INTRODUCTION TO GAS QUALITY

Western Gas Measurement Short Course

SoCalGas™

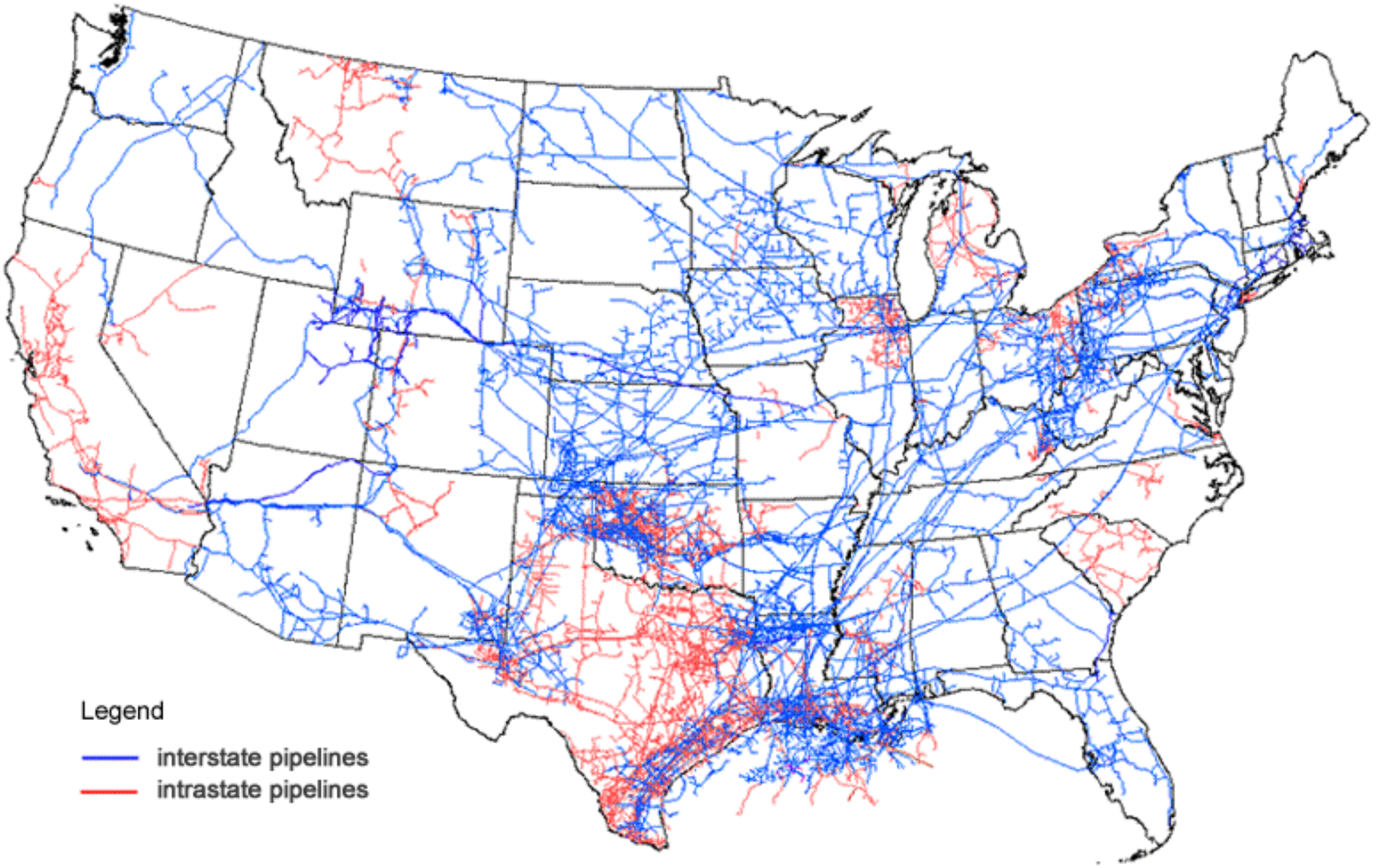
Overview

- Natural Gas and Gas Quality
- Gas Quality Specifications
- Gas Quality Monitors

What is Natural Gas

- Combustible gas
- Found in
  - Underground rock formation
  - Associated gas
  - Biogas
  - Imported LNG
  - Manufactured

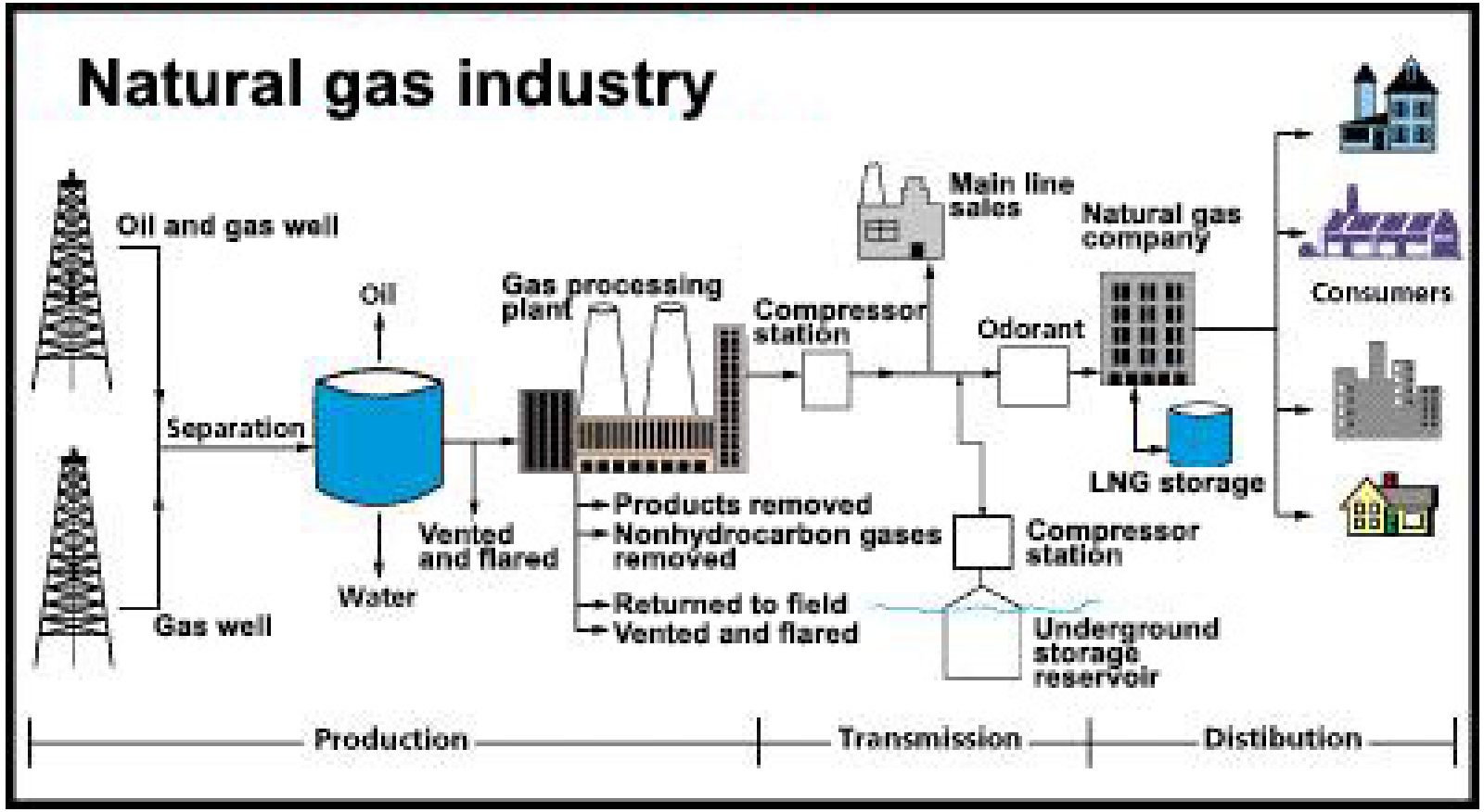
Map of U.S. interstate and intrastate natural gas pipelines



Source: U.S. Energy Information Administration, *About U.S. Natural Gas Pipelines*

Compounds and parameters that impact Gas Life Cycle

» (production, processing and delivery)



Natural Gas Composition

Component Name	Mole Percent
C6+ 57/28/14	0.0136
PROPANE	0.2953
i-BUTANE	0.0360
n-BUTANE	0.0485
NEOPENTANE	0.0000
i-PENTANE	0.0129
n-PENTANE	0.0098
NITROGEN	0.6417
METHANE	95.2589
CARBON DIOXIDE	1.2927
ETHANE	2.3905
TOTALS	100.0000

Example

Corrosive Compounds

- Carbon Dioxide
- Oxygen
- Hydrogen Sulfide
- Water

Corrosive Compounds

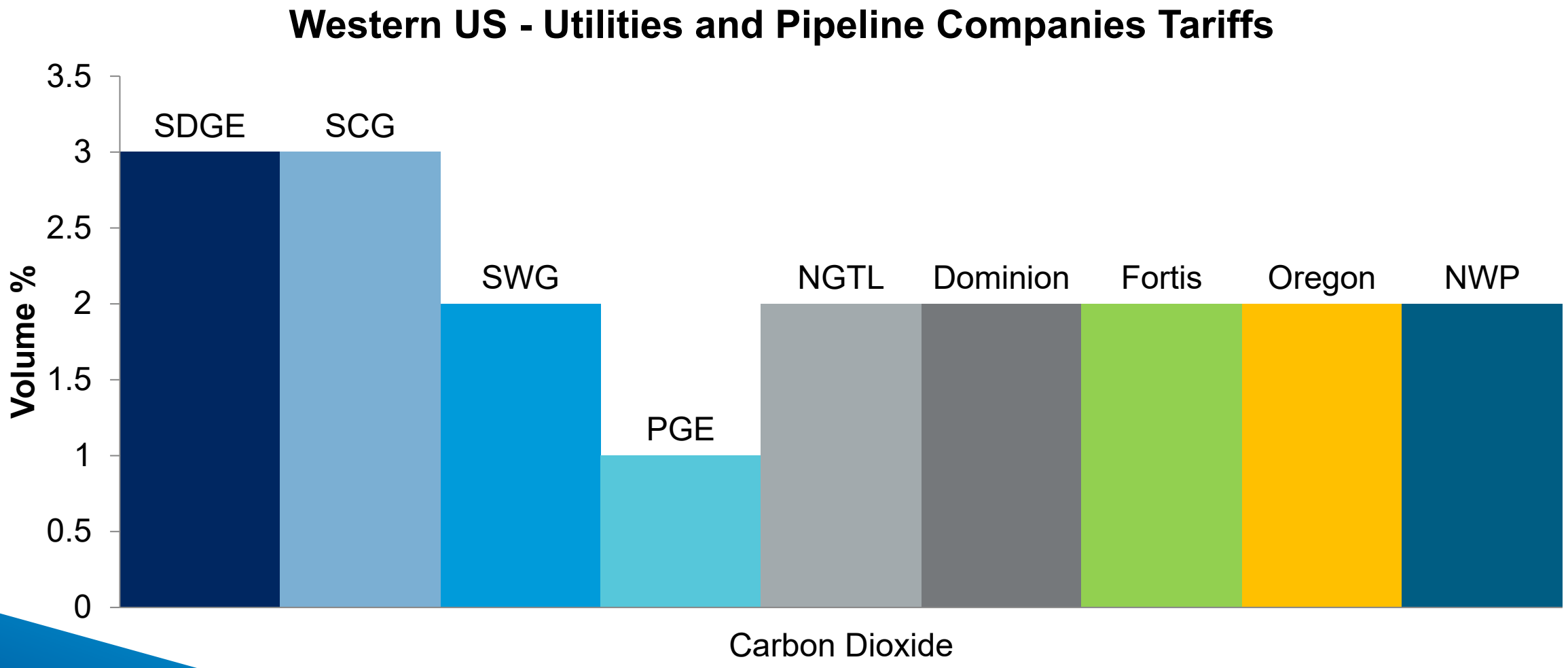
- Carbon Dioxide
  - CO2 dissolved in water forms carbonic acid, will corrode pipelines

$$H_2O_{liq} + CO_2 \rightarrow H_2CO_3$$

$$H_2CO_3 + Fe \rightarrow FeCO_3 + H_2$$

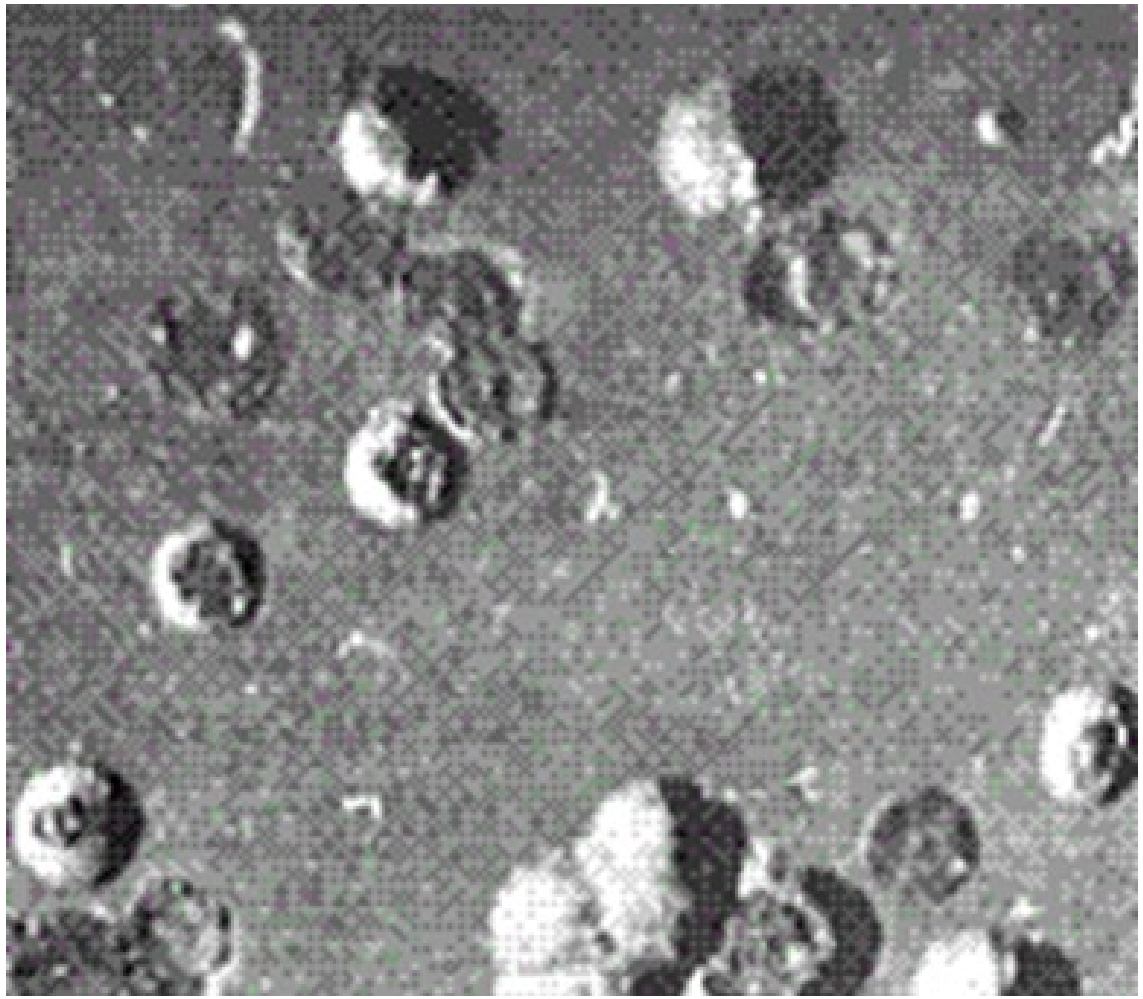
$$3FeCO_3 + \tfrac{1}{2}O_2 \rightarrow Fe_3O_4 + 3CO_2$$

Gas Quality Specifications – Carbon Dioxide

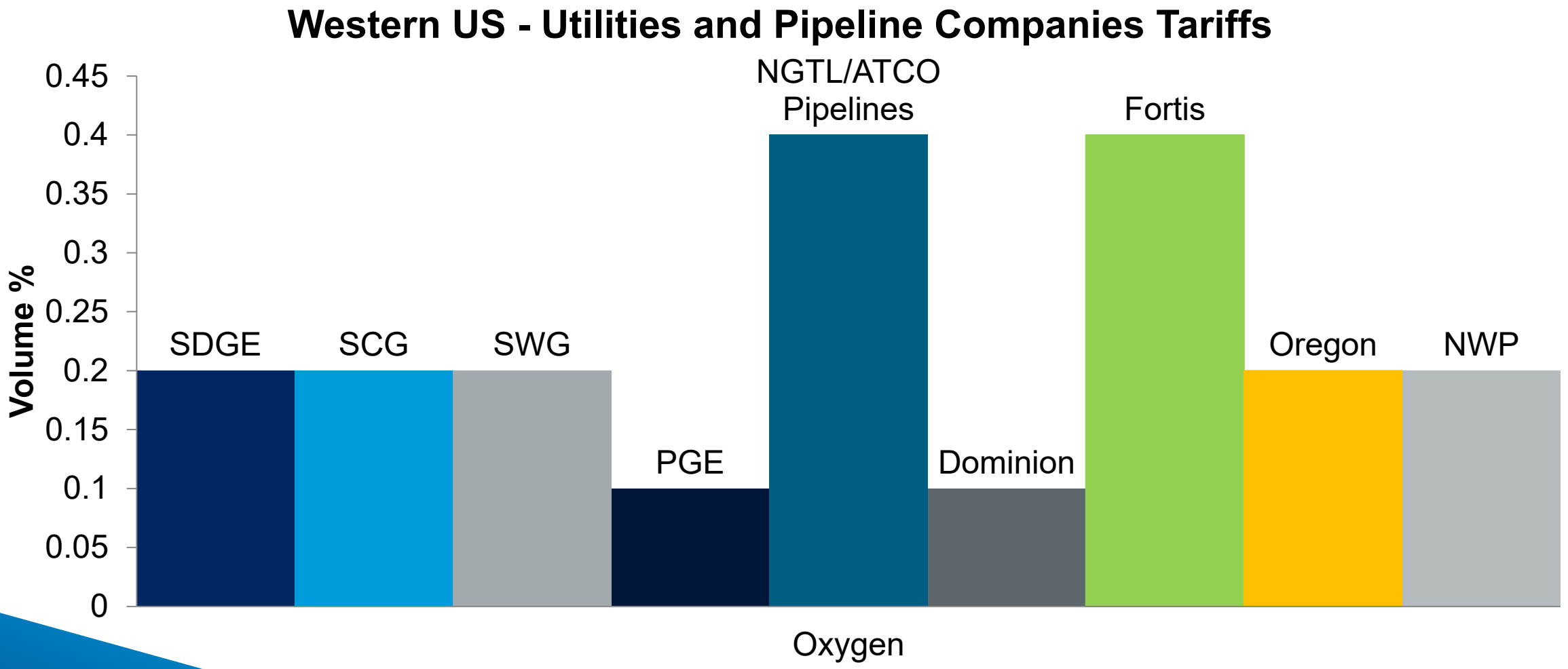


Corrosive Compounds

- Oxygen
  - O_2 can increase pitting corrosion rates 10X
  - O_2 in the presence of CO_2 or H_2S drastically increases their corrosivity
  - Direct oxidation of pipeline forms iron oxides

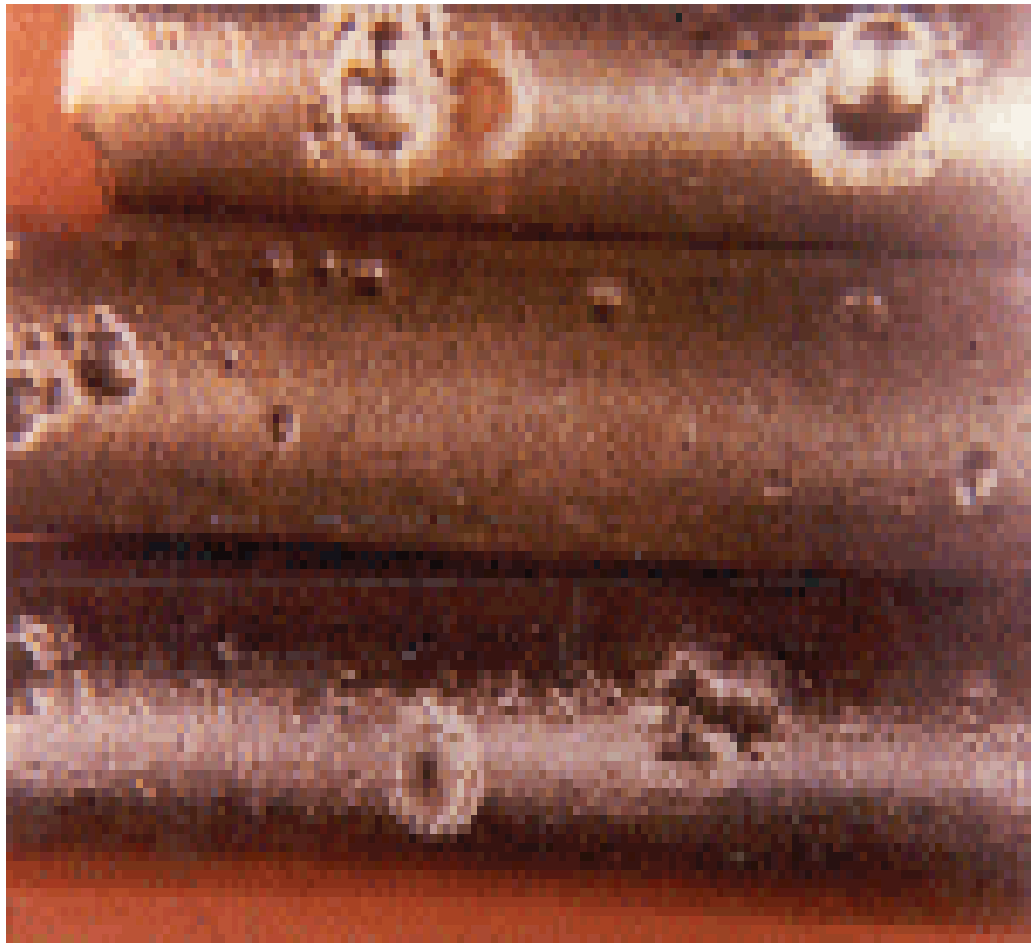


Gas Quality Specifications - Oxygen

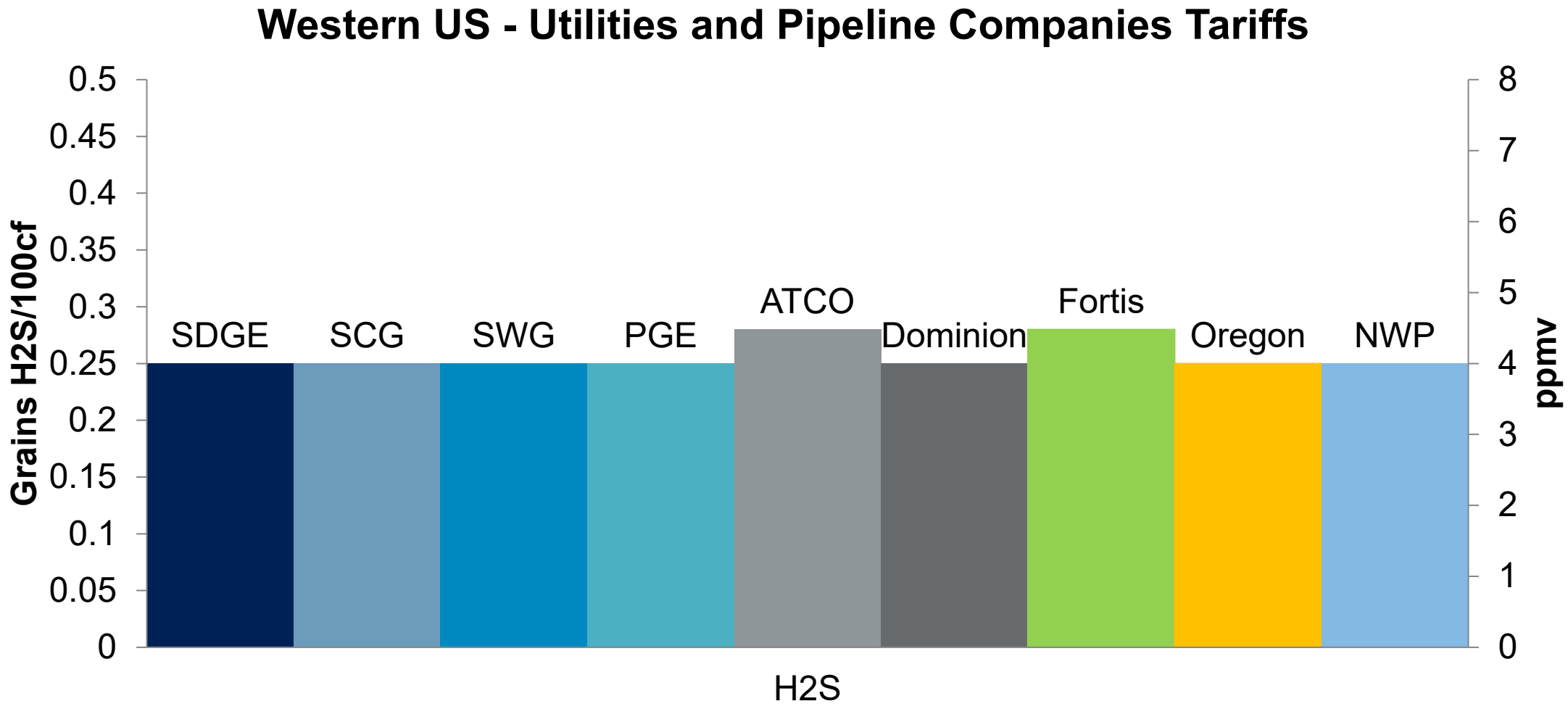


Corrosive Compounds and Safety

- Hydrogen Sulfide
  - $H_2S + H_2O$ dissolves to form a weak acid which can then dissolve iron creating iron sulfide.
  - SOx emissions
  - Health and safety issues

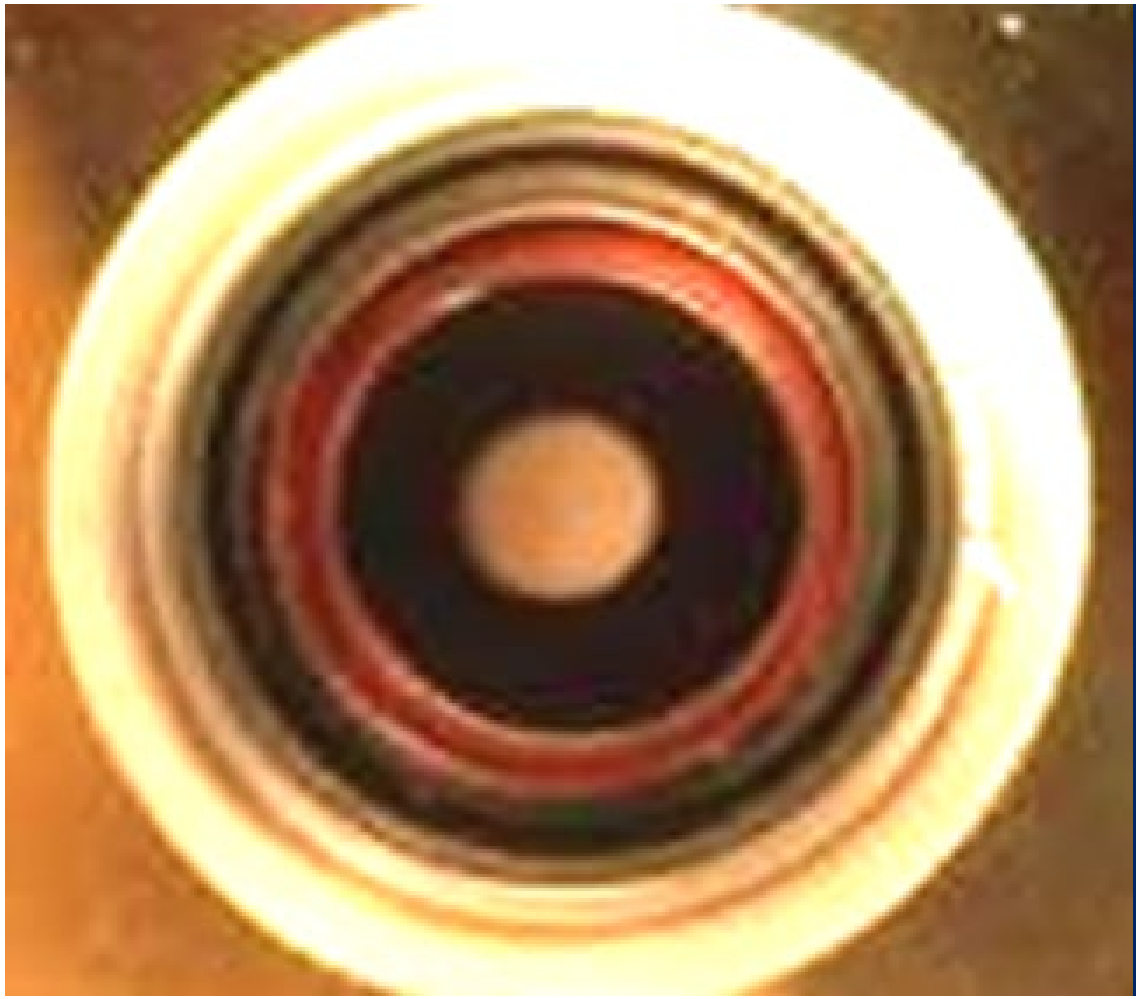


Gas Quality Specifications – Hydrogen Sulfide



Liquids

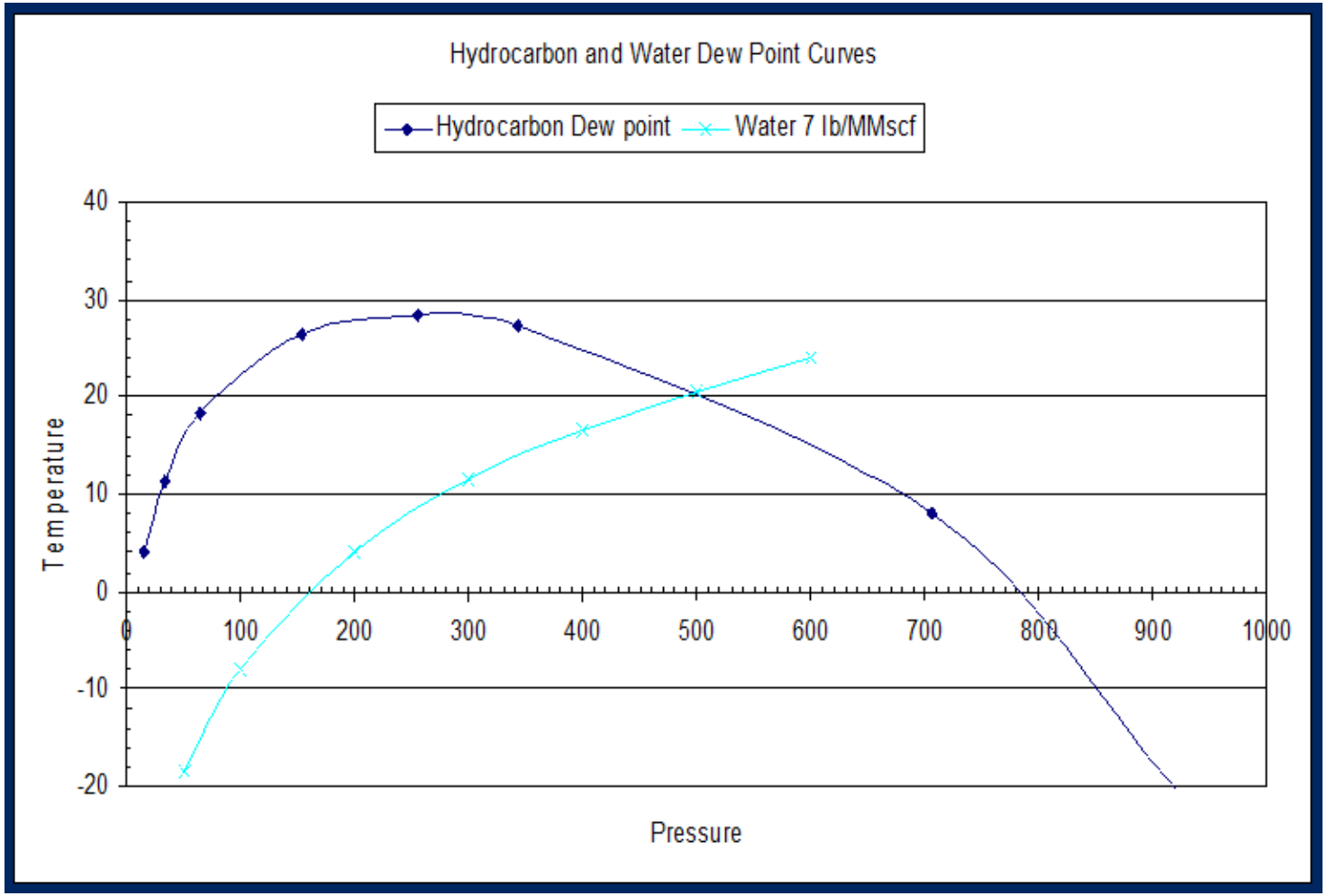
- Liquid water
  - Corrosion in wet environment
  - MIC occurs in water
- Hydrocarbon liquids
  - Hydrocarbon Dew points
- Condensation
- Accumulation in low spots



Dewpoint

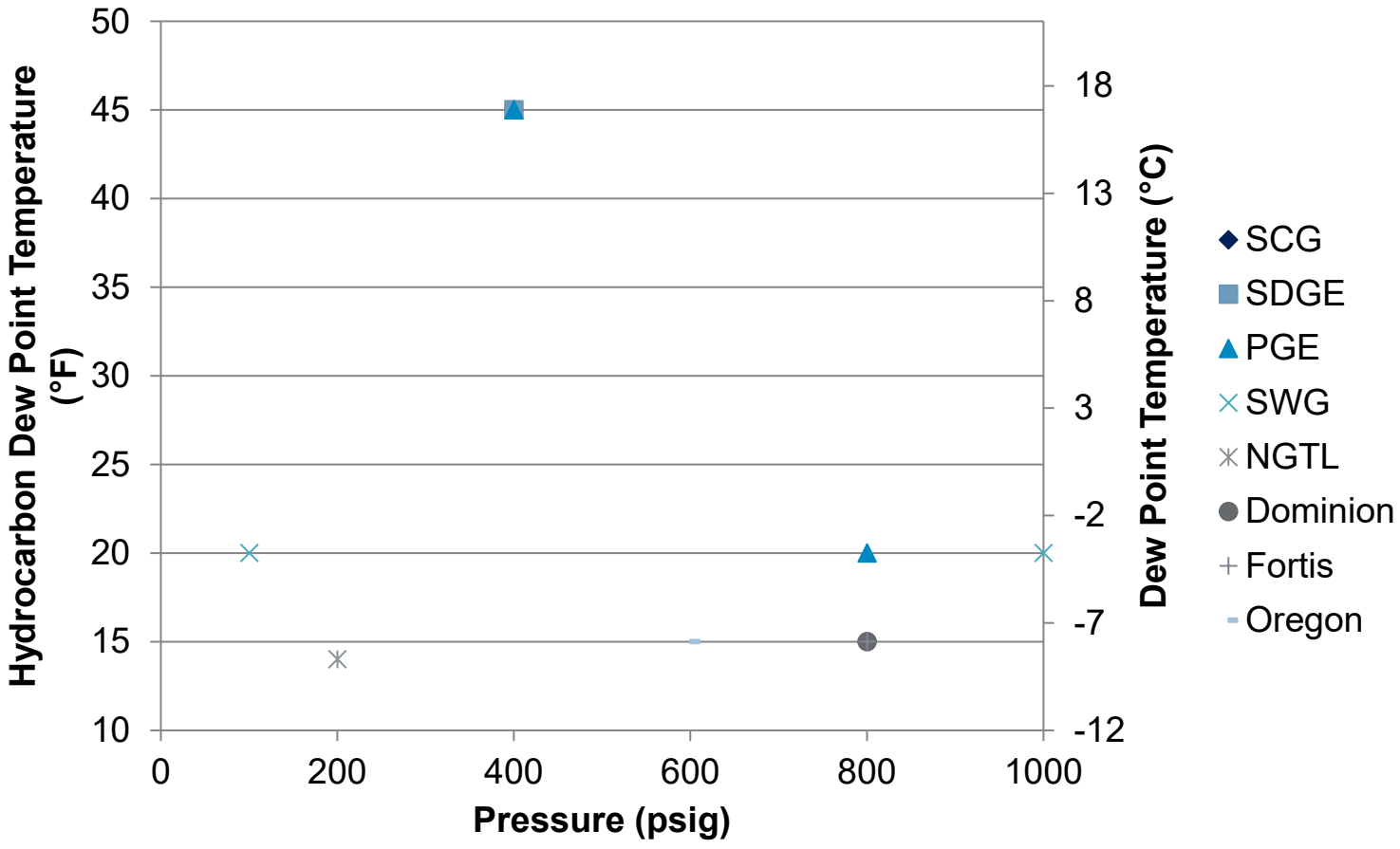
» When gas temperature falls below the dewpoint; it begins to “rain” in the pipeline.

Dew point curves

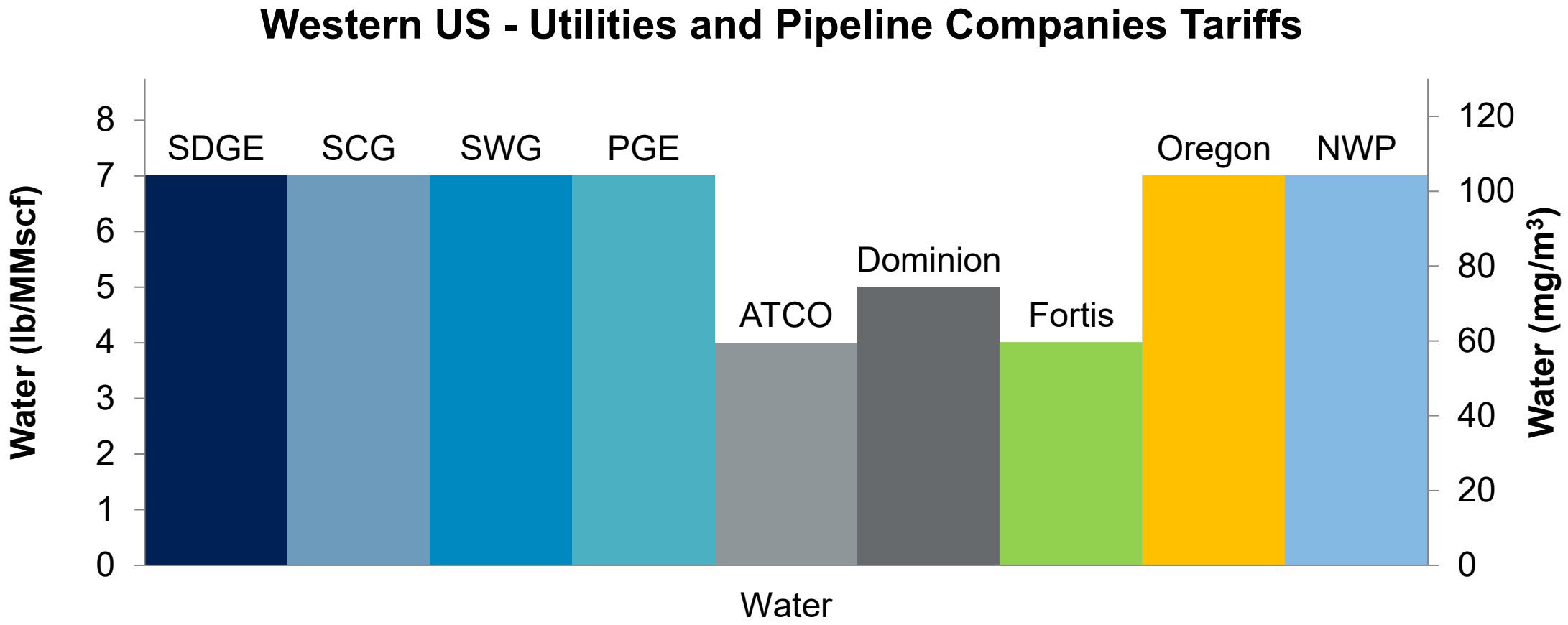


Gas Quality Specifications – Dew point

» **Western US- Utilities and Pipeline Companies Tariffs**

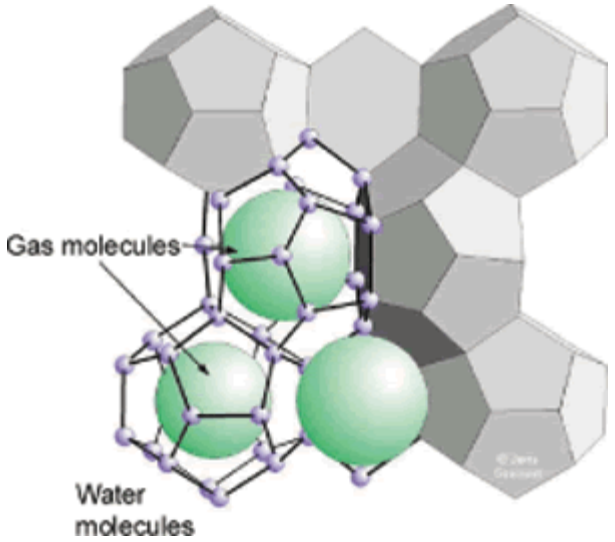


Gas Quality Specifications – Water dew point

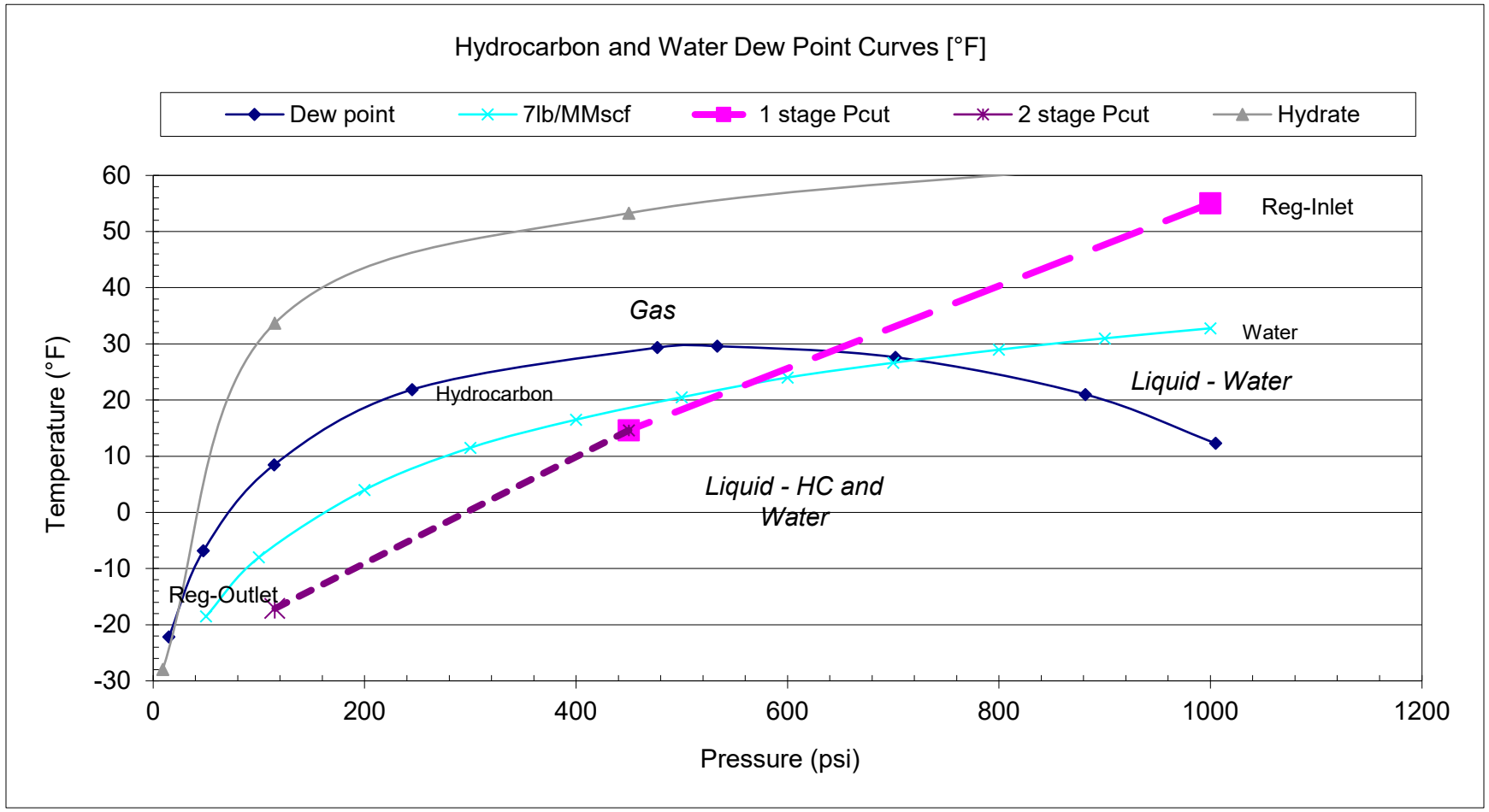


Hydrates, Ice & Water

- Water vapor dew point
- Water vapor content
- Hydrate formation



Dew Point Curves

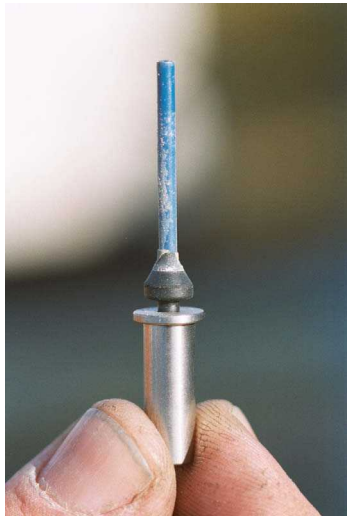


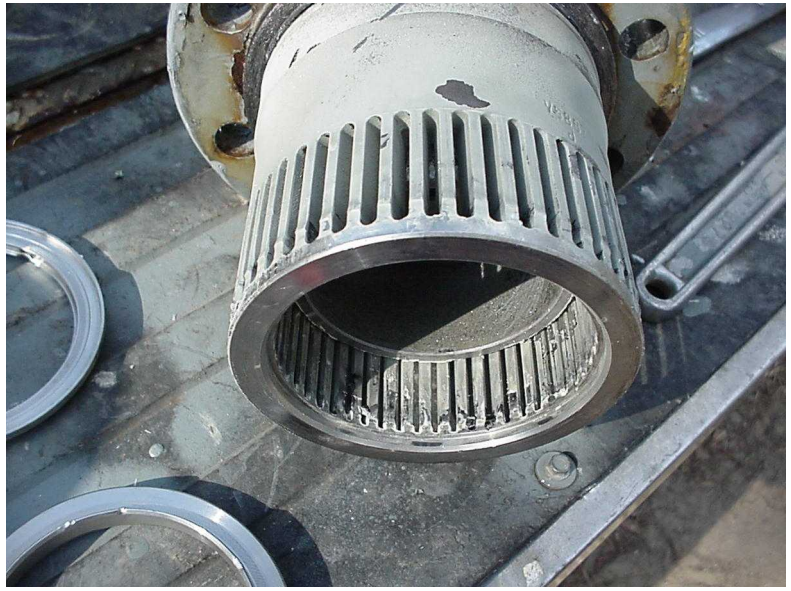
Sulfur

- Hydrogen Sulfide
- Mercaptans
- Odorant
- Total Sulfur
- Emissions

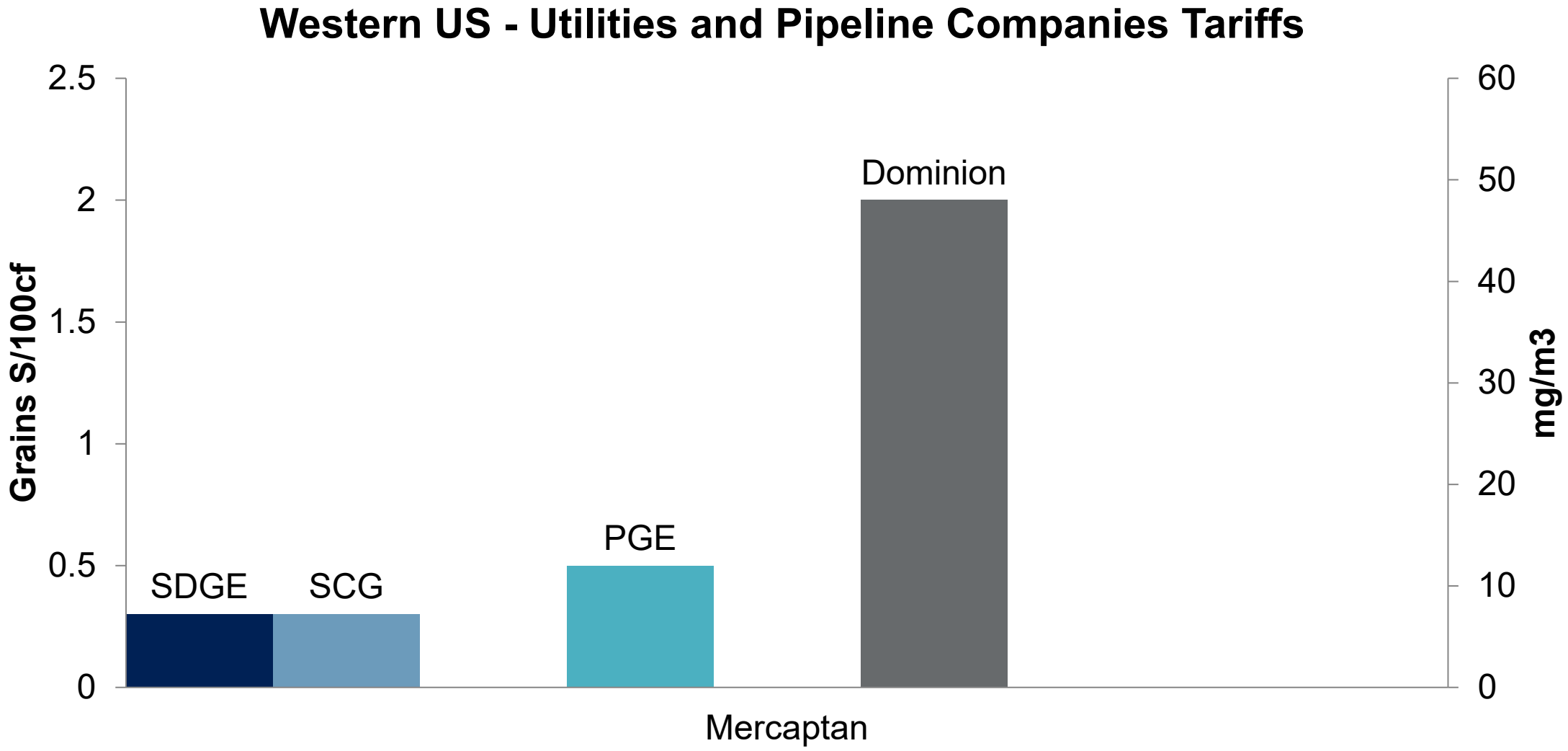
Other considerations

- Elemental Sulfur
- Dithiazine

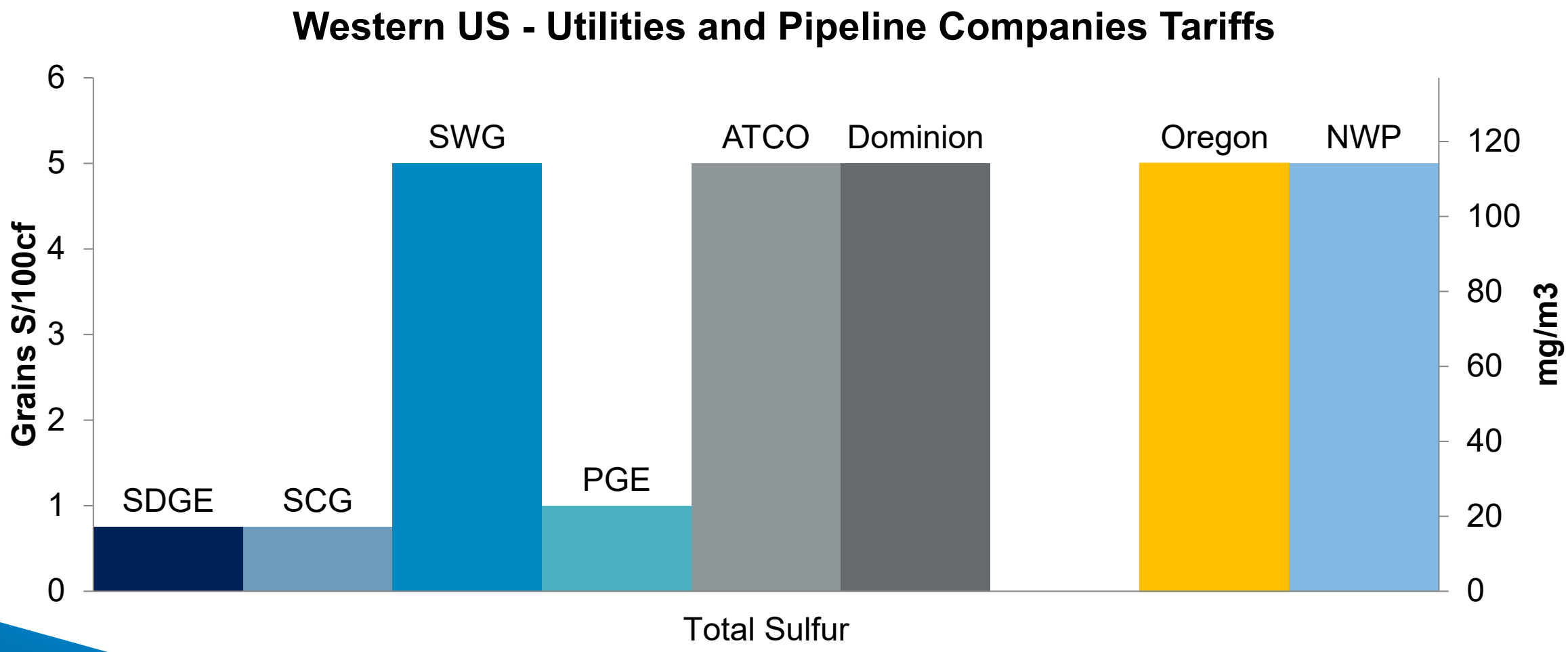




Gas Quality Specifications - Mercaptans



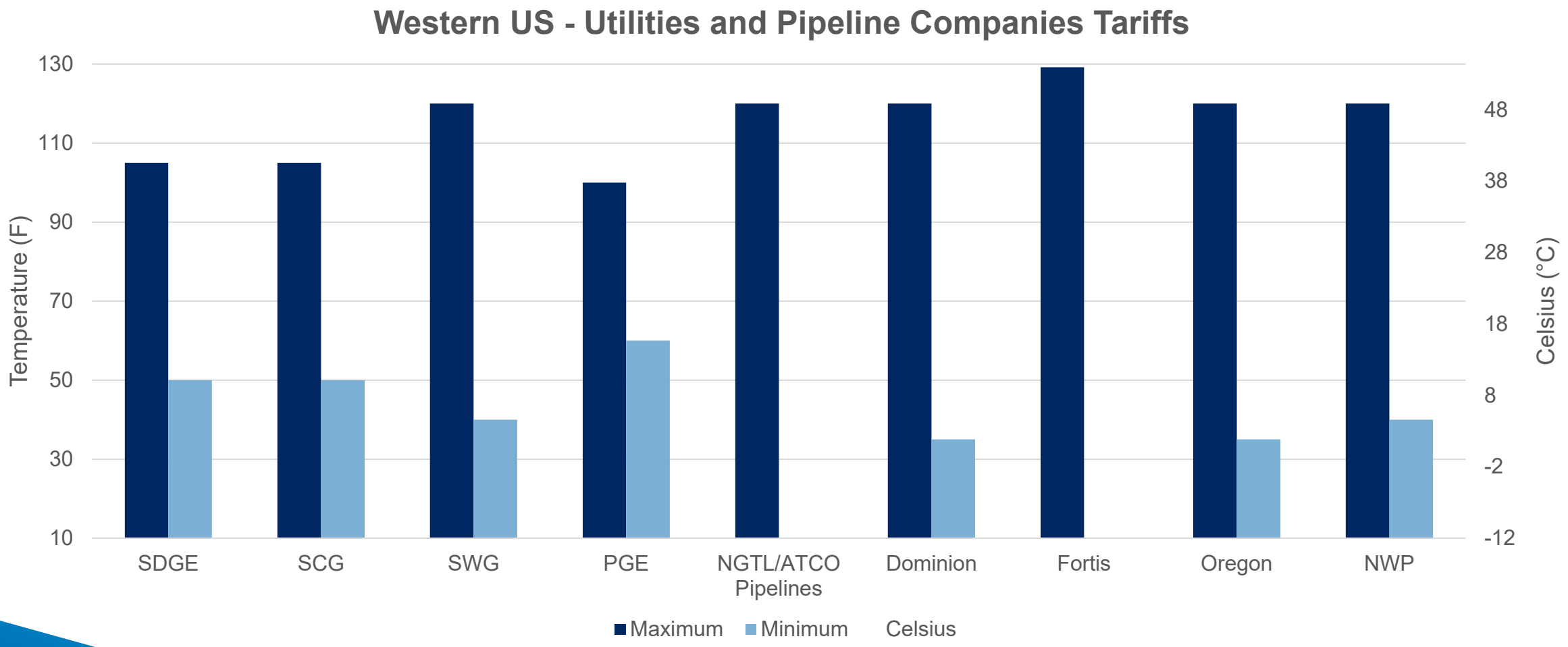
Gas Quality Specifications - Sulfur



Temperature

- Gas temperatures affect materials, equipment and fittings
  - There are standard temperature limits in conjunction with pipeline materials' design pressure ratings
  - Coatings and soft materials have design temperature restrictions

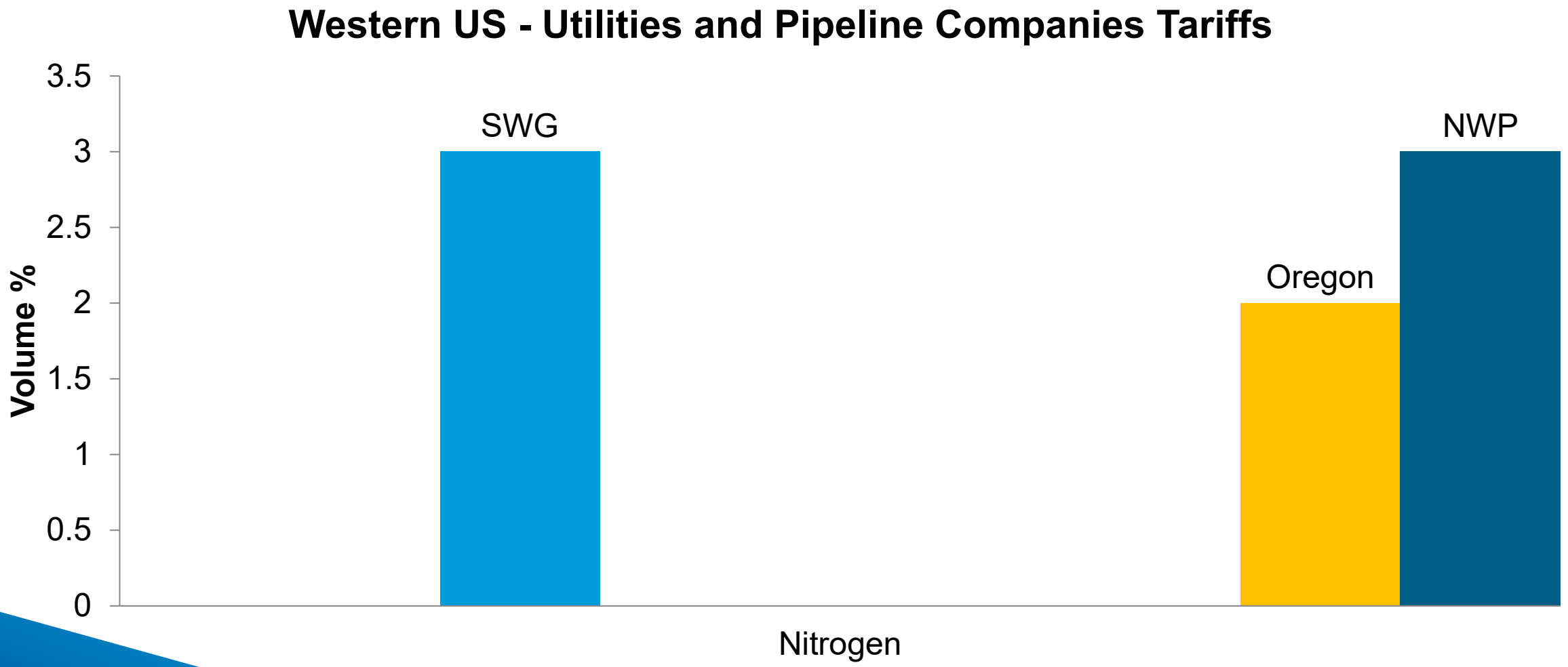
Gas Quality Specification - Temperature



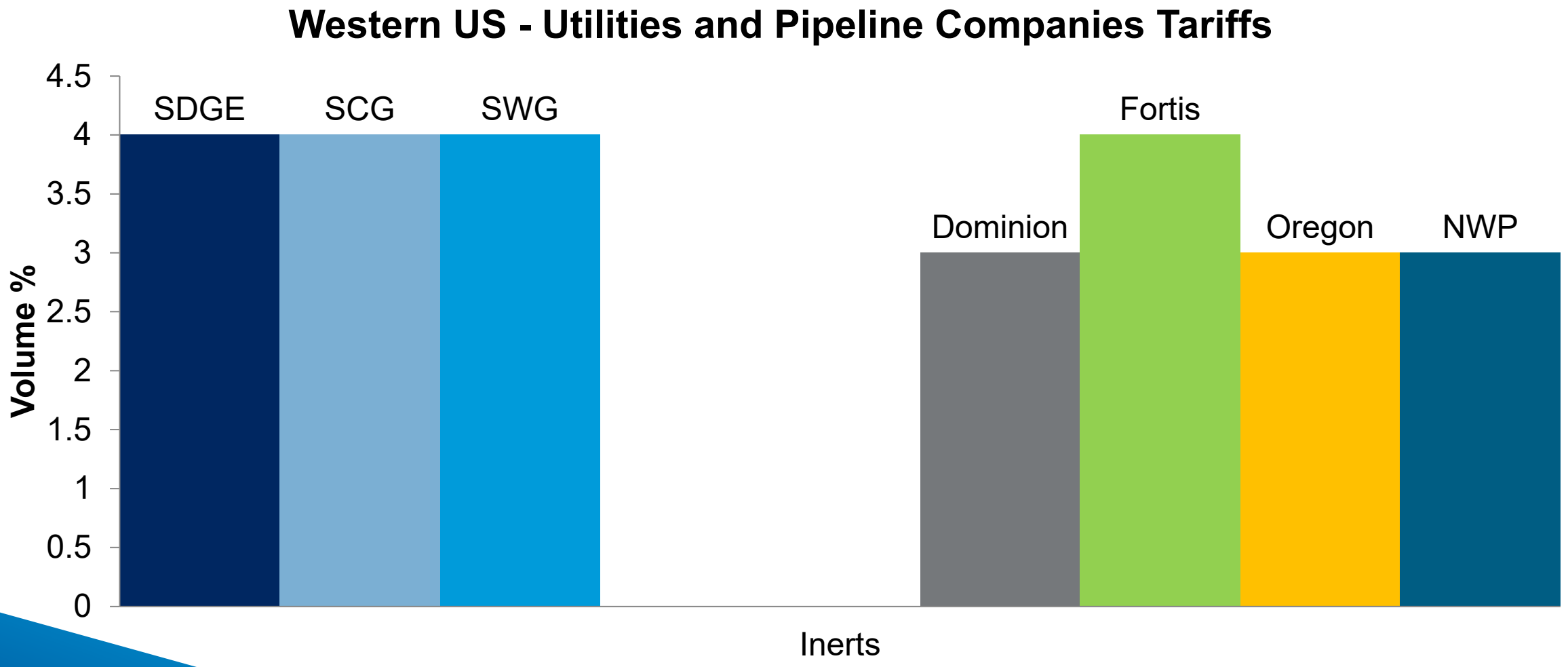
Gas Quality Parameters for Measurement

- Inerts (nitrogen, carbon dioxide)
  - Lowers the heating value
  - Lowers the wobbe number
- Heating value (HHV, BTU)
  - Consistent HHV
  - Billing or BTU districts
- Uniform gas composition

Gas Quality Specifications - Nitrogen



Gas Quality Specifications - Inerts



Natural Gas Composition

Component Name	Mole Percent	BTU Gross	BTU Net	Relative Density
C6+ 57/28/14	0.0136	0.71	0.66	0.0004
PROPANE	0.2953	7.45	6.85	0.0045
i-BUTANE	0.0360	1.17	1.08	0.0007
n-BUTANE	0.0485	1.59	1.46	0.0010
NEOPENTANE	0.0000	0.00	0.00	0.0000
i-PENTANE	0.0129	0.52	0.48	0.0003
n-PENTANE	0.0098	0.39	0.36	0.0002
NITROGEN	0.6417	0.00	0.00	0.0062
METHANE	95.2589	964.34	868.29	0.5276
CARBON DIOXIDE	1.2927	0.00	0.00	0.0196
ETHANE	2.3905	42.40	38.79	0.0248
TOTALS	100.0000	1018.57	917.97	0.5855

'*' indicates user-defined components

Compressibility Factor (1/Z) @ 14.73000 PSIA & 60.0 DEG.F= 1.00213

Base Pressures 14.73000

Gross Dry BTU	=	1020.74	Corrected/Z
Net Dry BTU	=	919.93	Corrected/Z
Real Relative Density Gas	=	0.5865	
Unnormalized Mole Percent	=	99.367	
WOBBE	=	1332.84	

User Defined Calculations

Label	Value
Total inerts	1.93

High Heating Value
(Gross Dry BTU)
Btu/cf

Gas Quality Parameters for End Use

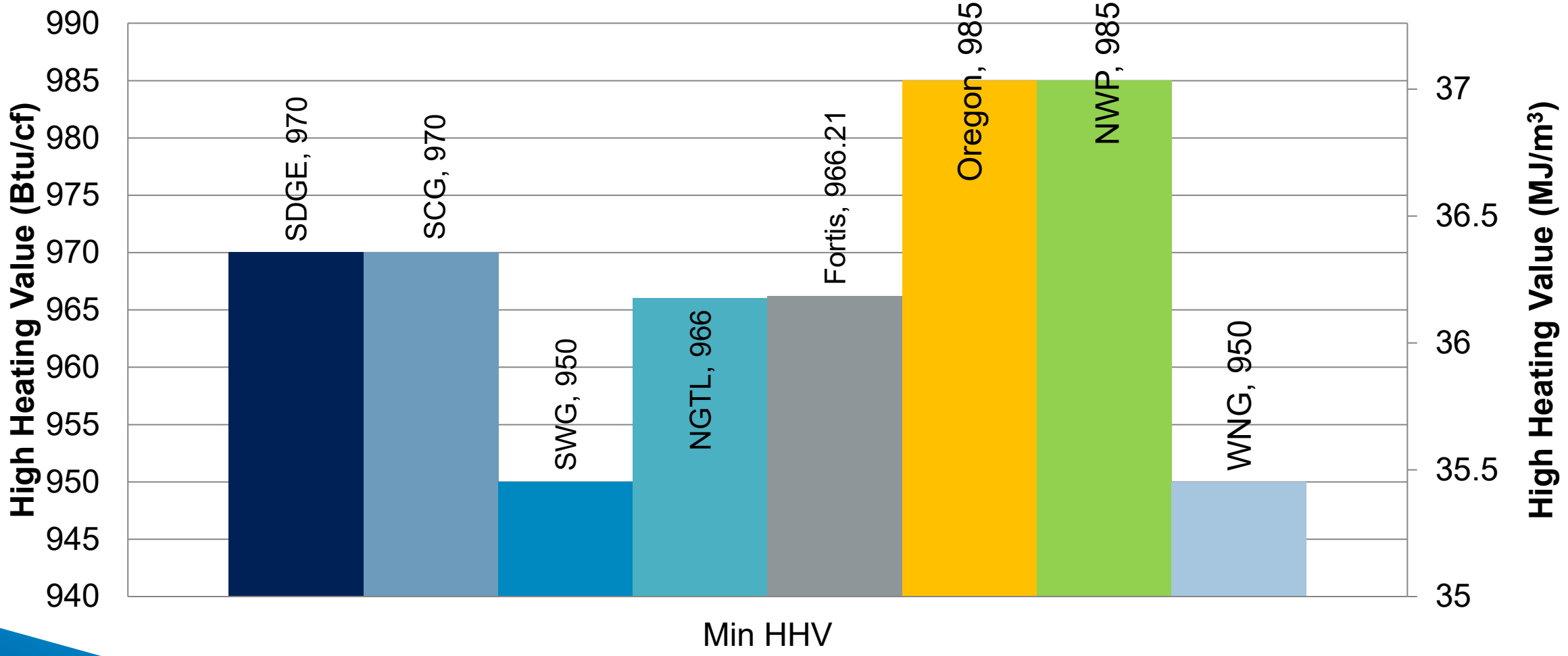
Heating Value

Wobbe Index

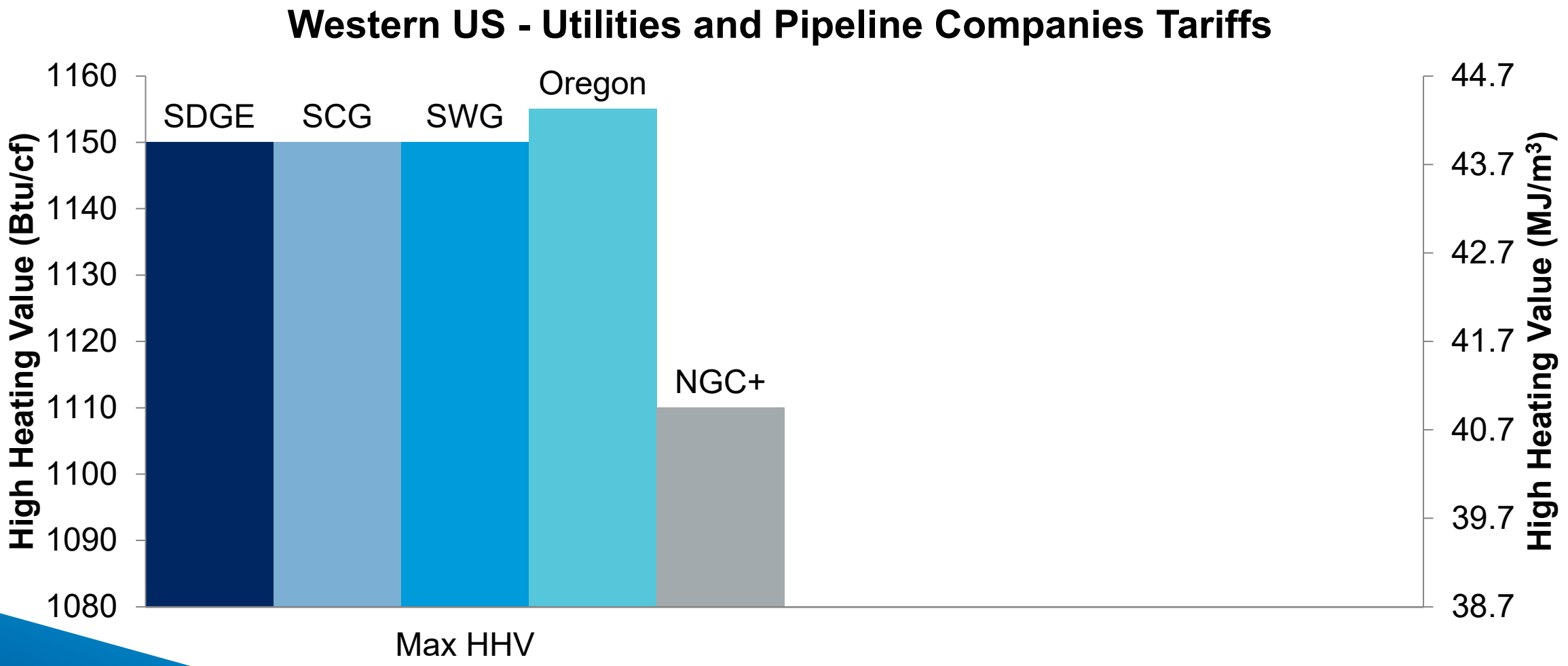
Interchangeability Indices

- AGA 36
- NYSEARCH Range

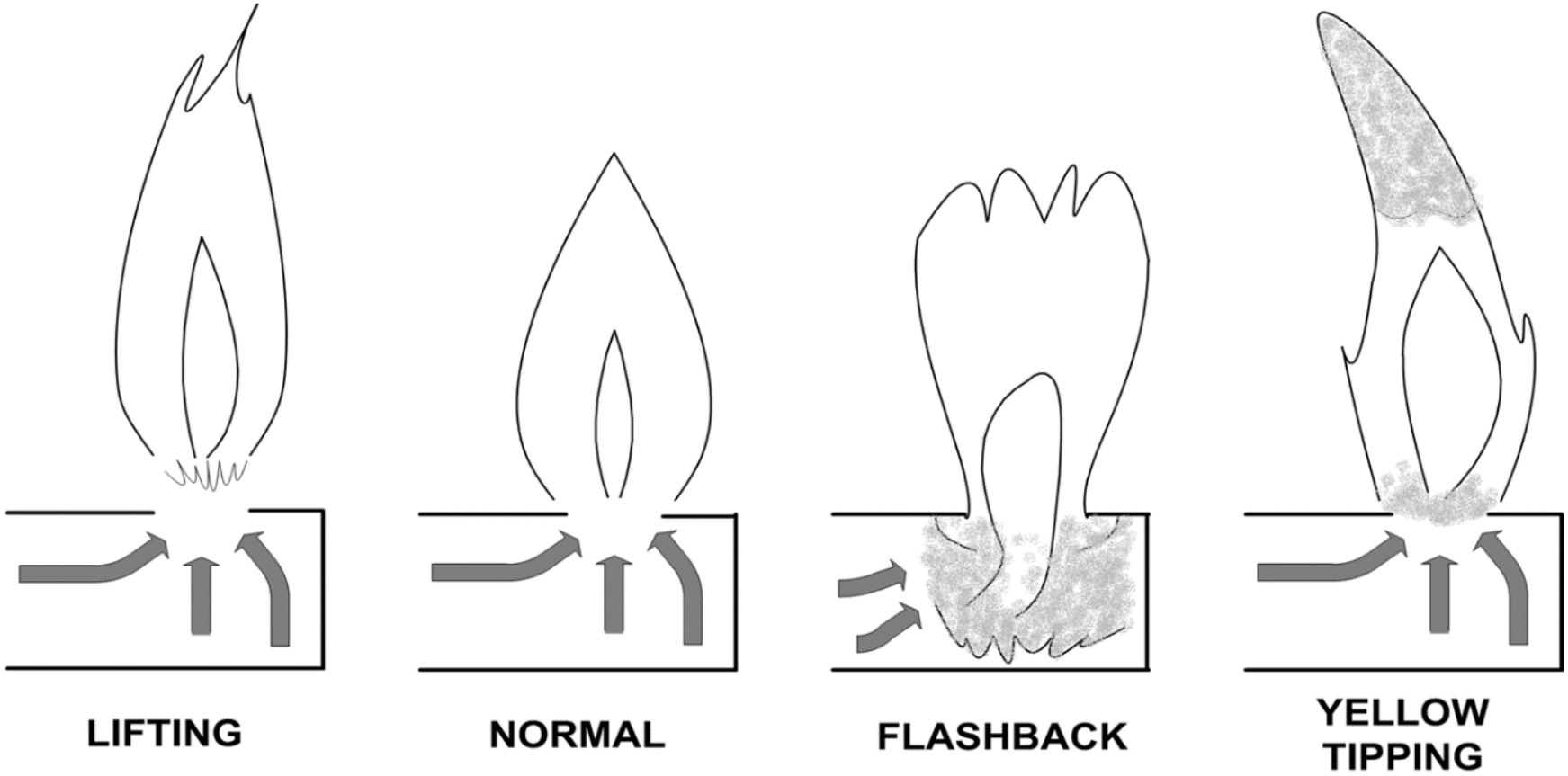
Gas Quality Specifications – Minimum Heating Value



Gas Quality Specifications – Max Heating Value



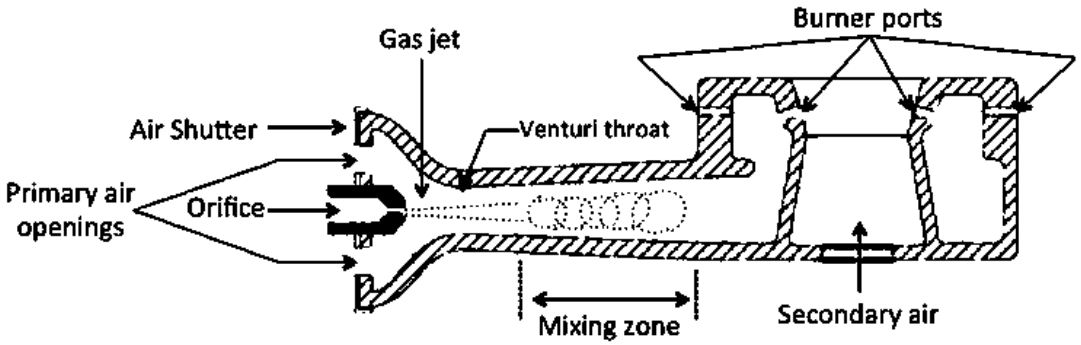
Interchangeability



Interchangeability - Lifting

Interchangeability -Yellow tipping

Wobbe Number



- Wobbe number is the firing rate or heat release rate, which is stated as heat released (Btu) per flow of gas (scf).

$$W = HHV * Q$$

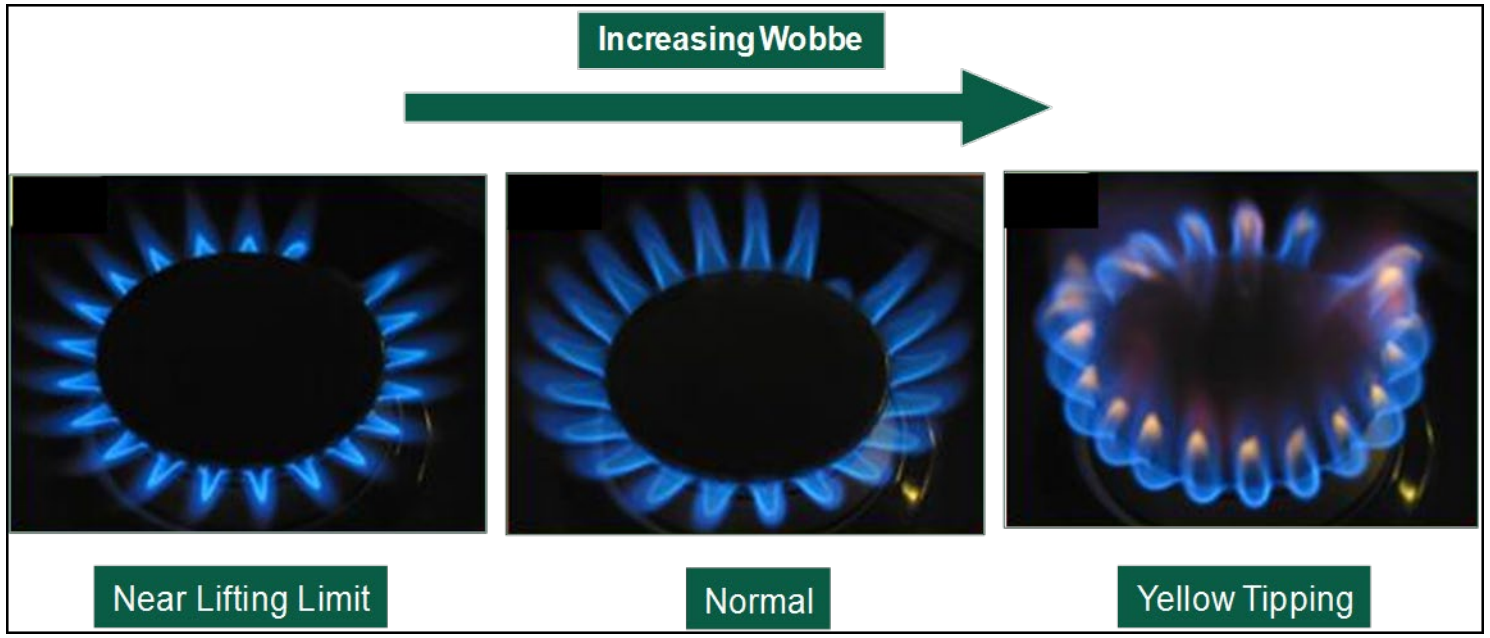
- Since we obtained the following in the previous slide: $Q \propto {}^{1}/_{\sqrt{\rho}}$

- The Wobbe Number equation is:

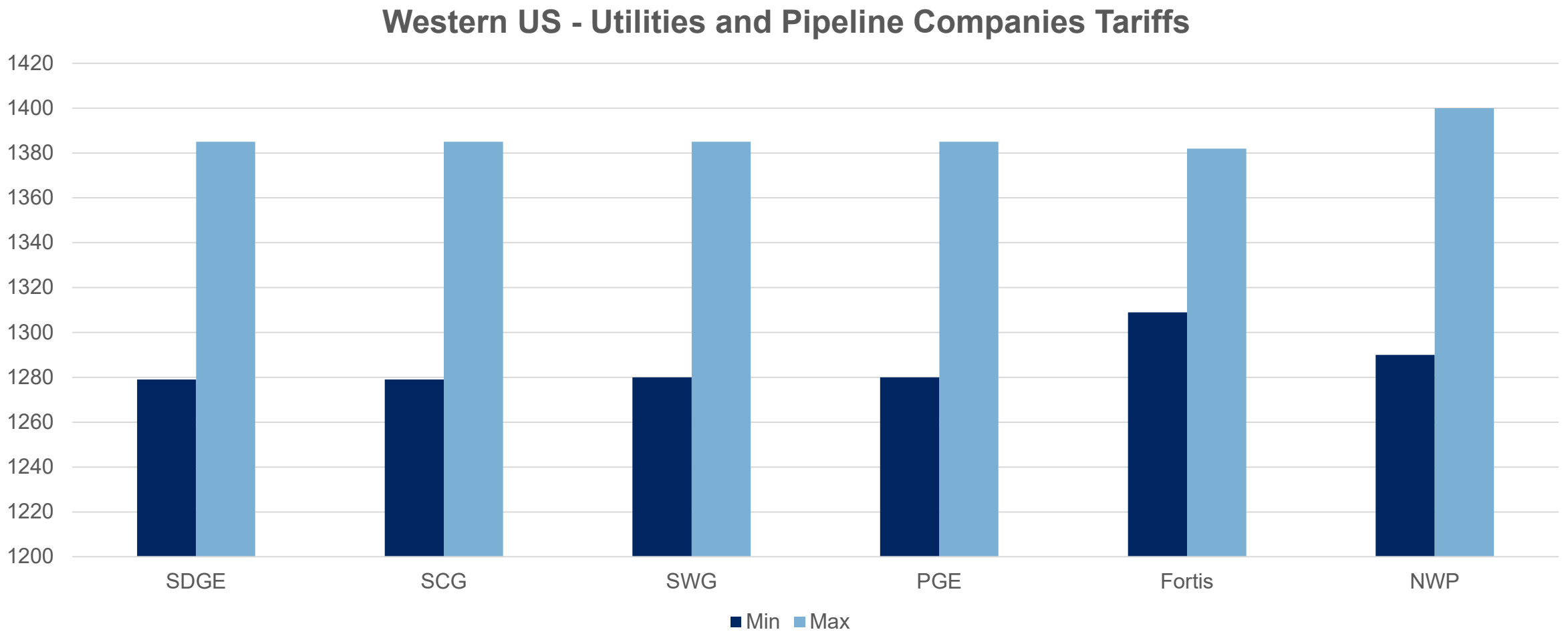
$$\boldsymbol{W \propto HHV/\sqrt{sg}}$$

Wobbe Number Range

$$Wobbe = {}^{HHV}/_{\sqrt{RD}}$$



Gas Quality Specification – Wobbe Index



Interchangeability Calculations

Limits of interchangeability for various indices

In the green shaded cells, enter your limits for the various interchangeability indices

Defaults are taken from the GRI Research Report

Recommend accepting the defaults unless experimental data is available supporting different limits

Heat Rate Indices	Selected	Default
Wobbe Index	5.0%	+or- 5.0%
Knoy Factor	5.0%	+or- 5.0%

AGA Bulletin #36 Interchangeability Limits	Selected	Default
Lifting, IL	1.06	<=1.10
Flashback, IF	1.2	<=1.20
Yellowtipping, IY	0.8	>=0.86

Weaver Limits	Selected	Default
Flashback, JF	0.26	<=0.26
Yellowtipping, JY	0.3	<=0.30
Incomplete Combustion, JI	0.05	<=0.05
Lifting, JL	0.64	>=0.64

Weaver Limits	Selected		Default
	Lower	Upper	Range
Heat Rate, JH	0.95	1.05	0.95 to 1.05
Air Requirement, JA	0.8	1.2	0.80 to 1.20

Merchantability

- Excerpt from KRGT:
  - will be merchantable Natural Gas commercially free from objectionable odors, solid matter, dust, gums, and gum forming constituents, or any other substance which interferes with its intended purpose, or causes interference with the proper and safe operation of the lines, meters, regulators, or other appliances through which it may flow
  - will not contain any toxic or hazardous substance, in concentrations which, in the normal use of the Gas, results in an unacceptable risk to health, is injurious to pipeline facilities, is a limit to merchantability or contrary to applicable governmental standards;

Gas Quality Specifications

- Company websites
- Interconnect Agreements
- Contractual Agreements
- State Public Utility Commissions
- FERC Tariffs

https://www.ferc.gov/industries/gas/gen-info/fastr/htmlall/index.asp

- Only natural gas quality specifications contained in a FERC approved tariff can be enforced.

Gas Quality Specifications

- Limits will vary from company to company
  - Dependent on source of gas
  - Pipeline operating conditions
  - Customer equipment

Biomethane/Renewable Gas (RNG) Considerations

Compound or Parameter	NGA Guide (2019) (commercially free of)	Others considered
Ammonia	10 ppmv	3 mg/m^3
Bacteria	0.2 microns	
Siloxanes	0.5 mg Si/m^3	1 ppmv - 0.1 mg Si/m^3
Non-Halogenated Volatile Compounds	500 ppmv	3.7 ppmv
Non-Halogenated Semi-Volatile	500 ppmv	
Halocarbons	0.1 ppmv	10 mg/m^3 Cl, 1 mg/m^3 F
Hydrogen	0.1% - 0.3%	0.1%
Volatile metals	0.213 mg/m^3	0.03 mg/m^3 Cu, As
Aldehydes/Ketones	100 ppbv	

Equipment Requirement – such as CNG/NGV

TABLE 1 Detailed Requirements for Natural Gas Fuel								
Substance/Property	Units	Test Methods	Fuel Grades					
			MNc 65 S5	MNc 65 S16	MNc 65 S32	MNc 75 S5	MNc 75 S16	MNc 75 S32
Calculated Methane Number	MNc per Practice D8221, min	D8221	65	65	65	75	75	75
Wobbe Index (based on Higher Heating Value) Footnote 1	MJ/m3	ISO 6976	46 to 53	46 to 53	46 to 53	46 to 53	46 to 53	46 to 53
Lower Heating Value	MJ/m^3, min	D3588	33.2	33.2	33.2	33.2	33.2	33.2
Hydrogen	% by volume, max	D1945, D7833	0.3	0.3	0.3	0.3	0.3	0.3
Oxygen	% by volume, max	D1945, D7607, D7833	1	1	1	1	1	1
Water Dew Point Footnote 2	°C max below the 99.0% winter design temperature at dispenser	D1142, D5454, D7904	6	6	6	6	6	6
Total Sulfur (includes odorant) Footnote 4	ppmv, max	D4468, D5504, D6228, D6968, D7165, D7493, D7551	5	16	32	5	16	32
Hydrogen Sulfide Footnote 5	ppmv, max	D4468, D5504, D6228, D6968, D7165, D7493, D7551, D1945, D7833	5	5	5	5	5	5
Maximum Particulates	mg/kg, max	D7651	1	1	1	1	1	1
Siloxanes Footnote 6	mg of Si/m3, max	D8230	0.1	0.1	0.1	0.1	0.1	0.1
Compressor Oil	mg/kg, max	WK49305	10	10	10	10	10	10

Regulatory Requirements

- 49 CFR DOT 192.475 (a) Internal corrosion control
  - Corrosive gas may not be transported by pipeline, unless the corrosive effect of the gas on the pipeline has been investigated and steps have been taken to minimize internal corrosion.
- States have limits on gas quality
  - Public Utility Commissions
- Air Districts

Industry groups

- National groups may recommend standards on interchangeability and corrosive elements
  - Natural Gas Council NGC+ task group
    - White Paper on Liquid Hydrocarbon Drop Out in Natural Gas Infrastructure – NGC+ Liquid Hydrocarbon Drop Out Task Group
    - Parameters to be considered in establishing a Cricondentherm Hydrocarbon Dew Point and C6+ Gallons per thousand (GPM) Cubic Feet Based Limits
    - Interim Guidelines: +/- 4% Wobbe; Max 1400 Wobbe; 1110 HHV; C4+ 1.5%; Inerts 4%
  - Pipeline Research Council International (PRCI)

Questions