What’s Up With the 526 Valves?

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What's Up With the 526 Valves?

- The API Standard 526 lists standard characteristics for relief devices for a given orifice size:
  - Inlet / Outlet Diameters
  - Flange Ratings
  - Temperature / Pressure Limits
  - Backpressure Limits
  - Dimensions
- Relief Device Installation Requirements dictate:
  - Inlet pressure loss requirements
  - Outlet pressure loss requirements

Table 4—Spring-loaded Pressure-relief Valves "E" Orifice (Effective Orifice Area = 0.196 in.^{2})

Materials [b]	Valve Size	ASME Flange Class		Maximum Inlet Flange (Set) Pressure Limit [a] (psig)						Outlet Pressure Limit [a] (psig)		Center-to-Face Dimensions (in.)	
				Conventional and Balanced Bellows Valves									
Body/ Bonnet	Inlet by Orifice by Outlet	INLET	OUTLET	–450 °F to –75 °F	–75 °F to –21 °F	–20 °F to 100 °F	450 °F	800 °F	1000 °F	Flange Rating Limit [a] 100 °F	Bellows Rating Limit [a] 100 °F	INLET	OUTLET
Temperature Range Inclusive –20 °F to 800 °F													
Carbon Steel	1E2	150	150			285	185	80		285	230	4 1/8	4 1/2
	1E2 [c]	300	150			(285)	(285)	(285)		285	230	4 1/8	4 1/2
	1E2	300	150			740	615	410		285	230	4 1/8	4 1/2
	1E2	600	150			1480	1235	825		285	230	4 1/8	4 1/2
	1 1/2E2	900	300			2220	1845	1235		(600)	500	4 1/8	5 1/2
	1 1/2E2	1500	300			3705	3080	2060		(600)	500	4 1/8	5 1/2
	1 1/2E3	2500	300			6000	6000	3430		740	500	5 1/2	7
Temperature Range Inclusive 801 °F to 1000 °F													
Chrome Molybdenum Steel	1E2	300	150					510	215	285	230	4 1/8	4 1/2
	1E2	600	150					1015	430	285	230	4 1/8	4 1/2
	1 1/2E2	900	300					1525	650	(600)	500	4 1/8	5 1/2
	1 1/2E2	1500	300					2540	1080	(600)	500	4 1/8	5 1/2
	1 1/2E3	2500	300					4230	1800	740	500	5 1/2	7
Temperature Range Inclusive –450 °F to 1000 °F													
Austenitic Stainless Steel	1E2	150	150	275	275	275	180	80	20	275	230	4 1/8	4 1/2
	1E2 [c]	300	150	(275)	(275)	(275)	(275)	(275)	(275)	275	230	4 1/8	4 1/2
	1E2	300	150	720	720	720	495	420	350	275	230	4 1/8	4 1/2
	1E2	600	150	1440	1440	1440	975	845	700	275	230	4 1/8	4 1/2
	1 1/2E2	900	300	2160	2160	2160	1485	1265	1050	(600)	500	4 1/8	5 1/2
	1 1/2E2	1500	300	3600	3600	3600	2480	2110	1750	(600)	500	4 1/8	5 1/2
	1 1/2E3	2500	300	(4000)	6000	6000	4130	3520	2915	720	500	5 1/2	7
Temperature Range Inclusive –20 °F to 900 °F [d]													
Nickel/Copper Alloy [d]	1E2	150	150			230	175	80	50	230	230	4 1/8	4 1/2
	1E2 [c]	300	150			(230)	(230)	(230)	230	230	230	4 1/8	4 1/2
	1E2	300	150			600	475	460	275	230	230	4 1/8	4 1/2
	1E2	600	150			1200	945	915	550	230	230	4 1/8	4 1/2
	1 1/2E2	900	300			1800	1420	1375	825	600	500	4 1/8	5 1/2
Temperature Range Inclusive –20 °F to 300 °F [e]													
Alloy 20 [e]	1E2	150	150			230	180			230	230	4 1/8	4 1/2
	1E2 [c]	300	150			(230)	(180)			230	230	4 1/8	4 1/2
	1E2	300	150			600	465			230	230	4 1/8	4 1/2
	1E2	600	150			1200	930			230	230	4 1/8	4 1/2
	1 1/2E2	900	300			1800	1395			600	500	4 1/8	5 1/2
	1 1/2E2	1500	300			3000	2330			600	500	4 1/8	5 1/2
	1 1/2E3	2500	300			5000	3880			600	500	5 1/2	7

[a] Inlet and outlet flange pressure limits correspond to the values in ASME B16.34 unless enclosed in parentheses. A value that is shown in parentheses is less than that provided in ASME B16.34. The outlet flange values at 100 °F above are the limits for this standard. Inlet and outlet flange pressure values at other temperatures may only be interpolated using graphs from Annex B or from tables in ASME B16.34, if these values do not exceed the values in parentheses or the outlet flange values at 100 °F above. Pressure changes within the temperature ranges above may not be linear. Bellows outlet pressure limits are the design pressure of the bellows at the outlet temperature of 100 °F, and pressure values at other temperatures may be determined from Annex C. User is cautioned to review the outlet temperature for possible cryogenic applications and select the appropriate materials.

[b] Materials given are minimum requirements for the pressure and temperature ratings. Other suitable materials may be used, as required for the service involved.

[c] Set pressure limited for low-pressure applications where a class 300 inlet flange is preferred over a class 150 flange.

[d] Materials limited to 900 °F. Pressure ratings indicated in the 1000 °F column are limited to 900 °F.

[e] Materials limited to 300 °F. Pressure ratings indicated in the 450 °F column are limited to 300 °F.

What's Up With the 526 Valves?

- For many orifice sizes, there are multiple sizes depending on the required set pressure.

Size	D	E	F	G	H	J	K	L	M	N	P	Q	R	T
1x2	■	■												
1½x2	■	■	■											
1½x3	■	■	■	■	■									
2x3				■	■	■								
3x4						■	■	■						
3x6							■							
4x6								■	■	■	■			
6x8												■	■	
6x10													■	
8x10														■

- Inlet Pipe Area / Orifice Area less than ~ 3 tend to have difficulty meeting the 3% rule.
- Outlet Pipe Area / Orifice Area less than ~ 5.5 tend to have difficulty meeting the backpressure requirements (Hisao Izuchi, API Conference Meetings)

What's Up With the 526 Valves?

- For many orifice sizes, there are multiple valve configurations depending on the required set pressure.

Size	D	E	F	G	H	J	K	L	M	N	P	Q	R	T
1x2	■	■												
1½x2	■	■	■											
1½x3	■	■	■	■	■									
2x3				■	■	■								
3x4						■	■	■						
3x6							■							
4x6								■	■	■	■			
6x8												■	■	
6x10													■	
8x10														■

- $\frac{\textit{Orifice Area}}{\textit{Inlet Pipe Area}} < 3$ tend to have difficulty meeting the 3% rule.
- $\frac{\textit{Orifice Area}}{\textit{Outlet Pipe Area}} < 5.5$ tend to have difficulty meeting the backpressure requirements (Hisao Izuchi, API Conference Meetings)

What's Up With the 526 Valves?

Orifice	Area	Size	M-IFR	OFR	CS P_{limit}	IP Sch	OP Sch	C - P_{Outlet}	B - P_{Outlet}	IPA / OA	OPA / OA
D	0.11	1x2	600	150	1,480	160	STD	285	230	4.7	30.5
	0.11	1½x2	1,500	300	3,705	XXS	STD	600	500	8.6	30.5
	0.11	1½x3	2,500	300	6,000	XXS	STD	740	500	8.6	67.2
E	0.196	1x2	600	150	1,480	160	STD	285	230	2.7	17.1
	0.196	1½x2	1,500	300	3,705	XXS	STD	600	500	4.8	17.1
	0.196	1½x3	2,500	300	6,000	XXS	STD	740	500	4.8	37.7
F	0.307	1½x2	600	150	1,480	160	STD	285	230	4.6	10.9
	0.307	1½x3	2,500	300	5,000	XXS	STD	740	500	3.1	24.1
G	0.503	1½x3	900	300	2,220	160	STD	740	470	2.8	14.7
	0.503	2x3	2,500	300	3,705	XXS	STD	740	470	3.5	14.7
H	0.785	1½x3	300	150	285	160	STD	285	230	1.8	9.4
	0.785	2x3	1,500	300	2,750	160	STD	740	415	2.8	9.4
J	1.287	2x3	300	150	285	STD	STD	285	230	2.6	5.7
	1.287	3x4	1,500	300	2,700	160	STD	600	230	4.2	9.9
K	1.838	3x4	600	150	1,480	XS	STD	285	200	3.6	6.9
	1.838	3x6	1,500	300	2,220	160	STD	600	200	2.9	15.7
L	2.853	3x4	300	150	285	STD	STD	285	100	2.6	4.5
	2.853	4x6	1,500	150	1,500	160	STD	285	170	3.3	10.1
M	3.6	4x6	900	150	1,100	XS	STD	285	160	3.2	8.0
N	4.34	4x6	900	150	1,000	XS	STD	285	160	2.6	6.7
P	6.38	4x6	900	150	1,000	XS	STD	285	150	1.8	4.5
Q	11.05	6x8	600	150	600	XS	STD	115	115	2.4	4.5
R	16	6x8	300	150	100	STD	STD	60	60	1.8	3.1
	16	6x10	600	150	300	XS	STD	100	100	1.6	4.9
T	26	8x10	300	150	300	STD	STD	100	100	1.9	3.0

Set Pressure Limit (CS P_{LIMIT}) is for Carbon Steel @ 100 °F; M-IFR = Maximum Inlet Flange Rating, OFR = Outlet Flange Rating, IP Sch = Inlet Pipe Schedule, OP Sch = Outlet Pipe Schedule, C - P_{Outlet} = Conventional Outlet Pressure limit, B - P_{Outlet} = Bellows Outlet, IPA / OA = Inlet Pipe Area / Orifice Area, OPA / OA = Outlet Pipe Area / Orifice Area.

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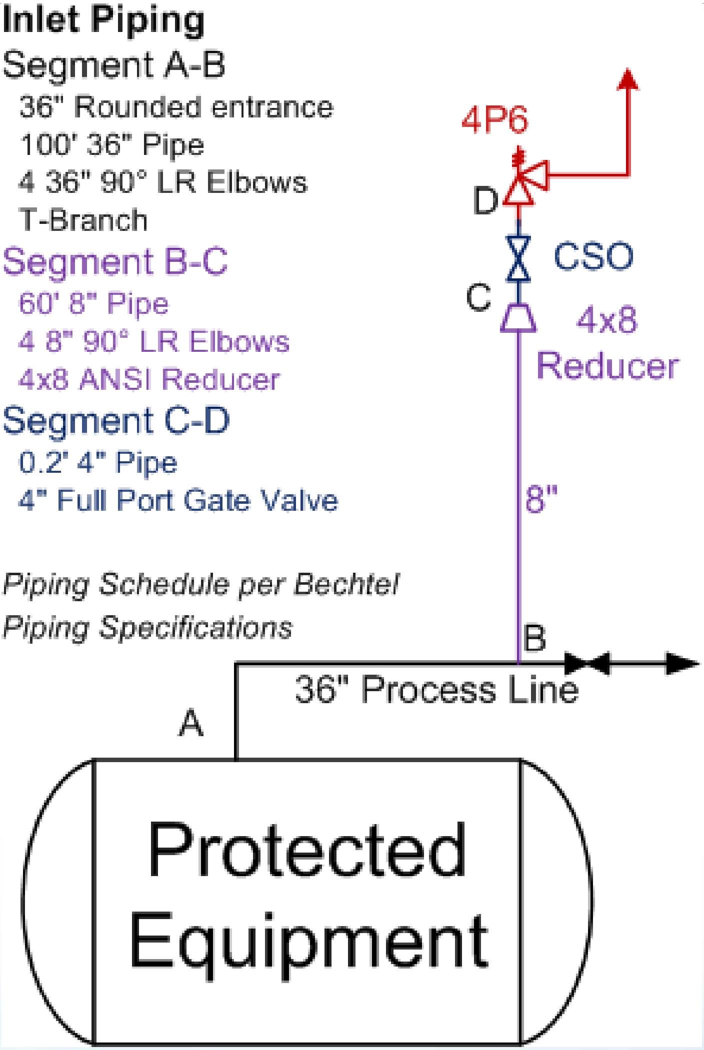
What's Up With the 526 Valves?

- Methodology to identify valves with inlet installation problems:
  - Standard Common New Installation used (see figure)
  - Set Pressure varied from 15 psig to 5,000 psig (or the STD 526 limits)
  - Piping schedule varied to meet Bechtel Pipe Spec's based on the pressure limits @ 200°F
  - Relief device body sized varied to meet API STD 526 pressure limits @ 200°F
- Other Valve Sizes
  - A – B, always 36" pipe
  - B – C, 2x PSV Inlet Diameter



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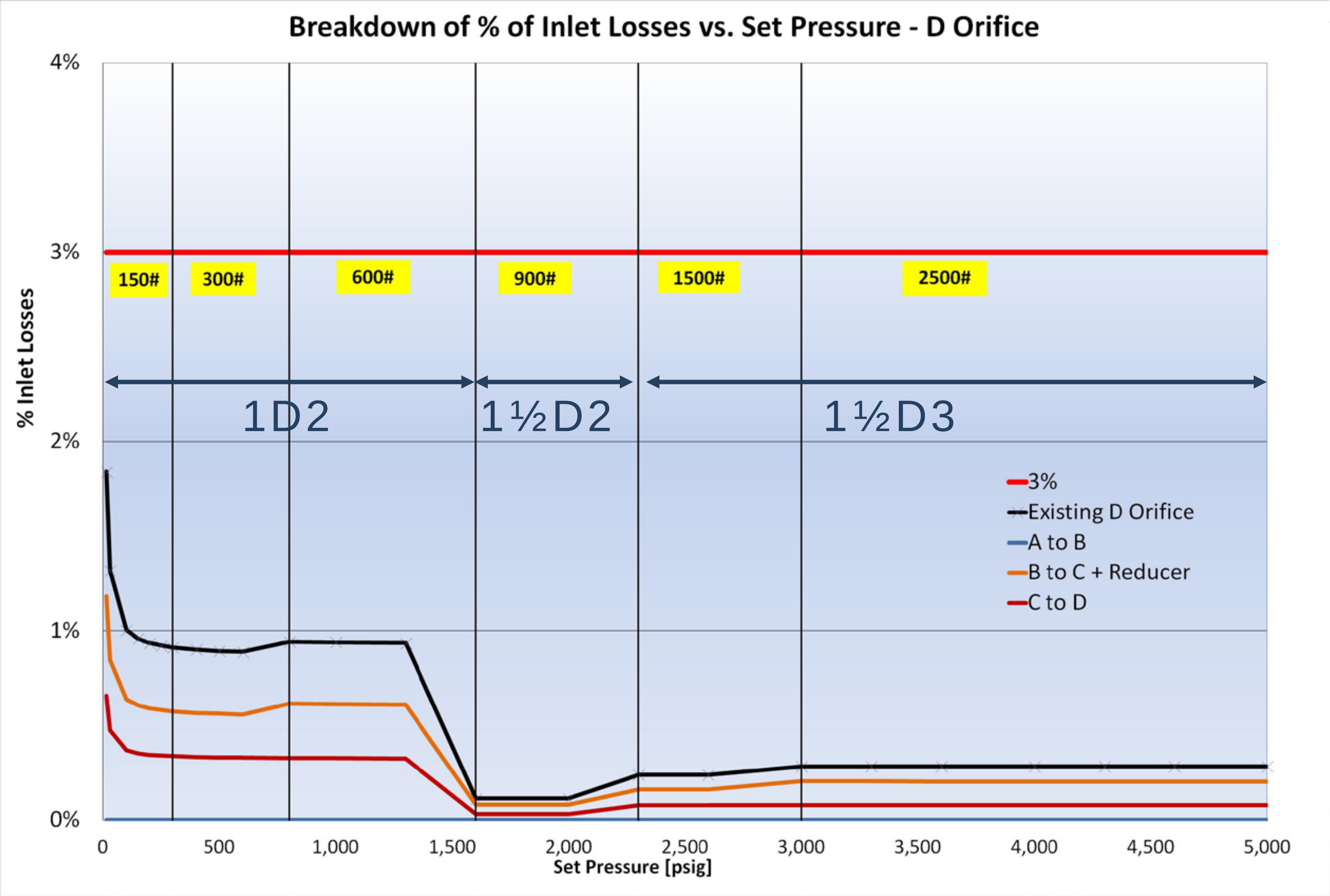

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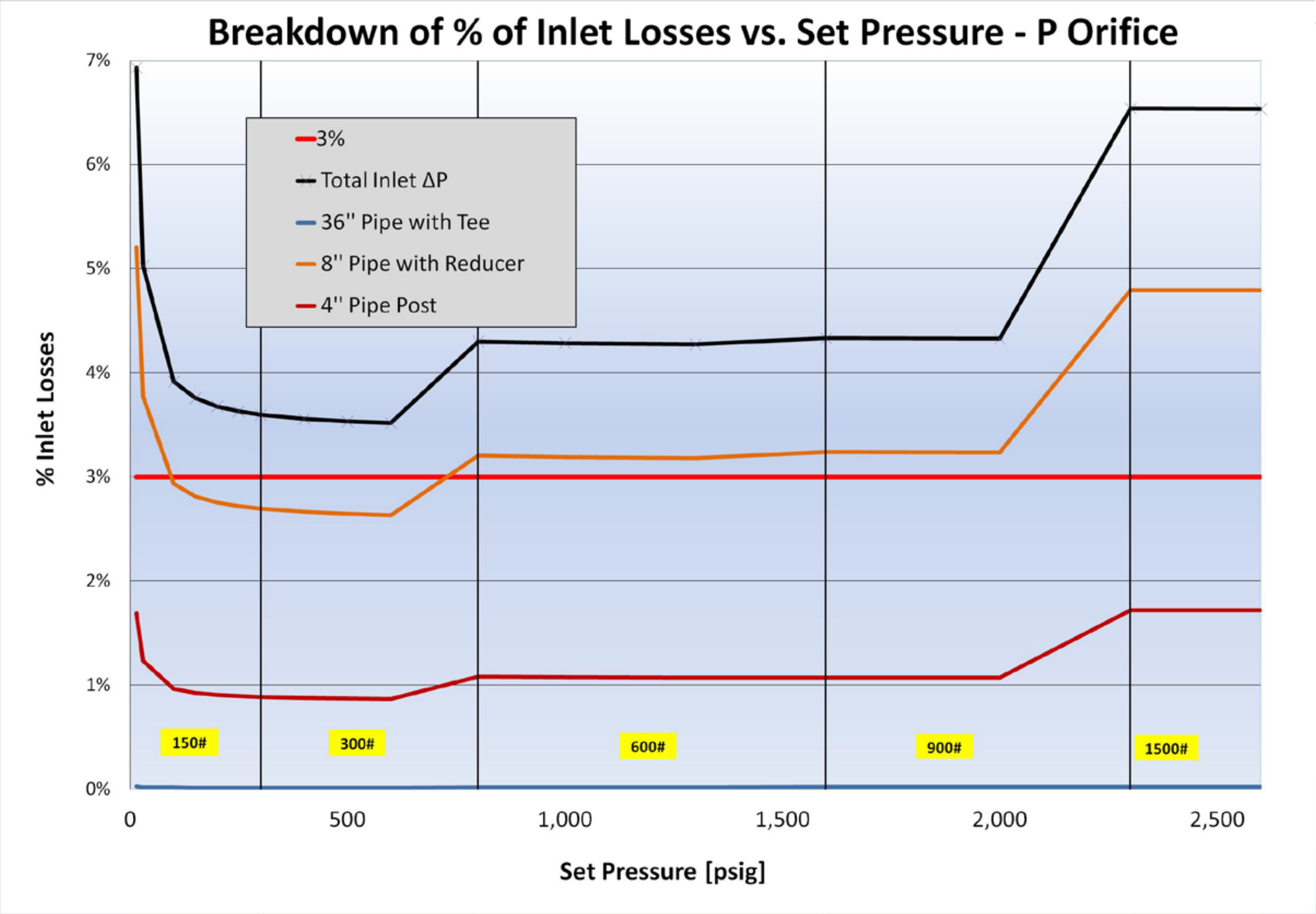

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What's Up With the 526 Valves?

- The API Standard 526 Sizes that are difficult to install (over all set pressure ranges)
    - Purple Boxes are valves that have inlet installations concerns
    - Red Boxes are valves that have inlet and outlet installations concerns

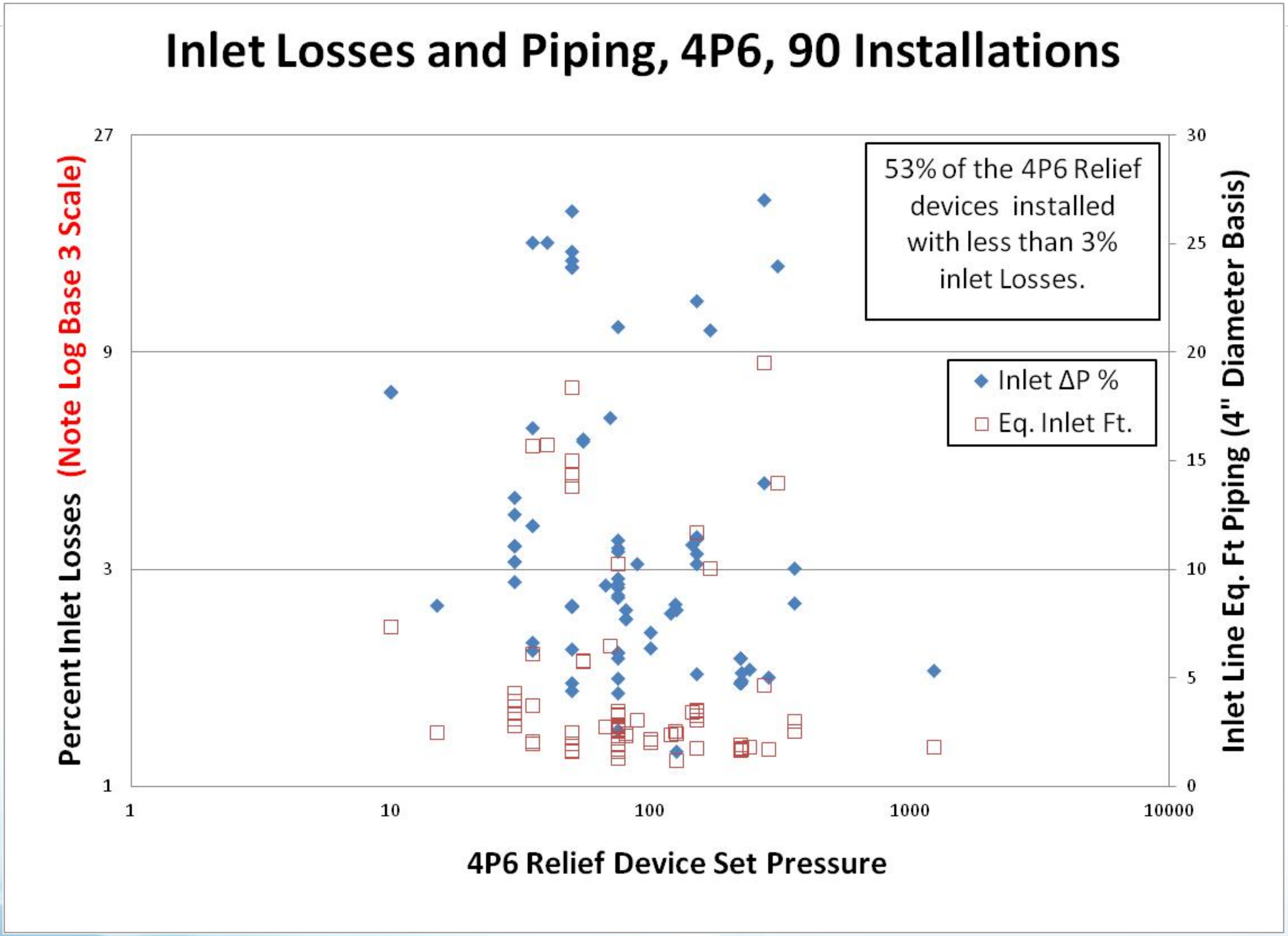
Size	D	E	F	G	H	J	K	L	M	N	P	Q	R	T
1x2														
1½x2														
1½x3														
2x3														
3x4														
3x6														
4x6														
6x8														
6x10														
8x10														

- Outlet Pipe Area / Orifice Areas less than ~ 5.5 tend to have difficulty meeting the backpressure requirements (Hisao Izuchi, API Conference Meetings)

What's Up With the 526 Valves?

- What does this mean in the real world? Is it a problem?
  - For a large chemical plant in the USA:
    - 90 unique 4P6 relief devices
    - Set Pressure varied from 10 psig to 1,230 psig
    - Inlet piping equivalent feet varied from 4 ft to 116 ft
    - Inlet ΔP varied from 1.2% to 19.5%
  - Results
    - Inlet ΔP was less than 3% for 54% of the 4P6 relief devices (48/90)
    - Inlet ΔP was greater than 3% for 46% of the 4P6 relief devices (42/90)
- Previous standard common installation equivalent feet ~11

What's Up With the 526 Valves?



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Q: How do we fix this real world problem?

A: Form a committee of course

What's Up With the 526 Valves?

- So API 526 formed a Task Force to investigate how:
  - To modify the relief device standard to ease meeting inlet piping installations requirements (e.g the API 3% rule)
  - To modify the relief device standard to ease meeting the outlet piping installation requirements
  - This information has come out of the *API STD 526 Task Force* and is being shared for comment
- A lot of work has been done to-date, a very brief summary of working solutions proposed are:
  - Option 1 - Increase the body size for existing orifice sizes (e.g. a 6P8)
  - Option 2 - Add an optimized size for each inlet valve diameter (e.g. 6Q'8, where Q' is ~8.82 in^2; OA / IPA = 3.0 & OA / OPA = 5.7)
  - Option 3 - Allow an option for manufacturers to provide valves of a customizable area (e.g. adjustable lift)
  - Option 4 – Do nothing

What's Up With the 526 Valves?

- Option 1 - Increase the body size for existing orifice sizes (e.g. a 6P8)

- Pros:
  - Easy for industry to understand the change; does not introduce any new concepts
  - Increased flexibility for new installations

- Cons
  - Does little to help mitigate the existing installation problems
  - New options will drive up manufacturers' costs (and new relief device prices)
  - If the standard eliminates or reduces the ability to use problem valves, will tend to drive up total installed costs for new installations
  - Maintenance costs may increase due to the additional valve types to be stored, repaired, and spared

What's Up With the 526 Valves?

- Option 2 - Add an optimized size for each inlet valve diameter (e.g. 6Q'8, where Q' is ~8.82 in^2; OA / IPA = 3.0 & OA / OPA = 5.7)

- Pros:
  - Will allow the resolution of some inlet piping installation concerns (e.g. Inlet $\Delta P > 3\%$) to be resolved with piping changes
  - Increased flexibility for new installations

- Cons
  - Introduces a new series of orifice letters and may cause confusion (as there are currently no letters between P and Q for the new Q')
  - New options will drive up manufacturers' costs (and new relief device prices), but conceivably less than Option 1
  - If the standard eliminates or reduces the ability to use problem valves, will tend to drive up total installed costs for new installations
  - Maintenance costs may increase due to the additional valve types to be stored, repaired, and spared

What's Up With the 526 Valves?

- Option 3 - Allow an option for manufacturers to provide valves of a customizable area (e.g. adjustable lift).

- Pros:
  - Will allow the most resolution of inlet piping installation concerns (e.g. Inlet $\Delta P > 3\%$) to be resolved without piping changes (of the 4 options)
  - Increased flexibility for new installations
  - Concept is already in use and has been accepted by the NB for UV stamping
  - May reduce sparing and maintenance cost due to a consolidation of relief devices and internal parts

- Cons
  - Confusion, as this is a paradigm shift in the way that relief devices are designed and specified
  - New options will drive up manufacturers' costs (and new relief device prices), but conceivably less than Option 1
  - Whole new set of requirements will need to be codified and/or RAGAGEP'ed to deal with variable orifice areas in standard valve sizes

What's Up With the 526 Valves?

- Option 4 – Do Nothing
- Pros:
    - Easiest to implement
    - No change-related PSV costs
- Cons
    - Few options other than piping modifications for retrofitting valves that do not meet installation requirements
    - Not actually a real solution

Comments?

What's Up With the 526 Valves?

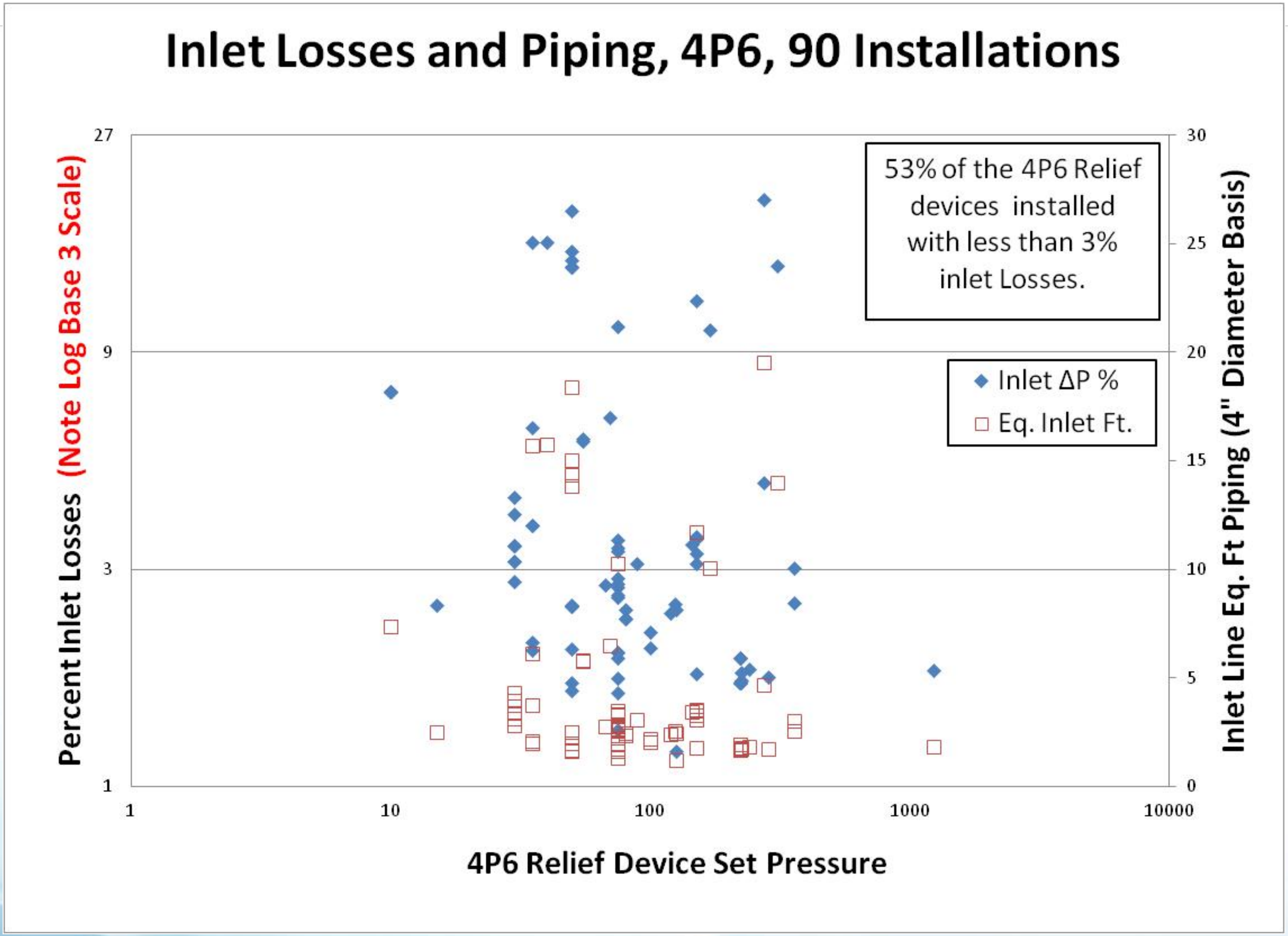
- Back to our real world problem?
- Options 4/1 do not solve any of these problems without piping modifications; arguably Option 1 will assist in the mitigation process
- Options 2/3 will reduce the number of installations that require piping modifications; let's look at the numbers:

- 48 4P6 PSVs with Inlet losses less than 3%
  - 15 were undersized so will require additional mitigation
  - 33 were acceptable

- 42 4P6 PSVs with Inlet losses **greater than** 3%
  - 12 were undersized so will require additional mitigation
  - 30 were adequately sized, but improperly installed

- 90 4P6 PSVs
  - 27 were undersized so will require additional mitigation
  - 63 can potentially be mitigated with PSV only changes

What's Up With the 526 Valves?



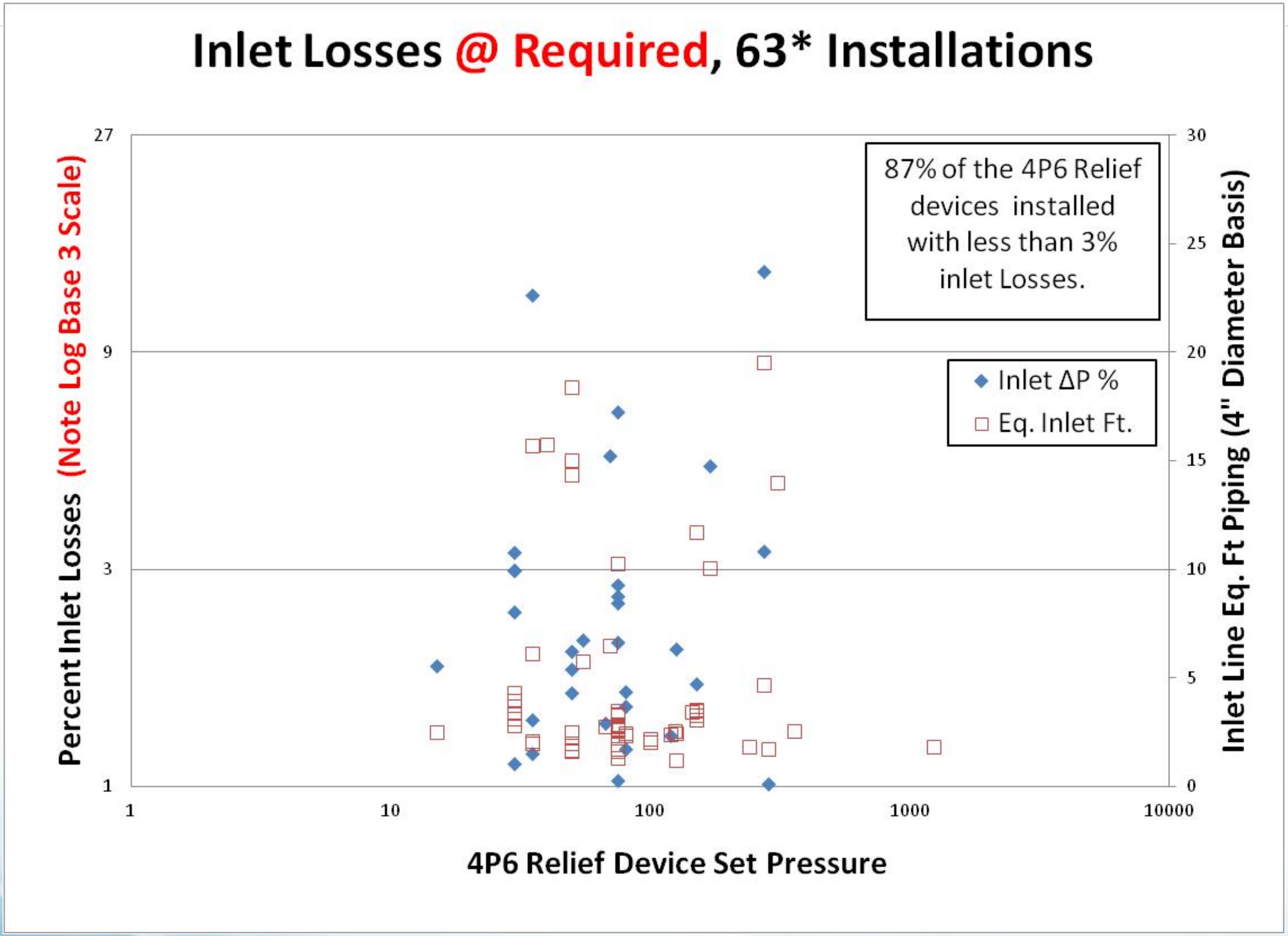
What's Up With the 526 Valves?

- Some assumptions made
- $\Delta P \propto \Delta V^2 \propto \Delta w^2 \propto (A_{Required} / A_{Orifice})^2$
- Estimated $\Delta P_{Required} \approx \Delta P_{Capacity} \times (A_{Required} / A_{Orifice})^2$

- 63 4P6 PSVs were adequately sized
  - 33 were adequately sized **and** Inlet Δ P **less than** 3%
  - 30 were adequately sized, **but** Inlet Δ P is **greater than** 3%
    - 22 have Inlet Δ P **less than** 3% @ the *required flow rate*
    - 8 have Inlet Δ P is **greater than** 3% @ the *required flow rate*

- Option 3 resolves 22 inlet Δ P cases without piping modifications
- Option 2 would resolved somewhat less than 22 cases depending on the optimized orifice size

What's Up With the 526 Valves?



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QUESTIONS?