Kistler-Morse®

BOLT-ON MICROCELL® SYSTEM SELECTION GUIDE

INTRODUCTION

The heart of a bolt-on system is the Microcell® sensor, a highly sensitive and thermally stable semi-conductor strain gage module. When bolted to the support structure of a storage vessel, the Microcell sensor measures changes in compression of the steel and provides an electrical output directly proportional to the contents of the vessel.

Because bolt-on level sensing includes parts of the vessel structure in the measurement system, getting the best performance out of your system requires a thorough understanding of your vessel and the environment in which it operates. Characteristics such as vessel type, support structure size, vessel location (indoors and outdoors), and maximum weight of the live load all influence the performance of your system.

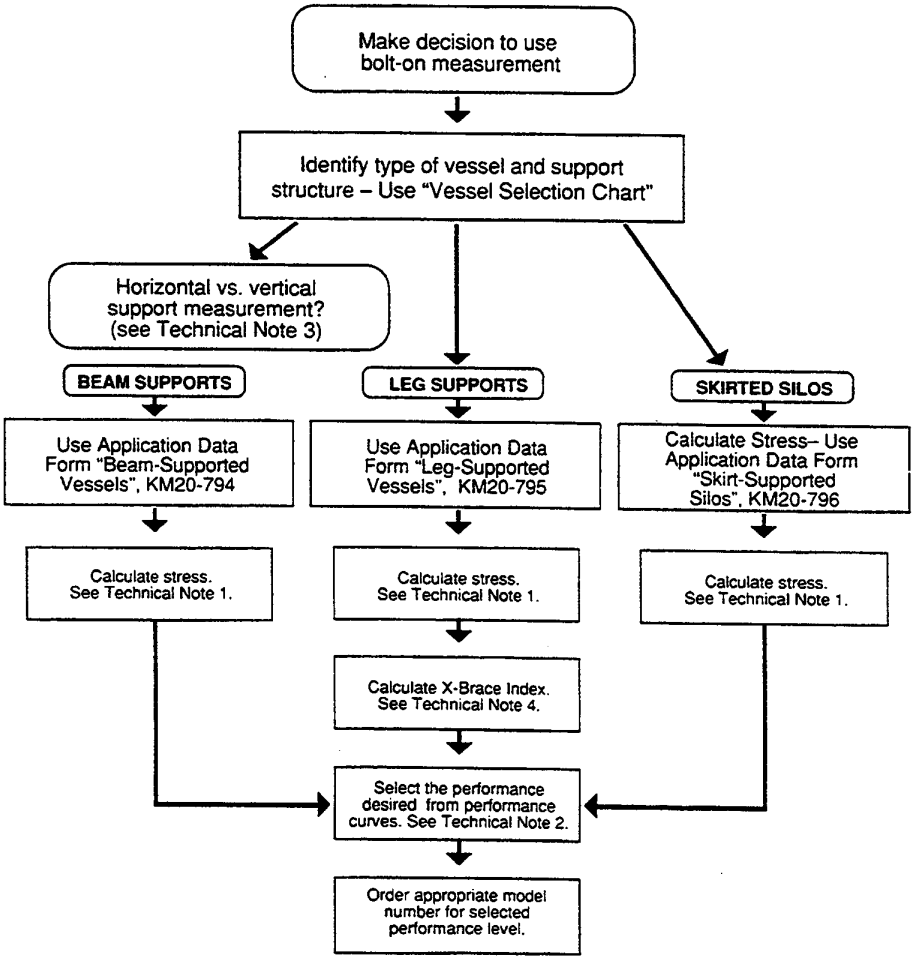
It is equally important to know characteristics that do not influence performance. Bolt-on level sensing measures material volume by weight and is not dependent on surface level for measurement. Therefore, the type of material, material density, and vessel weight or diameter do not affect performance. Rat-holing, side buildup, and bridging do not affect performance either.

This guide is designed to aid you in selecting the bolt-on system that best meets your requirements. In order to ensure the best performance and the greatest satisfaction, thoroughly read everything that pertains to your vessel and make sure all information is correct.

VESSEL CALCULATION FLOW CHART

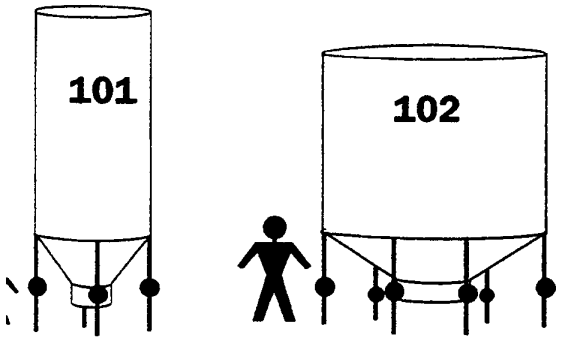
Use this flow chart to understand the major steps in selecting a bolt-on system for a given application.

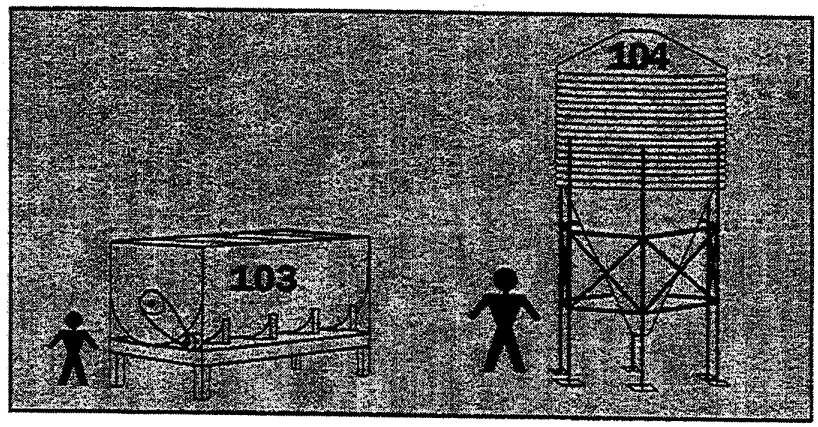
VESSEL CALCULATION FLOW CHART



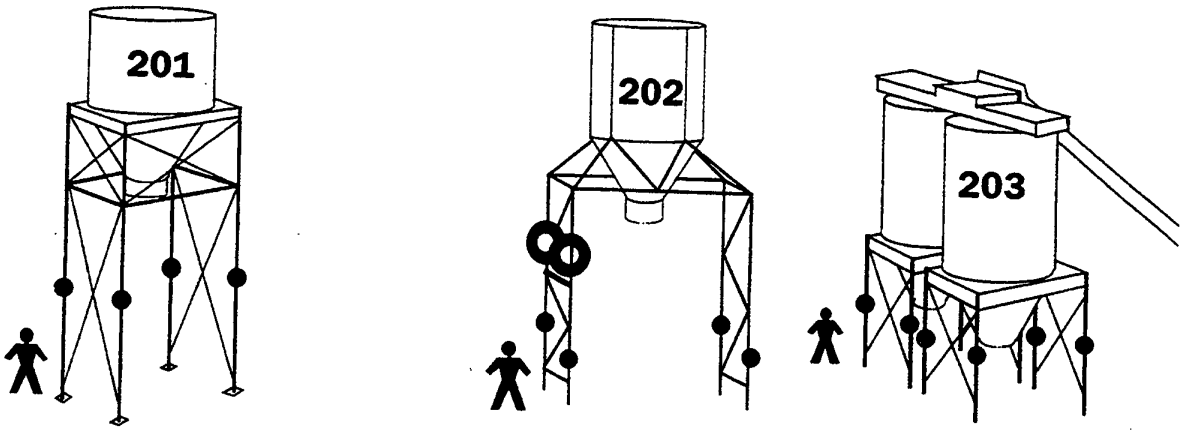
LEG-SUPPORTED VESSELS – Use Application Data Form KM20-795

Series 100 – No X-Braces (N = 0)

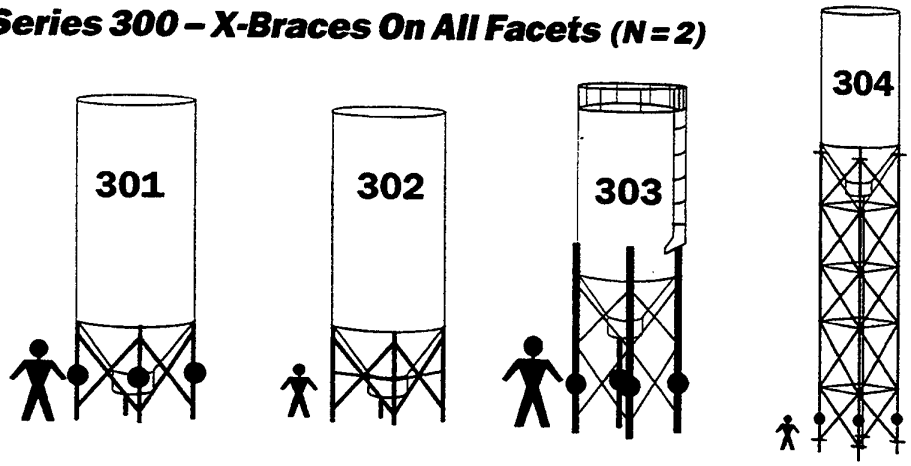




Series 200 – LOADOUT SILOS – X-Braces On Two Facets (N = 1)



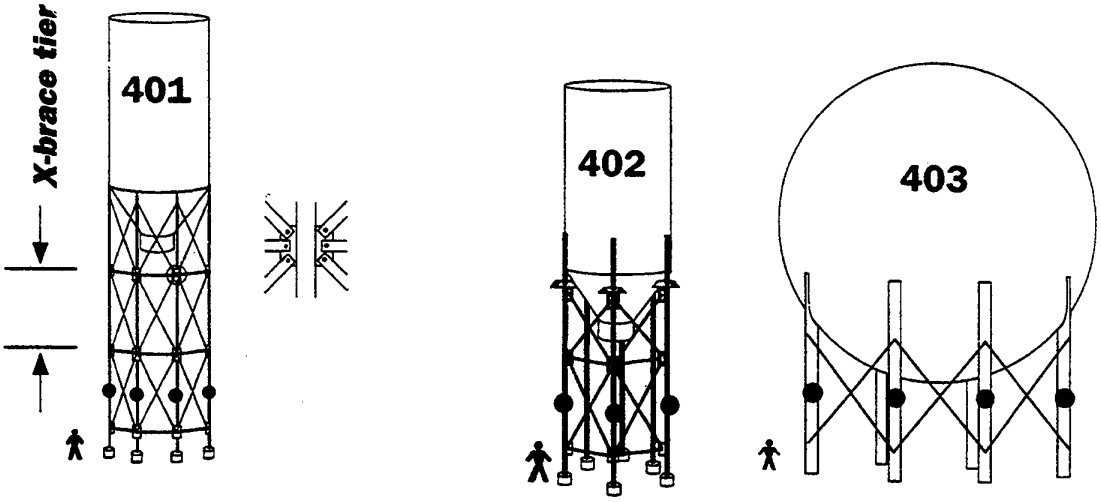
Series 300 – X-Braces On All Facets (N = 2)



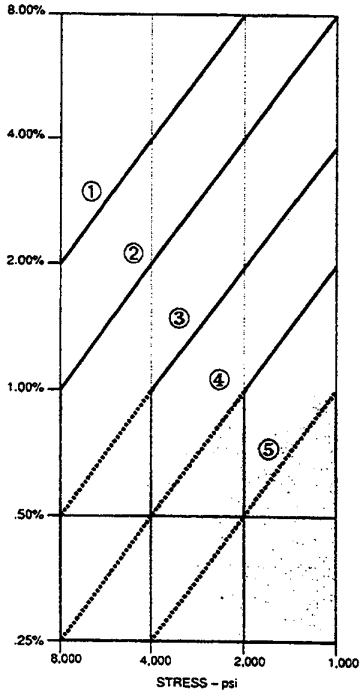
● ***Represents typical mounting location for placement of two-sensor array.***
Error specifications published in this document are effective for all bolt-on products shipped after July 1, 1990.

LEG-SUPPORTED VESSELS

Series 400 – LARGE VESSELS – X-Braces On All Facets (N = 2)



Typical Performance



OUTDOOR VESSELS

① MODEST PERFORMANCE

② STANDARD PERFORMANCE

③ BEST PERFORMANCE

INDOOR VESSELS

③ STANDARD PERFORMANCE

④ BEST PERFORMANCE

⑤ BEST PERFORMANCE UNDER OPTIMUM CONDITIONS. VESSEL MUST BE INDOORS AT CONSTANT TEMPERATURE WITH SOLID FOUNDATION. REQUIRES FACTORY QUOTE AND INSTALLATION, AND PERHAPS ADDITIONAL EQUIPMENT.

Performance is a function of the full-scale stress in the vertical support structure, and the vessel location (indoors or outdoors). Performance in the shaded area of the graph requires factory quotation and installation. Optimum performance on any system requires the following qualifications.

- Live load must be 100,000 lbs (45,000 kg) or greater.
- Supports must be securely bolted to a solid foundation such as concrete.
- All outdoor vessels require wrap on legs with sensors.
- Vessels with X-braces (Series 200 through 400) may require wrap on X-braces for Best Performance applications. Certain applications may require sensors to be mounted on the X-braces. See Technical Notes.

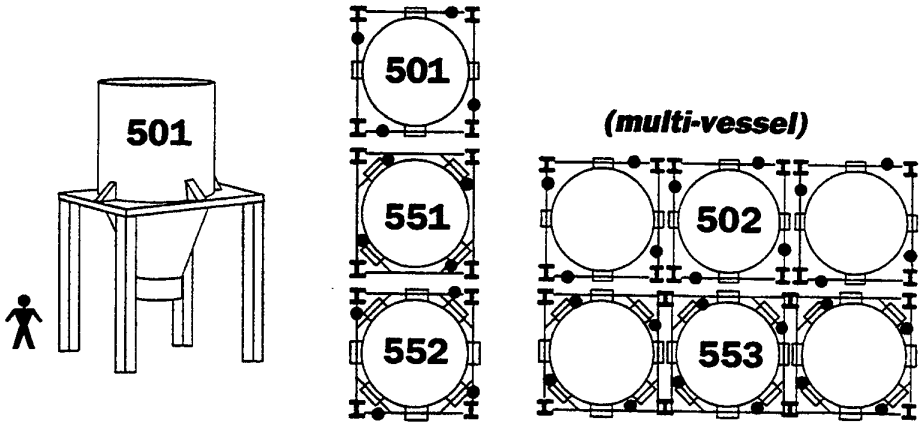
Application Notes (See Shaded Drawings)

Long Structures (Series 103). Stiffness of the horizontal and longitudinal beams is an important consideration on long structures with short legs. Inadequate stiffness can cause excessive bending in the legs and consequent performance degradation. Consider Direct Support transducers for these applications.

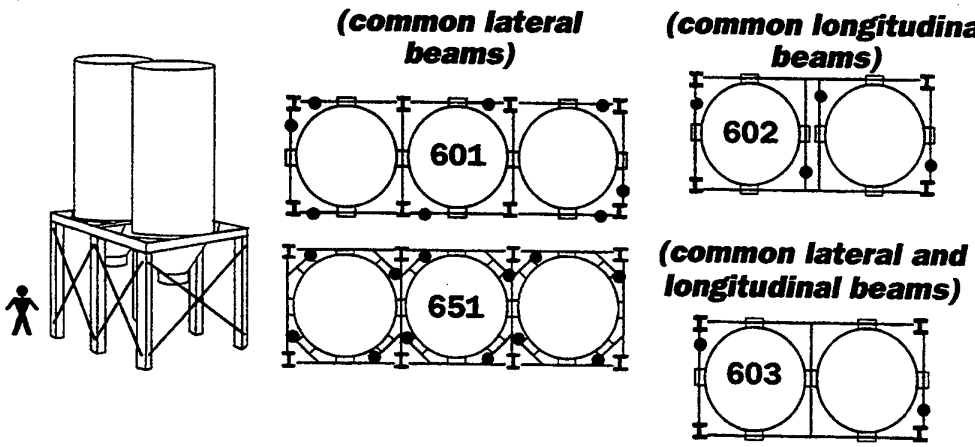
Feed Bins (Series 104). If the vessel is of corrugated construction, the entire support structure may be too flexible for Bolt-On sensors. Direct Support transducers will give better performance.

BEAM-SUPPORTED VESSELS – Use Application Data Form KM20-794, "Beam-Supported Vessels" (See Technical Note 3)

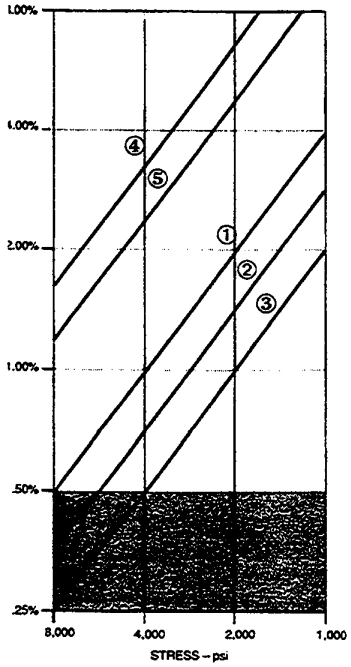
Series 500 – Independent Horizontal Beams and Vertical Columns



Series 600 – Common Horizontal Beams and Vertical Columns



Typical Performance



SERIES 500 AND 550 VESSELS

① MODEST PERFORMANCE

② STANDARD PERFORMANCE

③ BEST PERFORMANCE

SERIES 600 AND 650 VESSELS

④ MODEST PERFORMANCE

⑤ STANDARD PERFORMANCE

(Series 600 and 650 vessels typically exhibit errors greater than similar free-standing vessels. The degree of coupling is difficult to predict so actual performance may be greater or lesser than these curves predict.)

Performance is a function of the full-scale stress in the horizontal support structure. Performance in the shaded area requires factory quotation and installation. Optimum performance for any application must meet the following qualifications.

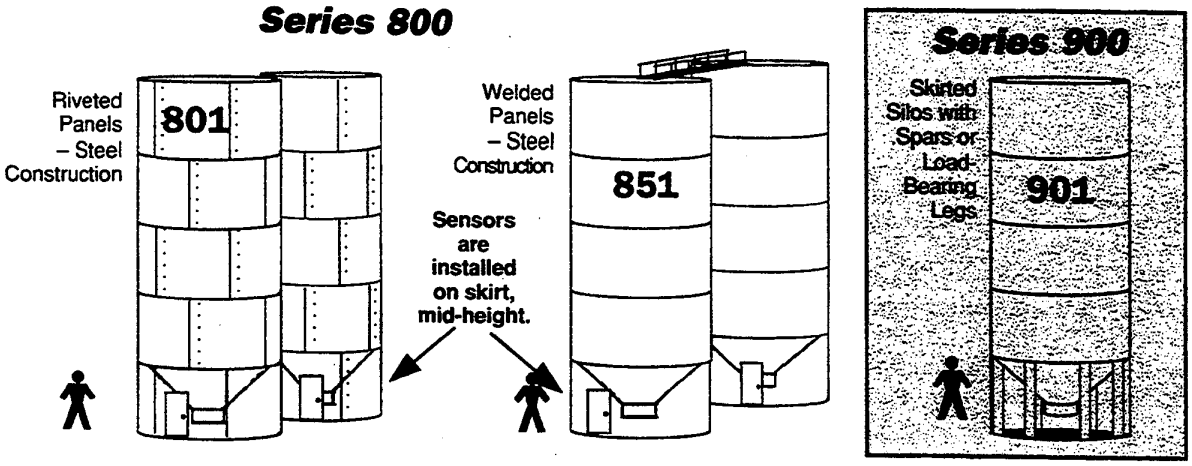
- Live load must be 100,000 lbs (45,000 kg) or greater.
- At least 12" (30 mm) of free length, or twice the web height, whichever is greater, must exist between support points.

Application Notes

Multiple Vessels. In order to meet Series 500 performance, all horizontal beams must be decoupled from adjacent vessels. If vessels share any horizontal or lateral supports, use Series 600 Performance Charts.

Single Vessels. Single vessels can also be treated as vertical-leg structures (Series 100 to 400) if instrumenting the horizontal beams proves impractical. See Technical Note 3.

SKIRT-SUPPORTED VESSELS – Use Application Data Form KM20-796 "Skirted Silo

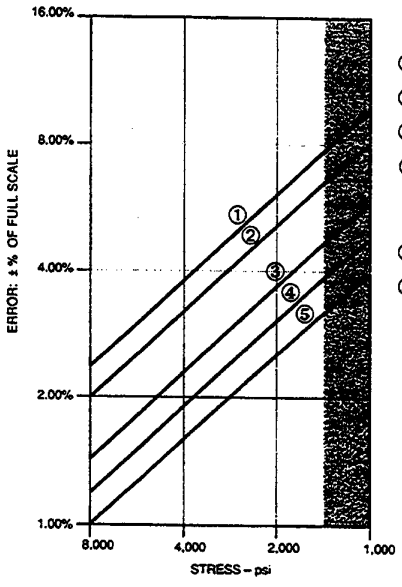


- The silo should be white.
- The silo must have a solid foundation with grout between the steel and the concrete pad for even weight distribution in the panels.
- Outdoor vessels require customer-supplied wrap for Standard Performance.

Application Notes (See shaded drawing)

Silos with spars or load-bearing legs (Series 901). Performance is difficult to predict on these vessels. Consult factory for performance specifications.

Typical Performance



OUTDOOR VESSELS

① MODEST PERFORMANCE – SERIES 850
② MODEST PERFORMANCE – SERIES 800
③ STANDARD PERFORMANCE - SERIES 850
④ STANDARD PERFORMANCE - SERIES 800

INDOOR VESSELS

② MODEST PERFORMANCE - SERIES 850
⑤ STANDARD PERFORMANCE - SERIES 800 AND 850

SHADED AREA: CONSULT FACTORY

Performance is a function of the full-scale stress in the cross section of the supporting skirt. For optimum performance the application must meet the following qualifications.

- Live load must be 100,000 lbs (45,000 kg) or greater.

NECESSARY CONDITIONS FOR ACHIEVING STATED ACCURACIES

In order to achieve the stated level of performance with bolt-on strain sensors, it is important to heed some fundamental rules.

Isolated Vessels

Independent, isolated vessels with no connection to any other vessel or adjacent structure are of course the best measurement candidates, although this condition is difficult to achieve in practice. Vessel types 203 may not appear to be coupled. However, depending on the methods of construction, the "pants leg" at the top may cause interaction between the two vessels. As one vessel fills, its support structure compresses slightly, thereby pulling down on the adjacent vessel and registering a false change in the second vessel's weight indication.

Rigid piping connections between the measured vessel and any other adjacent structure must be "softened up", perhaps with flexible couplings or with a horizontal section leading directly to the vessel. Catwalks and ladders may also cause measurement errors.

Independent Support Members

Bolt-on sensors deliver the most accurate results when mounted on independent support members. For example, the vessels in type 553 share common interior vertical columns. The same is true of vessel types 602 and 603 which have shared corner columns. Because of the shared vertical columns, these vessel types are instrumented as "Horizontal-Beam" vessels, and not as "Leg-Supported" vessels.

Horizontal beams are generally better candidates for bolt-on measurement because stresses can be as low as 50% of the stress in a vertical column for the same levels of performance. However, common horizontal beams must not be instrumented. For example, vessel types 601, 603, and 651 have common internal lateral beams. These vessels are instrumented with fewer bolt-on sensors, and will have slightly diminished performance than vessels with no common horizontal beams.

Two sources of error arise in using bolt-on sensors to measure material level in adjacent connected vessels:

1. If bolt-on sensors are not placed symmetrically around the vessel, a change in the location of the center of gravity of the vessel contents will cause a change in the indicated weight. (E.g., sensors on only three of the four horizontal beams, or on only two of the four vertical columns.)

2. If the live load in an adjacent vessel changes, the loading on a shared beam changes, thus causing that beam to deflect or spring back slightly. This changes the loading and therefore the stress in the independent support members of the measured vessel even though its level remains constant.

Well-Built Facility

Vessels must have rigid foundations to prevent uneven settling during a fill or an unload cycle. All joints and mechanical connections must be rigid and well-maintained. (There is one exception to this rule: some vessels have rod and eye-bolt X-braces. If these connections remain loose under all operating conditions of the vessel, the error effects of X-braces will be absent.) Vessels and support structures must have adequate rigidity. Vessel 103, for example, must have sufficiently stiff longitudinal members to prevent the legs from splaying during a fill cycle. Vessel 104 is a marginal one for bolt-on measurement because its sidewalls and support structure are generally quite flexible.

TECHNICAL NOTES

General

1. UNDERSTANDING AND CALCULATING STRESS. The magnitude of compressive stress in each support member resulting from the vessel's live load has the greatest influence on system performance. Microcell sensors produce an output voltage proportional to stress. Environmental conditions such as the sun's radiation on the vessel structure cause a sensor error voltage independent of the stress caused by changes in the live load. Therefore if the full-scale stress is large, the error as a percent of full-scale will be smaller. Consequently, performance is much better for a vessel with a large live-load stress (3,000 psi or greater).

2. CHOOSING PERFORMANCE LEVELS. Three performance levels are available for most bolt-on applications. They are:

Best Performance. This performance ranges from 0.5% to 4% of full scale, depending on the application. Select Best Performance when monitoring the inventory of high-value materials, or for most loadout applications.

Standard Performance. This performance ranges from 0.5% to 8% of full scale. Choose Standard Performance for most inventory measurement applications.

Modest Performance. This performance ranges from 2% to 12% of full scale. Choose this performance when cost is a major factor or as an alternative to point level or mechanical measurement methods.

All three performance levels can be calculated for all applications when the full-scale stress and brace factor are known.

3. GUIDELINES FOR MOUNTING THE MICROCELL SENSORS ON HORIZONTAL OR VERTICAL SUPPORT MEMBERS. Many storage vessels are supported by a square or rectangular framework of H- or I-beams supported by vertical legs. The question of whether to install the Microcell sensors on the vertical columns (measuring compressive stress) or on the horizontal beams (measuring shear stress) must be answered. Mount the sensors on the horizontal beams if any of the following holds:

a. more than one vessel is supported by common vertical columns. See vessel types 553, 601, 602, 603, and 651;

b. independent horizontal beams have 50% or greater full-scale stress relative to the vertical legs;

c. the vessel is supported by horizontal diagonal beams only.

Mount the sensors on the vertical columns if:

a. the compressive stresses in the vertical columns are more than twice the shear stresses in the horizontal beams.

In general, bolt-on level measurement is more accurate on horizontal installations than on vertical installations.

Outdoor Vessels with Sensors on Vertical Legs and with X-Braces

4. DESCRIBING THE EFFECTS OF X-BRACES. On outdoor vessels, X-braces connected to the vertical columns of the vessel can add to the measurement error. This portion of the structure typically has a smaller cross-sectional area than that of the main load-carrying members; i.e., the vertical columns. Under the influence of the sun's radiant energy, the braces change temperature much more rapidly than the columns. This causes the braces to push up on the legs during heating periods and to pull down on the legs during cooling periods, thereby inducing strains which affect the Microcell sensors in the same way that a changing live load affects the strain sensors. (See vessel series 200, 300, and 400 for some typical X-brace patterns.)

5. DETERMINING THE EFFECTS OF X-BRACES. The magnitude of the X-brace error effects can be assessed by calculating a quantity known as the Brace Index. If the vessel has legs and X-braces that are made up of flat shapes such as H- or I-beams, angle iron, or channel iron, the legs and braces are referred to as "webbed." The brace index for this structural shape is called "Index – Webbed" or "IW." This index is essentially the ratio of the load-carrying capacities of the braces and legs multiplied by a heat transfer effect that is the ratio of the leg and the brace web thicknesses. If the legs are an enclosed form such as pipe or hollow rectangular tubing, the brace index is called "Index - Pipe" or "IP." It is the ratio of the load-carrying capacities of the braces and of the legs. (The heat transfer effect for enclosed-form legs is too complex to be characterized by a thickness ratio as for IW.)

For both brace indices, the larger the value of the index, the greater will be the errors caused by the environment interacting with the leg and brace support structure.

6. COMPENSATING FOR THE EFFECTS OF X-BRACES. Several methods have been developed to compensate for the effects of X-braces: 1) install wraps on the X-braces to equalize the expansion and contraction rates between the instrumented vertical columns and the braces; 2) install strain sensors on the braces; 3) install both strain sensors and wraps on the X-braces if the brace index is large enough to require such double treatment.

Table 1 shows the required X-brace treatment versus brace index if a Best Performance system is selected. Table 2 shows the required brace treatment for Standard and Modest Performance systems.

TABLE 1: BRACE TREATMENT FOR BEST PERFORMANCE SYSTEMS

IP	*IW*	*Brace Wrap*	*Brace Sensors*
0→0.05	0→0.05	Not Applicable (N.A.)	N.A.
0.05→0.15	0.05→0.25	YES	N.A.
0.15→0.30	0.25→0.40	N.A.	YES
0.30→0.45	0.40→0.55	YES	YES
0.45→	0.55→	PERFORMANCE FALLS BELOW GUIDELINES	

TABLE 2: BRACE TREATMENT FOR STANDARD AND MODEST PERFORMANCE SYSTEMS

IP	*IW*	*Standard Performance*	*Modest Performance*
0→0.30	0→0.40	No Brace Treatment	No Brace Treatment
0.30→0.45	0.40→0.55	Brace Wrap	Brace Wrap
0.45→	0.55→	PERFORMANCE FALLS BELOW GUIDELINES	

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