569 |
| **30** | " | 496 | 552 | 595 | 631 | 661 | 687 | 711 |
| **36** | " | 595 | 663 | 714 | 757 | 793 | 825 | 854 |
| **38.4** | " | 635 | 707 | 762 | 807 | 846 | 880 | 910 |
| **42** | | 694 | 773 | 833 | 883 | 925 | 962 | 996 |


Meter Station
Wolf Swamp School
697' Radius (U.S. Federal Standard)
660' Radius (Complete Destruction, "Rs/4")
1,320' Radius (Rhodes "Rs/2" Standard)
24", 30" Pipeline
16" Pipeline, 155' Radius, 397' Radius
500'
N
S
E
W
NW
NE
SW
SE

# Subject Metering Station



# Edison N.J. (Durham Woods Apartments)
# March 23, 1994

https://www.youtube.com/watch?v=NyMbaZ9FVjA

https://www.youtube.com/watch?v=4TLZZmwmtW4

https://www.youtube.com/watch?v=w_uDDoIga7E

http://www.gendisasters.com/new-jersey/19145/edison-nj-gas-pipeline-explosion-mar-1994

# San Bruno, California, September 9, 2010

# It was first thought to be a jet plane crash

http://fracdallas.org/docs/sanbruno.html

Natural gas pipeline explosion, 6:11 PM PDT on September 9, 2010.

The explosion created a crater measuring 167 feet long, 26 feet wide and 40 feet deep, sending what was described by eye witnesses as a "wall of fire more than 1,000 feet high."

The Pacific Gas & Electric (PG&E) pipeline was a 30-inch high pressure distribution line buried underground.

The shock of the explosion was felt more than 2 miles away at San Francisco International Airport.

It was about 90 minutes after the event before gas was shut off to the distribution line.

8 people killed; 58 injured.

Burned about 10 acres

Destroyed 38 homes, severely damaged another 120 homes.

# https://www.youtube.com/watch?v=EZ6YbUrnxVM

https://www.youtube.com/watch?v=P--2xdwSm44


Blast damage disrupted a water line to fire hydrants requiring firefighters to transport water to the site. Additional ground and aerial assistance was provided in the form of 25 fire engines, 4 air-tankers, 2 air attack planes, and 1 helicopter sent by the California Department of Forestry and Fire Protection. Residents assisted firefighters by dragging hoses 4,000 feet to working fire hydrants, and others drove burn victims to hospitals.

The fire was only 50% contained by 10:00 PM, and continued to burn until 11:40 AM the following day.

PG&E reduced pipeline pressure by 20% after it was revealed that the pipeline may have been improperly installed. After the San Bruno pipeline failure, PG&E was required to re-evaluate how it determines the maximum operating pressure for some 1,800 miles of pipeline throughout its system.

On January 13 2012, an independent audit from the State of California issued a report stating that PG&E had illegally diverted over $100 million from a fund used for safety operations, and instead used it for executive compensation and bonuses.

# 12” Natural Gas Pipeline Explosion Midland County, Texas

## Casualties: 5 critical, 1 injured, 1 fatality

## [August 1, 2018]

## Courtesy Marty Baeza

https://www.reuters.com/article/us-texas-pipeline-blast/officials-identify-texas-pipeline-worker-killed-in-explosion-idUSKBN1KP0IZ

https://www.cbs7.com/content/news/Officials-responding-to-major-fire-east-of-Midland-489779741.html

# 30” Gas Pipeline Explosion in Summerfield, Ohio
# Injures one, damages 3 homes, 2 barns
## [January 21, 2019]

https://www.wtap.com/content/news/Pipeline-related-fire-reported-in-Noble-County-504652651.html

# Notes

# Calculation of Safety Setbacks from Natural Gas Pipelines
# Rhodes Equation ~ Dr. Charles Rhodes, PE, PhD

- $I = \frac{HFr}{4\pi R^2}$
- $R^2 = \frac{H \bullet Fr}{4\pi I}$
- $H = 2 \bullet Fm \bullet Ec$
- $R^2 = \frac{2 \bullet Fm \bullet Ec \bullet Fr}{4\pi I}$

- Dp – Pipe Diameter (m)
- Ec – Combustion heat release per unit mass of natural gas (52,437 kJ/kg)
- En – Nozzle efficiency (non-dimensional)
- Fm – Gas mass flowrate (kg/s)
- Fr – Fraction of combustion heat emitted by radiation (dimensionless)
- H- Total Combustion Heat Release (kJ/s)
- I – Irradiation from fire at building surface ($W/m^2$)
- Pa – Internal Pipe pressure (Pascals)
- Pb – External atmospheric pressure (Pascals)
- R- Radial distance between center of flame and irradiated object (m)
- ρ – Density of natural gas at standard atmospheric conditions ($0.714\ Kg/m^3$)

- $Fm = \pi \left(\frac{Dp}{2}\right)^2 [2 \cdot \rho \cdot En(Pa - Pb)]^2$
- $R^2 = \frac{2 \bullet \pi \left(\frac{Dp}{2}\right)^2 [2 \cdot \rho \cdot En(Pa - Pb)]^{1/2} \bullet Ec \bullet Fr}{4\pi I}$
- $R = Dp \frac{[En(Pa - Pb)]^{1/4} \bullet [2\rho^{1/2} Ec \bullet Fr]^{1/2}}{(8 \bullet I)^{1/2}}$

- Dp – Pipe Diameter (m)
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# Surface Energy Balance

**For Insulated Exterior Wall or Roof:**

0= Qsolar gain – Qradiation - Qconvective - Qconductive

Qsolar = I$\alpha$

I ~ Irradiation (Btu/(hr-sf))
$\alpha$ ~ Absorptivity of wall or roof surface (Dimensionless)

**Radiation Loss:**

Qradiation/A = $\varepsilon \bullet \sigma$ x ($Ts^4$ – $Tamb^4$) Btu/(hr-sf))

Where:

$\sigma$ = 1.73 E-9 Btu/(hr-sf- $^{o}R^4$)
$\varepsilon$ = Emissivity (Dimensionless)
A = Area (sf)
Ts = Wall Surface Temperature (ºR)
Tamb = Ambient Temperature (ºR)

# Surface Energy Balance

**Convective Loss:**

$$Q_{convective}/A = h \times (T_s - T_{amb}) \; (\text{Btu/(hr-sf)})$$

Where:

$$h = .99 + 0.21 \times [\text{Wind Velocity (ft/s)}] \; (\text{Btu/(hr-sf-°F)})$$

A= surface area (sf)

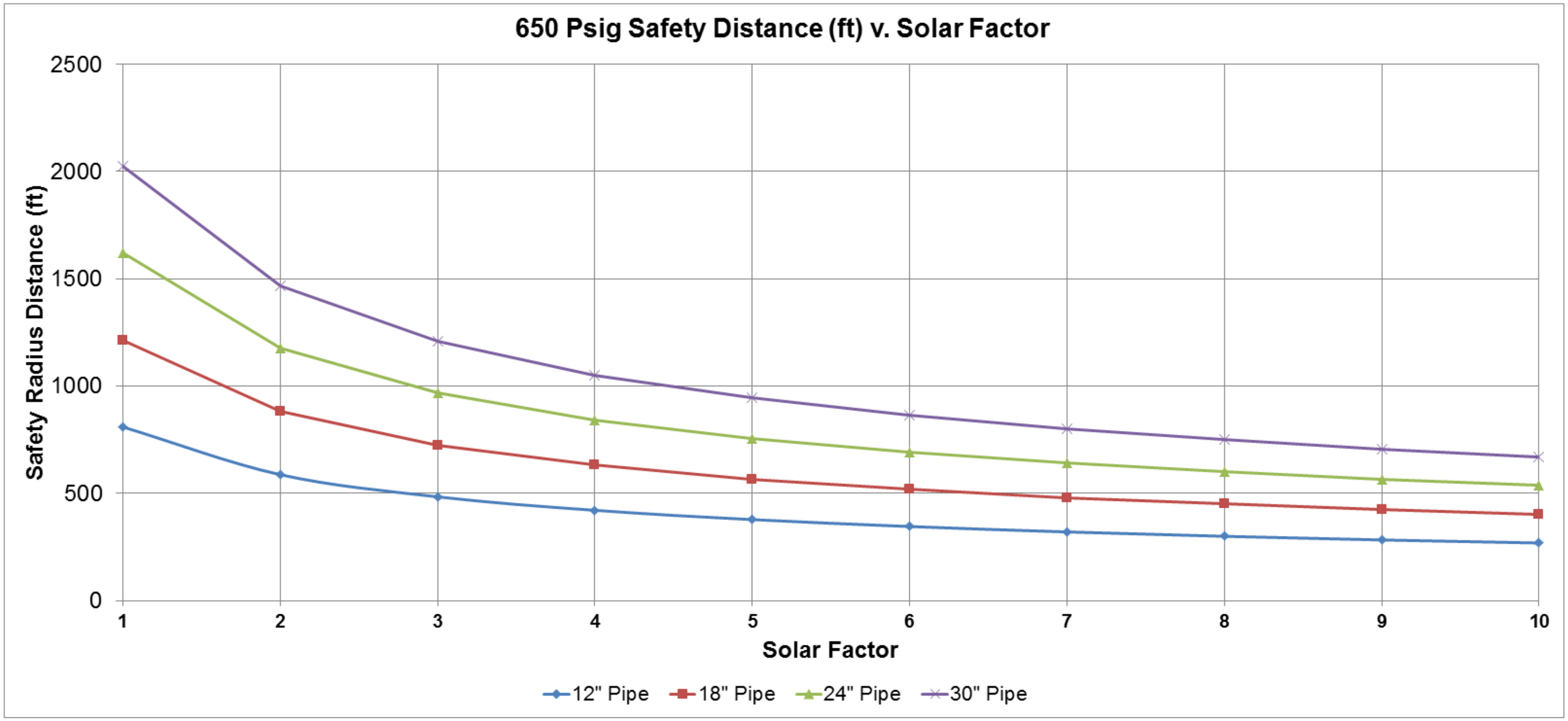
**Conductive Wall Losses**

$$Q_{wall}/A = (T_s - T_{interior})/R_{wall} \; (\text{Btu/(hr-sf)})$$

A= surface area (sf)

$$R_{wall} = \; (\text{hr-sf-°F})/(\text{Btu})$$

| Solar Factor | 1.0 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 |
|---|---|---|---|---|---|---|---|---|---|---|
| Btu/(hr-sf): | 433 | 780 | 1,170 | 1,560 | 1,950 | 2,340 | 2,730 | 3,120 | 3,510 | 3,900 |
| $W/m^2$ | 1,365 | 2,461 | 3,691 | 4,921 | 6,152 | 7,382 | 8,612 | 9,842 | 11,073 | 12,303 |



# Newton's Method (Newton-Raphson)

$\boldsymbol{f}(\mathrm{Ts})_{new} = (\mathbf{T}\mathrm{s})_{Old}$ - $\frac{\boldsymbol{f(Ts)old}}{\boldsymbol{f\prime(Ts)old}}$

$\Delta = \boldsymbol{f}(\mathrm{Ts})_{new}$ - $(\mathbf{T}\mathrm{s})_{Old}$

$\boldsymbol{f(Ts)old}$ = $I\alpha - \varepsilon \bullet \sigma \times (Ts^4 - Tsky^4) - h \times (Ts - Tamb) - (Ts - Tinterior)/Rwall$

$\boldsymbol{F'}(Ts) = -4 \bullet \varepsilon \bullet \sigma \times (Ts)^3 - h - 1/Rwall$

# Rs Distance (ft)

| | | Pressure (psi) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Pressure (psig): | **500** | **600** | **700** | **800** | **900** | **1000** | **1100** | **1200** |
| | | | | | | | | | |
| | Setback Radius: | **(ft)** | **(ft)** | **(ft)** | **(ft)** | **(ft)** | **(ft)** | **(ft)** | **(ft)** |
| Diameter | | | | | | | | | |
| **6** | **"** | 378 | 397 | 412 | 427 | 440 | 452 | 463 | 473 |
| **12** | **"** | 757 | 793 | 825 | 854 | 880 | 903 | 925 | 946 |
| **18** | **"** | 1,135 | 1,190 | 1,237 | 1,280 | 1,319 | 1,355 | 1,388 | 1,419 |
| **24** | **"** | 1,514 | 1,586 | 1,650 | 1,707 | 1,759 | 1,807 | 1,851 | 1,892 |
| **30** | **"** | 1,892 | 1,983 | 2,062 | 2,134 | 2,199 | 2,258 | 2,314 | 2,365 |
| **36** | **"** | 2,270 | 2,379 | 2,475 | 2,561 | 2,639 | 2,710 | 2,776 | 2,838 |
| **38.4** | **"** | 2,422 | 2,538 | 2,640 | 2,731 | 2,814 | 2,891 | 2,961 | 3,027 |
| | | | | | | | | | |
| **42** | **"** | 2,649 | 2,776 | 2,887 | 2,987 | 3,078 | 3,162 | 3,239 | 3,311 |

# Rs/2 Distance (ft)

| | Pressure (psig): | 500 | 600 | 700 | 800 | 900 | 1000 | 1100 | 1200 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | Setback Radius: | (ft) | (ft) | (ft) | (ft) | (ft) | (ft) | (ft) | (ft) |
| Diameter | | | | | | | | | |
| 6 | " | 189 | 198 | 206 | 213 | 220 | 226 | 231 | 237 |
| 12 | " | 378 | 397 | 412 | 427 | 440 | 452 | 463 | 473 |
| 18 | " | 568 | 595 | 619 | 640 | 660 | 678 | 694 | 710 |
| 24 | " | 757 | 793 | 825 | 854 | 880 | 903 | 925 | 946 |
| 30 | " | 946 | 991 | 1,031 | 1,067 | 1,099 | 1,129 | 1,157 | 1,183 |
| 36 | " | 1,135 | 1,190 | 1,237 | 1,280 | 1,319 | 1,355 | 1,388 | 1,419 |
| 38.4 | " | 1,211 | 1,269 | 1,320 | 1,366 | 1,407 | 1,445 | 1,481 | 1,514 |
| | | | | | | | | | |
| 42 | " | 1,324 | 1,388 | 1,444 | 1,494 | 1,539 | 1,581 | 1,620 | 1,656 |

# Rs Distance (ft)

| | | Pressure (psi) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Pressure (psig): | **500** | **600** | **700** | **800** | **900** | **1000** | **1100** | **1200** |
| | | | | | | | | | |
| | Setback Radius: | **(ft)** | **(ft)** | **(ft)** | **(ft)** | **(ft)** | **(ft)** | **(ft)** | **(ft)** |
| Diameter | | | | | | | | | |
| **6** | **"** | 378 | 397 | 412 | 427 | 440 | 452 | 463 | 473 |
| **12** | **"** | 757 | 793 | 825 | 854 | 880 | 903 | 925 | 946 |
| **18** | **"** | 1,135 | 1,190 | 1,237 | 1,280 | 1,319 | 1,355 | 1,388 | 1,419 |
| **24** | **"** | 1,514 | 1,586 | 1,650 | 1,707 | 1,759 | 1,807 | 1,851 | 1,892 |
| **30** | **"** | 1,892 | 1,983 | 2,062 | 2,134 | 2,199 | 2,258 | 2,314 | 2,365 |
| **36** | **"** | 2,270 | 2,379 | 2,475 | 2,561 | 2,639 | 2,710 | 2,776 | 2,838 |
| **38.4** | **"** | 2,422 | 2,538 | 2,640 | 2,731 | 2,814 | 2,891 | 2,961 | 3,027 |
| | | | | | | | | | |
| **42** | **"** | 2,649 | 2,776 | 2,887 | 2,987 | 3,078 | 3,162 | 3,239 | 3,311 |

# (2/3)•Rs/2 Distance (ft)

| | (2/3)Rs/2 Distance (feet) for Pipe Diameter and Pipeline Pressure (Natural Gas) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | Pressure (psig): | **500** | **600** | **700** | **800** | **900** | **1000** | **1100** | **1200** |
| | | | | | | | | | |
| | Setback Radius: | **(ft)** | **(ft)** | **(ft)** | **(ft)** | **(ft)** | **(ft)** | **(ft)** | **(ft)** |
| Diameter | | | | | | | | | |
| 6 | " | 126 | 132 | 137 | 142 | 147 | 151 | 154 | 158 |
| 12 | " | 252 | 264 | 275 | 285 | 293 | 301 | 308 | 315 |
| 18 | " | 378 | 397 | 412 | 427 | 440 | 452 | 463 | 473 |
| 24 | " | 505 | 529 | 550 | 569 | 586 | 602 | 617 | 631 |
| 30 | " | 631 | 661 | 687 | 711 | 733 | 753 | 771 | 788 |
| 36 | " | 757 | 793 | 825 | 854 | 880 | 903 | 925 | 946 |
| 38.4 | " | 807 | 846 | 880 | 910 | 938 | 964 | 987 | 1009 |
| | | | | | | | | | |
| 42 | " | 883 | 925 | 962 | 996 | 1026 | 1054 | 1080 | 1104 |