Reconsideration of Maximum Allowable Operating Pressure:

Costs and Benefits – A Macroeconomic View

A view by:

Energy Experts International

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Introductory Items

- Begin today's meeting with a *qualitative* macro view of impacts from MAOP increase
- This presentation addresses the high-impact items, with full recognition that the realities are in the details
- Other presentations address details of materials, risks, engineering, actual operating history, other critical evaluation factors
- Affects of any MAOP change will be different for each operator:
  - Greenfield pipeline versus existing pipeline
  - Straight-line versus highly interconnected system
  - Highly versus lightly compressed

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Introductory Items

- Each operator would need to *quantitatively* evaluate their pipeline systems' potential for MAOP increase given the operator's:
  - Capacity position – increasing, stable, or decreasing?
  - Risk tolerance – increase MAOP or construct new pipeline?
  - Access to capital – is there enough to go around?
  - Rate structure – affects on pipeline and customers?
- Evaluation of a pipeline system would require technical and commercial input, analysis and decisions
- Reconsideration of MAOP viewed as a tool to potentially improve operations, not a requirement
- It's your pipeline asset to maximize

Discussion Items

- Reconsideration of current regulations governing MAOP generates opportunities and challenges
- High-level assessment of amount of gas pipeline installed around the globe
- Inventory of design factors available under regulations in certain countries
- Qualitative evaluation of cost and benefit of MAOP increase for certain pipelines in the U.S.
- High-level assessment of where increases in MAOP and pipeline capacity would have the most positive results
- How MAOP increase might impact infrastructure other than pipe, e.g. compressors, regulators, meters

Opportunities and Challenges

- What opportunities might result from increase in MAOP?
  - Capacity increase, or potential investment decrease, of proposed:
    - Alaska Natural Gas Transmission System (745 miles of 48”)
  - Capacity increase, or potential investment decrease, of other proposed *new* pipelines such as:
    - Pacific Texas Pipeline (825 miles of 36”, 1 Bcf/d)
    - Rockies Express Pipeline (1,350 miles of 42”, 2 Bcf/d)
  - Capacity increase of *existing* pipeline infrastructure:
    - Power generation loads attached to backbone or trunk systems

Opportunities and Challenges

- Opportunities continued ….
  - Offset requirement, or push out schedule for new pipeline
  - Increase pipeline operating efficiency; reduce compression fuel
    - Lower fuel retainage rates
    - Capacity not used to transport fuel available to transport commodity
  - Greater utilization of integrity management technologies
  - Line pack increase in pipelines represents additional storage available for short-term services
  - Reduce environmental affects of pipeline construction

Opportunities and Challenges

- What challenges might result from increase in MAOP?
  - Perception by public of decreased safety and increased risk
  - Capital requirements to upgrade, modify or replace aboveground facilities to accept new MAOP
  - Changes to operating company policies, procedures, operations, data systems, records, such as:
    - IMP HCAs get larger
    - Many overpressure protection devices to reset
  - Lost and unaccounted for gas may increase due to higher pressure

Opportunities and Challenges

- Which path will the industry take?

Global Gas Pipeline Infrastructure

- The world's oil and gas transmission pipeline system is a US$2 trillion vital asset
- *Over 25% of the world's established pipeline infrastructure is now over 30 years old*
- These older U.S. pipelines are not likely candidates for MAOP increase
- The U.S. operates approximately 44% of the global gas gathering and transmission pipeline
- The U.S. represents approximately 24% of the global consumption
- Globalization of the natural gas market through LNG trade is supporting pipeline development in the middle east

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Global Gas Pipeline Infrastructure

Table 1

Rank	Country	Gas Pipeline[1] (miles)	2003 Dry Gas Production[2] (Tcf)	2003 Dry Gas Consumption[3] (Tcf)	1/1/2006 Proved Reserves[4] (Tcf)
1	United States	343,061	19.040	22.375	192.513
2	Russia	93,172	21.770	15.291	1,680.000
3	Algeria	53,383	2.910	0.753	160.505
4	Canada	30,550	6.450	3.212	56.577
5	Australia	17,814	1.260	0.886	27.640
6	Argentina	16,873	1.450	1.221	18.866
7	Germany	15,710	0.780	3.315	9.076
8	United Kingdom	13,320	3.630	3.360	18.750
9	Ukraine	12,465	0.690	3.023	39.600
10	Italy	10,767	0.480	2.715	8.000
11	Iran	10,558	2.790	2.790	971.150
12	China	9,870	1.210	1.181	53.325
13	France	8,840	0.060	1.545	0.378
14	Mexico	8,232	1.490	1.823	15.985
15	Uzbekistan	5,683	2.030	1.670	66.200
16	Indonesia	5,283	2.620	1.229	97.786
17	Netherlands	4,347	2.580	1.780	62.000
18	Turkmenistan	4,068	2.080	0.551	71.000
19	Norway	3,850	2.590	0.146	84.260
20	India	3,833	0.960	0.957	38.880

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Global Gas Pipeline Infrastructure

Table 1

Rank	Country	Gas Pipeline[1] (miles)	2003 Dry Gas Production[2] (Tcf)	2003 Dry Gas Consumption[3] (Tcf)	1/1/2006 Proved Reserves[4] (Tcf)
21	Egypt	3,798	0.950	0.954	58.500
22	Venezuela	3,268	1.050	1.049	151.395
23	Malaysia	3,135	1.890	1.008	75.000
24	Thailand	1,933	0.790	1.029	14.754
25	Japan	1,689	0.100	3.055	1.400
26	United Arab Emirates	1,649	1.580	1.338	214.400
27	Saudi Arabia	1,106	2.120	2.121	241.840
28	Qatar	636	1.090	0.410	910.520
---	**Subtotal**	**688,891**	**86.440**	**80.787**	**5,340.300**
---	**World Total**	**789,394**	**95.180**	**95.504**	**6,112.144**
---	**U.S. % of World Total**	**43.5**	**20.0**	**23.4**	**3.1**

(1) *SOURCE:* U.S. CIA, EIA, operating company data. All but a few entries as of end of 2004. Excludes distribution.

(2) *SOURCE:* U.S. EIA, "World Dry Natural Gas Production" for calendar 2003.

(3) *SOURCE:* U.S. EIA, "World Dry Natural Gas Consumption" for calendar 2003.

(4) *SOURCE:* U.S. EIA, "World Proved Reserves of Oil and Natural Gas, Most Recent Estimates."

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U.S. Gas Pipeline Infrastructure

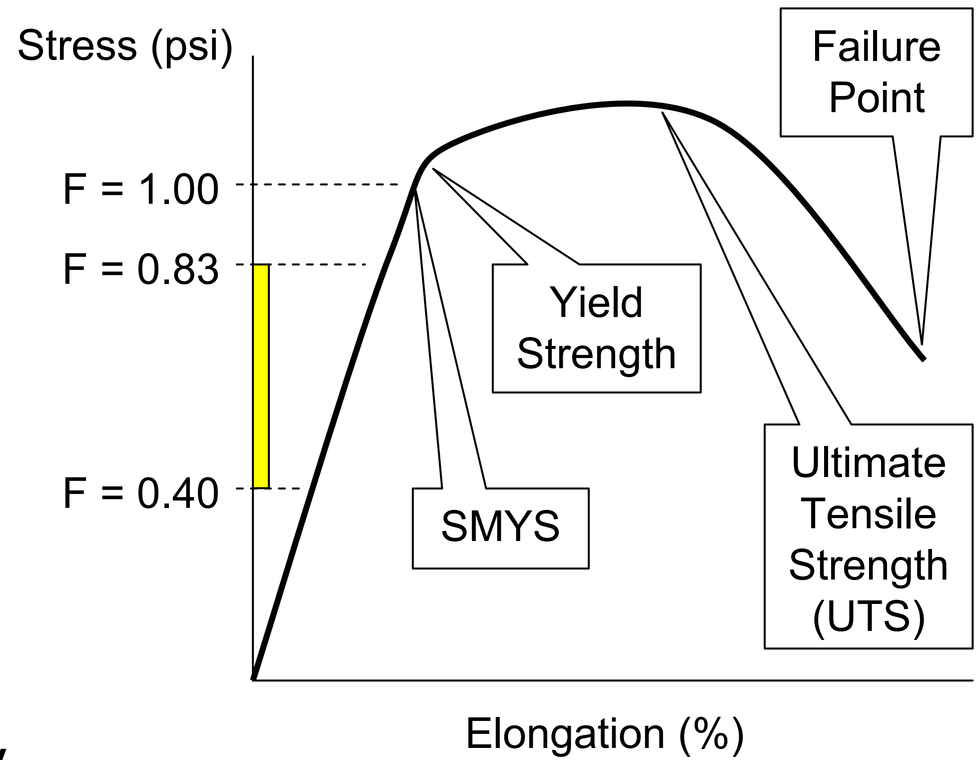
- The densest concentration of gas pipelines are those extending from the Gulf Coast production area to the Midwest and the Northeast; the second greatest concentration is from the West Central Texas and Oklahoma to the Midwest
- Nearly 100% of gas transmission pipelines are made of steel
- Over 96% of the total mileage is wrapped or coated steel pipe that is cathodically protected to prevent corrosion
- *The design limitation of 72% SMYS operating stress was developed decades ago based on technology at the time*
- *The 72% factor has served the industry well, but technology advances suggest reconsideration*

MAOP Regulations - Certain Countries

- In the U.S. the DOT pipeline safety regulations prescribe certain design and operational requirements
- In Europe, many regulations do not prescribe the methodologies and specific requirements as outlined in the U.S. pipeline safety regulations
  - the responsibility is often the pipeline operator's responsibility
  - Germany, France, Italy, Spain, others have both commonality and differences in pipeline design
- Pipeline codes, where they exist, typically use a variant of the Barlow formula to specify pipe wall thickness and allowable hoop stress
- *Note* - Different definitions are used for diameter, wall thickness, and yield strength ….. must be addressed when making rigorous comparisons

MAOP Regulations - Certain Countries

- Pipeline MAOP a function of:
  - pipe material
  - pipe wall thickness
  - pipe diameter
  - temperature and seam factors
  - *design factor*
- Design factor typically expressed as a percentage of SMYS



- Design factor (F) for rural class locations ranges from 0.40 to 0.83 in Codes around the world

MAOP Regulations - Certain Countries

Basic Design Formula:

$$P = \frac{(2)(t)(\sigma)(F)(E)(T)}{(D)}$$

Where

- P = design pressure
- t = wall thickness, varies among design codes, is typically t_{min} or t_{nom} (to address tolerance issues)
- σ = specified minimum yield stress
- F = *design factor*
- E = seam or joint factor
- T = temperature factor
- D = pipe outside diameter, varies among design codes, is typically D_{min} or D_{nom} (to address tolerance issues)

MAOP Regulations - Certain Countries

Table 2 - Representative World Gas Pipeline Design Codes – Transmission Pipeline

Country[0]	Primary Code[1]	Design Factor[2]
U.S.	ASME B31.8 – "Gas Transmission and Distribution Piping Systems"	0.80
Canada	CSA Standard Z662 – "Oil and Gas Pipeline Systems"	0.80
Australia	AS 2885.1 – "Pipelines – Gas and Liquid Petroleum – Design and Construction"	0.80[3]
Germany	DVGW Standard G463 – "Steel Gas Mains with an Operating Pressure Exceeding 16 bar – Construction"	0.62[4]
U.K.	IGE TD/1 – "Steel Pipelines for High Pressure Gas Transmission"	0.80[5]
Netherlands	NEN 3650 – "Requirements for Steel Pipeline Transportation Systems"	0.72[6]
Egypt	ASME B31.8 – "Gas Transmission and Distribution Piping Systems"	0.80
Japan	MITI (Japanese Ministry of Industry and Trade) - "Japanese Pipeline Safety Standards"	0.40[7]
(Other)	ISO 13623 – "Petroleum and Natural Gas Industries – Pipeline Transportation Systems"	0.83
	BS 8010 – "Code of Practice for Pipelines"	0.72
	BS EN 1594 – "Gas Supply Systems – Pipelines for Maximum Operating Pressure Over 16 bar – Functional Requirements"	0.72[8]
	IS 328 – "Code of Practice for Design and Installation of Gas Transmission Pipelines"	0.72

MAOP Regulations - Certain Countries

Table 2 - Representative World Gas Pipeline Design Codes – Transmission Pipeline

(0) Russia (93,172 miles), Algeria (53,383 miles), and Argentina (16,873 miles) excluded from list due to lack of data.
(1) Other Codes may be applied as long as they meet the intent of any applicable regulations.
(2) Design Factor applicable to the specific code's area classification that most closely matches onshore Location Class 1 in ASME B31.8. Values in this column represent the highest value allowed and may be subject to deration.
(3) Current Code specifies 0.72. Use of 0.80 proposed and under review.
(4) Use of 0.62 practiced in lieu of recognition that 0.72 likely provides sufficient safety.
(5) Use of 0.80 requires a Structural Reliability Analysis, otherwise limited to 0.72. Limited to operation between 16 bar and 100 bar.
(6) For onshore pipelines above 18 bar.
(7) Use of 0.40 practiced principally due to frequent earthquake activity and land use/development. Increase in design factor being sought.
(8) British Standard, for onshore pipelines above 16 bar in European Countries. Design Factor may be increased when special measures to prevent third-party damage are implemented.

MAOP Regulations - Comments

- Most regulations, standards and codes use similar approaches to design and regulation – U.S. and others
- Minimizing probability of occurrence of failure through design, construction and operation is used in the U.S. and other countries in lieu of requiring safety zones or separation distances
- U.S. pipeline safety regulations provide valuable service to the industry and the country
- *U.S. operates the most robust gas transmission pipeline system; sets the standard for many countries*
- *A change in U.S. regulations to permit higher design factors is likely to have long-term cascading affect on the rest of the world's gas pipeline design codes and regulations*

Qualitative Assessment - ANGTS

- What affects might a design factor increase have on the proposed Alaska Natural Gas Transportation System (ANGTS)?
- ANGTS current design basis:
  - Hoop stress in accordance with current 49CFR192 (Class 1 = 0.72 SMYS)
  - Grade 5L X80 pipe to meet API-5L or CSA Z245.1 and additional company specifications
  - 745 miles of 48” OD pipe, 1.042” wall, Class 1 Div. 2
  - 2,500 psig MOP
  - Minimum test pressure of 125% of MOP for 8 hours
  - Initial Capacity = 4,500 MMSCFD
  - Maximum Expansion Capacity = 5,900 MMSCFD

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Qualitative Assessment - ANGTS

- Assuming all pipeline is Class 1 suitable for F = 0.80 and other simplifying assumptions, four scenarios as follows:
  - Current design basis: F = 0.72; 264,000 Bhp; 4,500 MMSCFD
  - Opt. 1: F = 0.80; 4,500 MMSCFD; production sets capacity limit; operate at higher pressure to increase efficiency
  - Opt. 2: F = 0.80; 4,500 MMSCFD; production sets capacity limit; operate at original pressure to reduce pipe investment and increase efficiency
  - Opt. 3: F = 0.80; production does not set capacity limit, pipeline does; operate at higher pressure to increase capacity

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Qualitative Assessment - ANGTS

- Other major assumptions:
  - Pipe is 48” nominal, Grade 5L X80
  - Total project cost of $20 billion modeled as(1) of 30% material, 43% labor, 5% ROW, and 22% other(2)
  - Material cost is comprised of 85% pipe, 15% all other. Therefore, pipe is (0.85)(0.30) = 0.255, or 25.5% of total project cost
  - Compressor cost is 10% of total material. Therefore, compression is (0.10)(0.30) = 0.030, or 3.0% of total project cost
  - 100% Load Factor used for all calculations

(1) SOURCE: U.S. FERC Construction filings July 01, 2002 to June 30, 2003.

(2) Includes engineering, surveying, administration, supervision, overhead, contingencies, and interest.

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Qualitative Assessment - ANGTS

Metric -	Scenario -			
	Current	Opt. 1	Opt. 2	Opt. 3
Design Factor	0.72	0.80	0.80	0.80
MAOP (psig)	2,500	2,779	2,500	2,779
Capacity (MMSCFD)	4,500	4,500	4,500	4,869
Wall (inches)	1.042	1.042	0.9375	1.042
Horsepower (Bhp)	264,000	199,000	254,000	264,000
Fuel retainage (%)	1.28	0.96	1.23	1.18
Fuel at $7.50/MMBtu ($MM/yr)	173.4	130.7	166.9	173.4
Investment in Pipe ($MM)	5,100	5,100	4,589	5,100
Investment in Compression ($MM)	600	452	577	600
Upside results – Opt. vs Current				
Pipe investment ($MM)	-----	- none -	(511)	- none -
Compression investment ($MM)	-----	(148)	(23.0)	- none -
Fuel ($MM/yr)	-----	(34.3)	(6.5)	- none -
New capacity for shippers (MMSCFD)	-----	14.2	2.2	369

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Qualitative Assessment - Comments

- The upside potentials are generally applicable to all new pipelines
  - Lower investment in material - pipe, compression, or combination
  - Lower unit cost (e.g., $/Mcf) throughout pipeline life – construction and operation
  - Improved utilization of all resources – less fuel, smaller pipeline footprint, more pipeline capacity being used for commodity transportation
- *Bottom line …. avoided costs comparable to*
  - *several hundred million in capital, or*
  - *several hundred million in O&M (principally fuel), or*
  - *a 745 mile pipeline to transport 369 MMSCFD*

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MAOP Increase – Effective Locations

- Interstate operators typically have the majority of pipeline in Class1 locations
- Available data suggests on the order of 80% in Class 1; 10% each in Class 2 and Class 3
- Pipelines that can carry a higher MAOP along the backbone/trunk system to higher pressure and capacity delivery points could capitalize
  - Storage operators
  - Power generators
  - Large industrials
- Pipelines designed with lower levels of compression, e.g. where compression has been designed as a future addition

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MAOP Increase – Effective Locations

- Pipelines that rely on linepack to cover the peaks, supply short-term services
- Looped pipelines where currently mismatched MAOPs could be matched, allowing operation in common
- *Conclusions ……. locations exist where MAOP increase in Class 1 pipeline will improve a pipeline's ability to serve its customers*
- *Each pipeline system and operator would need to evaluate its system*
- *Sufficient take-away capacity must exist (or be planned) to support costs associated with an MAOP increase*
- *An amount of downstream 'debottlenecking' expected*

MAOP Increase – Other Locations

- Pipelines with significant latent capacity in Class 1 systems, low load factor
- Pipelines in Class 1 that supply capacity constrained pipelines in Class 2, 3 or 4

MAOP Increase – Other Facilities

- Other pipeline facilities are likely to require an MAOP revision commensurate with the pipeline to maximize benefits
- Compressors, meters, regulators, filters, odorizers, etc may become the limiting component(s)
- These are typically aboveground facilities
- Original strength/proof testing may or may not support MAOP increase
- Work at these facilities is likely to
  - be on property owned by the operator
  - be normal day-to-day activities observed by the public
  - result in relatively little disturbance to adjacent property owners

MAOP Increase – Other Facilities

- Detailed review and analysis required to identify lowest pressure-limiting component and upgrade/replace
- *Conclusions ….. maximizing capacity increase across the gas grid would necessitate MAOP increases in these other facilities to prevent formation of bottlenecks*
- *Facilities constructed with planned expansion capability are more likely to have been designed and constructed with a 'reserve margin' that would support MAOP increase*
- *Older pipeline systems, and highly interconnected pipeline systems present additional challenges*

MAOP Increase – Final Thoughts

- *Buried pipelines are the industry's largest investment. Need to make the most of it*
- *Sanctioning operation up to 80% SMYS can significantly enhance the physical and financial effectiveness of new pipelines*
- *Permitting existing pipelines that meet certain requirements to increase MAOP is likely to enhance deliverability and effectiveness in pipeline segments*
- *Operation at higher MAOP – where verified as appropriate – capitalizes the value of integrity management and related programs*

Questions addressed after the other panel presentations.

Thank you!