PENBERTHY / YARWAY application report

Section 2000
Application Report 2781.1
Issued 03/09
Replaces 05/05

For: STEAM/WATER GAGES – SELECTION GUIDE

Material and Option Comments

Steam/Water Gages are designed for use in saturated pressure and temperature conditions. Saturated steam tables should be consulted to check that operating pressure and temperature for the application is within the range shown in the appropriate table.

Tubular Glass

C to C Distance for Vessel Connections	Steam Boiler service UP to 425ºF [218ºC]		
	High pressure Tubular Glass	Heavy Wall Tubular Glass	Red Line Tubular Glass
	Max Pressure		
Max 10" [254mm]	310psig [2140kPag]	345psig [2380kPag]	275psig [1900kPag]
Max 15" [381mm]	280psig [1930kPag]	325psig [2240kPag]	265psig [1830kPag]
Max 20" [508mm]	265psig [1820kPag]	315psig [2170kPag]	260psig [1790kPag]
Max 25" [635mm]	250psig [1720kPag]	300psig [2070kPag]	250psig [1720kPag]

Notes:

1. C to C distances over 25" require the use of glass unions and refractive protectors to stabilize the glass.

Tubular Gagecocks

Max Pressure @ saturated temp.	Gagecock Model	Connection Size (Stuffing Box Gage X Vessel)
125 psig [860kPag] @ 353ºF [178ºC]	N6A	5/8" F X 1/2" NPTM
175 psig [1.21MPag] @ 377ºF [192ºC]	K3AJ	5/8" F X 1/2" NPTM
350psig [2.41MPag] @ 434ºF [223ºC]	N7A	5/8" F X 1/2" NPTM
350psig [2.41MPag] @ 434ºF [223ºC]	N7B	3/4" F X 3/4" NPTM
350psig [2.41MPag] @ 434ºF [223ºC]	N2AJ	5/8" F X 1/2" NPTM
350psig [2.41MPag] @ 434ºF [223ºC]	N2BJ	3/4" F X 3/4" NPTM
350psig [2.41MPag] @ 434ºF [223ºC]	N2CJ	3/4" F X 1" NPTM
350psig [2.41MPag] @ 434ºF [223ºC]	K2AP	5/8" F X 1/2" NPTM
350psig [2.41MPag] @ 434ºF [223ºC]	K2BP	3/4" F X 3/4" NPTM
350psig [2.41MPag] @ 434ºF [223ºC]	K2CP	3/4" F X 1" NPTM
360 psig [2.48MPag] @ 434ºF [223ºC]	K3BJ	3/4" F X 3/4" NPTM

Notes:

1. Grafoil® or PTFE glass packing and stem packing required for steam service.

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Nipple Ended Gage Configuration

	Max Pressure @ saturated temp.	Gage series	Gagecock (series)	Connection Type	Notes
Allowable	350psig [2.41MPag] @ 434ºF [223ºC]	RM/RMR	300 / 400 500 / 700	threaded nipple	1, 2, 9,11
		RM/RMR	780R	3/4" stuffing box	1, 2, 9
		STM	300 / 400 500 / 700	threaded nipple	2, 4, 9,11
Acceptable	450psig [3.10MPag] @ 459ºF [237ºC]	STM	780R 4000T/4000S	3/4" stuffing box	2, 4, 9
	650psig [4.48MPag] @ 497ºF [258ºC]	STM	780R 4000T/4000S	3/4" stuffing box	3 ,4, 9
Recommended	650psig [4.48MPag] @ 497ºF [258ºC]	TSL	780R 4000T/4000S	3/4" stuffing box	5, 9
	850psig [5.86MPag] @ 526ºF [274ºC]	TSM	780R 4000T/4000S	3/4" stuffing box	5, 9
	1500psig[10.34MPag]@ 596ºF [313ºC]	TSM	780R 4000T/4000S	3/4" stuffing box	5, 6, 9
	1800psig[12.41MPag]@ 621ºF [327ºC]	Colorport-4511N	780R 4000T/4000S	3/4" stuffing box	6, 7, 9

Flanged Expansion Loop Gage Configuration

	Max Pressure @ saturated temp.	Gage series	Gagecock	Flange Type	Notes
Recommended	650psig [4.48MPag] @ 497ºF [258ºC]	TSL-F	730R	STD 1/2" CL600 LF	5, 8, 10
	1500psig[10.34MPag]@ 596ºF [313ºC]	TSM-F	730R	STD 1/2" CL1500 LF	5, 8, 10
	1800psig[12.41MPag]@ 621°F[327°C]	Colorport-4595F	730R	STD 3/4" CL1500 RF	7, 8, 10
	3000psig[20.68MPag]@ 695ºF [368ºC]	Colorport-4595F	L200v	STD 3/4" CL2500 LTRF	7, 10

Notes:

1. Grafoil® gaskets w/ 316 STS inserts required at additional cost.
2. Belleville washers are highly recommended at additional cost to reduce thermal effects on clamping pressures.
3. Belleville washers are required at additional cost to reduce thermal effects on clamping pressures.
4. Grafoil® gaskets w/ 316 STS inserts and mica shields are standard.
5. Grafoil® gaskets w/ 316 STS inserts, mica shields and Belleville washers are standard.
6. Spacer (collar) is required at additional cost at pressures above 850 psig [5.86 MPag] on upper stuffing box nipple to prevent gage disengagement.
7. Mica shields, formed graphite gasket and Belleville washers (part of port assembly) are standard.
8. With ball checks omitted for ASME boiler service.
9. With ball checks omitted (320J / 330J / 420P / 430P / 520R / 530R / 720R / 730R / 780R / 4000T / 4000S) or with horizontal leaky ball seat upper and vertically rising ball check lower (320J / 420P / 520R / 720R / 780R / 4000T / 4000S) at additional cost for ASME boiler service (end connected only).
10. Model Hy-P-Check ball checks available at additional cost.
11. The recommended gagecock type is 500 or 700.

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Replaces 05/05

For: **STEAM/WATER GAGES – SELECTION GUIDE**

Penberthy/Yarway manufactures flat glass, direct reading liquid level gages. We provide gages for a variety of applications, pressures, and temperatures, including large-chamber gages for viscous or volatile liquids, and weld-pad gages for welding directly onto a vessel without the use of gagecocks.
Our standard liquid level gages are rated as high as 4000psig [27.58MPag] and 600°F [316°C]. These gages have tempered borosilicate glass. By substituting aluminosilicate glass we can increase the temperature rating to 800°F [427°C] depending on the application. Above 800ºF [427ºC], quartz may be substituted for the glass depending on the application - contact the factory for application assistance. (Note - Penberthy offers the Model TU ultra-high pressure gage, rated to 6000 psig [41.37MPag] but with a lower maximum temperature rating of 250ºF [121°C]. Model TU uses a self-activating sealing system and is the optimum choice for retaining pressurized gases over liquids.)

It is important to note that the above gages are designed for process (e.g. ANSI/ASME B31.3 and B&PV code Section VIII) type applications, which may include non-fired pressure vessels containing steam & water. Saturated steam is different. Steam has latent energy and must be treated differently. Extreme caution must be used when liquid level gages are used with superheated steam - any water present would immediately flash to steam. See FAQ #14 on Gage glasses with Superheated Steam for more information on this subject.

At very low pressures - under 300psig @ 417ºF [20.7MPag @ 214ºC] - tubular glass gages are allowable. These are high maintenance items because tubular glass cannot be mica protected. They are also limited in length unless glass unions and refractive protectors are used to stabilize the glass. Tubular glass and gagecocks also find use as temporary gages during the chemical cleaning, or boil-out, of a boiler drum. This cleaning typically takes place at low pressures and temperatures. Because the chemicals used during this cleaning are detrimental to glass, low-cost tubular gages are installed in place of more expensive flat glass or bi-color gages during the chemical cleaning, then discarded once the cleaning is completed and the permanent gage is installed.

At low steam pressures and temperatures - 350psig @ 434°F [2.41MPag @ 223°C] and below - our standard RM series liquid level gages and STM series gages and gagecocks (300, 400, 500 or 700 series) with Grafoil® gaskets with stainless steel inserts are allowable and the use of Belleville washers is highly recommended. The metallic portions of the gage will not be damaged and are safe for this service. Steam at any temperature and pressure is capable of leaching glass especially when at high pH values caused by most boiler additives. The rate of attack of the glass is considered allowable by some users. If unprotected glass is placed into steam service, a rigorous maintenance program should be instituted to monitor the glass. For transparent gages, etching will be noticeable by frosting of the glass above the water line. For reflex gages, the same frosting occurs but is much more difficult to detect. Frosting is an indication that glass failure will occur and the glass should be immediately changed following normal maintenance instructions. The decision to use RM or STM gages in this service is basically their lower purchase costs and higher maintenance requirements vs. other gages with higher purchase costs but lower total service costs.

At the next level - 350psig @ 434°F to 450psig @ 459°F [2.41MPag @ 223°C to 3.10MPag @ 237°C] - transparent gages (Model STM) are acceptable. Transparent glass is necessary because a mica shield is required to protect the glass from leaching by the steam. Shields cannot be applied to reflex (prism) glass. A mica shield is a thin, flexible sheet, which is the size and shape of the glass. It fits between the glass and the gasket. Some people specify mica shields for any glass protection. However, mica shields are specifically designed for steam service and caustic service. The use of Belleville washers is highly recommended in this range.

At this level, special gagecocks are also required. Model 780 / 4000T / 4000S gagecocks are available with a "stuffing box" which accepts an adapter nipple gage connection. This eliminates a union or rigid connection between the gage and gagecock. The stuffing box allows for expansion and contraction caused by temperature variances inherent in steam service.

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Issued 03/09
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For: **STEAM/WATER GAGES – SELECTION GUIDE**

From 350psig @ 434°F to 650psig @ 497°F [2.41MPag @ 223°C to 4.48MPag @ 258°C], Penberthy / Yarway recommends our special steam/water gages - Model TSL (stuffing box) or TSL-F (flanged). These gages have different dimensions and are of heavier construction than our standard gages. Fire Box Quality Steel Plate material is used to handle the high temperatures in this service. The TSL is end-connected and the TSL-F is side-connected with expansion loops and ANSI class CL600 flanges. Both of these gages have mica shields and both have graphite composite gaskets to withstand higher steam pressures and temperatures. The TSL requires Model 780 / 4000T / 4000S gagecocks discussed above. The TSL-F requires Model 730 gagecocks, with a CL600 flanged gage connection. The 730 has a solid shank vessel connection and a rigid gage connection. Thus we eliminate all union connections. This is desirable in steam service to help prevent leaks at the connections. The decision to use TSL or TSL-F is based on application and our factory should be consulted.
The next application range is 650psig @ 497°F to 850psig @ 526°F [4.48MPag @ 258°C to 5.86MPag @ 274°C]. In this range Model TSM is used with Model 780 / 4000T / 4000S gagecocks. This is an end-connected gage with stuffing box. Mica shield and graphite composite gaskets are standard.

From 850psig @ 526°F to 1500psig @ 596ºF [5.86MPag @ 274°C to 10.34MPag @ 313ºC] the TSM and TSM-F gages may be used. The TSM gage requires Model 780 / 4000T / 4000S gagecocks as before, but because of the increased pressure, a spacer (collar) must be placed around the upper stuffing box nipple. This spacer does not allow the gage to become disengaged from the lower gagecock during operation - a condition which would allow the escape of high pressure steam. The TSM-F gage is side-connected with expansion loops and ANSI class CL1500 flanges. Both of these gages have mica shields and both have graphite composite gaskets to withstand higher steam pressures and temperatures. The TSM-F requires Model 730 gagecocks, with a CL1500 flanged gage connection.

From 1500psig @ 596ºF to 1800psig @ 621ºF [10.34MPag @ 313ºC to 12.41MPag @ 327ºC] we switch from flat glass gages to ported, or bi-color, gages. The Colorport gages Models 4511N and 4595F are recommended in this range. The Colorport gages use circular glass, sometimes referred to as "bulls eyes", and a trapezoidal gage chamber. The Colorport gages take advantage of the different refractive properties of water and steam. Green and red light from the Model L10i illuminator enter the gage chamber. Steam in the chamber lets the light pass with its path virtually unchanged, but water refracts, or bends, the light. On the opposite side of the gage from the illuminator is the Model L30d display. If the light passed through steam, the red light will shine on the viewing slot. But if the light passed through water and was refracted, the green light will shine on the viewing slot. The illuminator and display are essential components of the Colorport system for proper discrimination of water space from steam space. The Model 4511N is a stuffing box nipple-ended gage and requires Model 780 gagecocks and a spacer (collar) on the upper stuffing box nipple. These gages have mica shields and have formed graphite gaskets to withstand higher steam pressures and temperatures. All Colorport gages utilize Belleville washers, however, on ported gages they are included between the cover and the glass instead of on the cover bolts.

Our highest application range is from 1800psig @ 621ºF to 3000psig @ 695ºF [12.41MPag @ 327ºC to 20.68MPag @ 368ºC]. In this range, the Colorport Model 4595F gage is recommended. The Colorport Model 4595F is a side-connected gage with expansion loops and ANSI class 2500# large tongue flanges. The 4595F requires Model L200v gagecocks with ANSI class CL2500 large groove flanges.

All of our steam/water gages can be supplied with a water column. Water columns provide several benefits: they provide support for the gage, they provide a buffer against vessel turbulence - helping to stabilize the level in the gage, and they provide a means of meeting vessel center distances that could not be met with a gage / gagecock combination alone. A water column can also contain conductivity probes as part of an electronic water level indication system, which can also be provided by Penberthy/Yarway.

In addition, flanged side-connected gages can also be supplied with a tie-bar. A tie-bar consists of a set of L200v gagecocks with a pipe welded between them. This is also referred to as a circulating tie-bar because water can circulate through the adjoining pipe. The tie-bar has some of the same benefits as a water column: they provide support for the gage and they provide a buffer against vessel turbulence - helping to stabilize the level in the gage, but the tie-bar vessel connection centers must be the same as the gage connection centers.

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Issued 03/09
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For: **STEAM/WATER GAGES – SELECTION GUIDE**

To meet code requirements, gagecocks in steam service preferably should be specified with "ball checks omitted". Alternately, vertically rising lower and horizontal upper "leaky" ball checks may be used with end connected gages. The code also strongly recommends the use of OS&Y type bonnets, Penberthy's 500 and 700 series gagecocks. At pressures above 1800psig [12.41MPag], Model Hy-P-Check ball checks are available as separate items. Consult the factory for application assistance.

As mentioned above, expansion and contraction of the parts during temperature cycles is a real problem. As this happens the gages lose their axial bolting loading. The gages must be re-torqued on a regular basis. Otherwise, leaks will occur around the gasket. This can lead to leaching of the glass, and even to steam cutting of the metal gasket surface. This in turn leads to down time and high maintenance costs, as glass, gaskets, and cushions have to be replaced. If this occurs too often, at some point the gasket will no longer seal and a new gage has to be ordered.

For these reasons Penberthy provides Belleville washers on all TSL/TSM gages. These are conical spring washers, 1 on TSL and 3 on TSM per nut, which absorb the expansion and contraction while maintaining the proper closure force. It reduces down time and maintenance costs. (See Penberthy's Steam/Water Gage TSL/TSM IOM #2957).

Mica in Steam Service

It is our experience that most glass failures are primarily related to the mica. Many postulations exist for this degradation of the mica, from poor mica, mineral inclusions, to water chemistry have been offered. However, it is our belief that most of these are secondary causes of degradation. We believe that most of the primary causes of mica degradation are hydrothermal alteration of the mica surface due to the high temperature, high pressure reactions of the mica with the boiler water coupled with the damaging effects of blowdown. This hydrothermal alteration is well documented in literature; essentially, the mica goes into solution resulting in a reduction in mica thickness and a mica surface that becomes "checked" with rhombic impressions. This can substantially reduce gage visibility. A blowdown will not improve the visibility in this case.

Gage blowdown can be very damaging to any mica. Since mica has a laminated structure, when it is cut into shape, the plane of the cut will cut across the plane of the laminates. When installed in a gage, the steam will filter through these cuts and pressurize the areas between these laminates. When the pressure within the gage is reduced during blowdown, the laminates can be "blown apart" since the restriction of the cut does not permit the pressure between the laminates to follow sudden gage pressure reduction. This can reduce port life significantly. In our opinion, blowdowns should be kept to a minimum to improve port life – washdowns are as effective as blowdowns for cleaning sediment and have negligible effect on port life.

Since there is no other substitute, (man made or otherwise) for mica, Penberthy/Yarway recommends a "washdown" procedure as outlined in our Colorport gage manual. In addition, as a rule, the higher the operating pressure and temperature the greater the attack on mica. A mica life of 4 to 8 months can be expected based on our experience, for operating pressures above 1550psig [10.69MPa].

It is up to the customer to establish a maintenance regimen based on his own experience. The last indication of impending mica (and glass) failure is when a particular port takes on a "milky white" appearance. Catastrophic glass failure with the violent discharge of high velocity steam is the result if corrective action is not taken. These problems are not exclusive to Penberthy but of all high pressure design steam/water gages in the industry.