PROPERLY INSTALL COLUMN INTERNALS

Good installation is crucial for trouble-free startups and optimum tower performance

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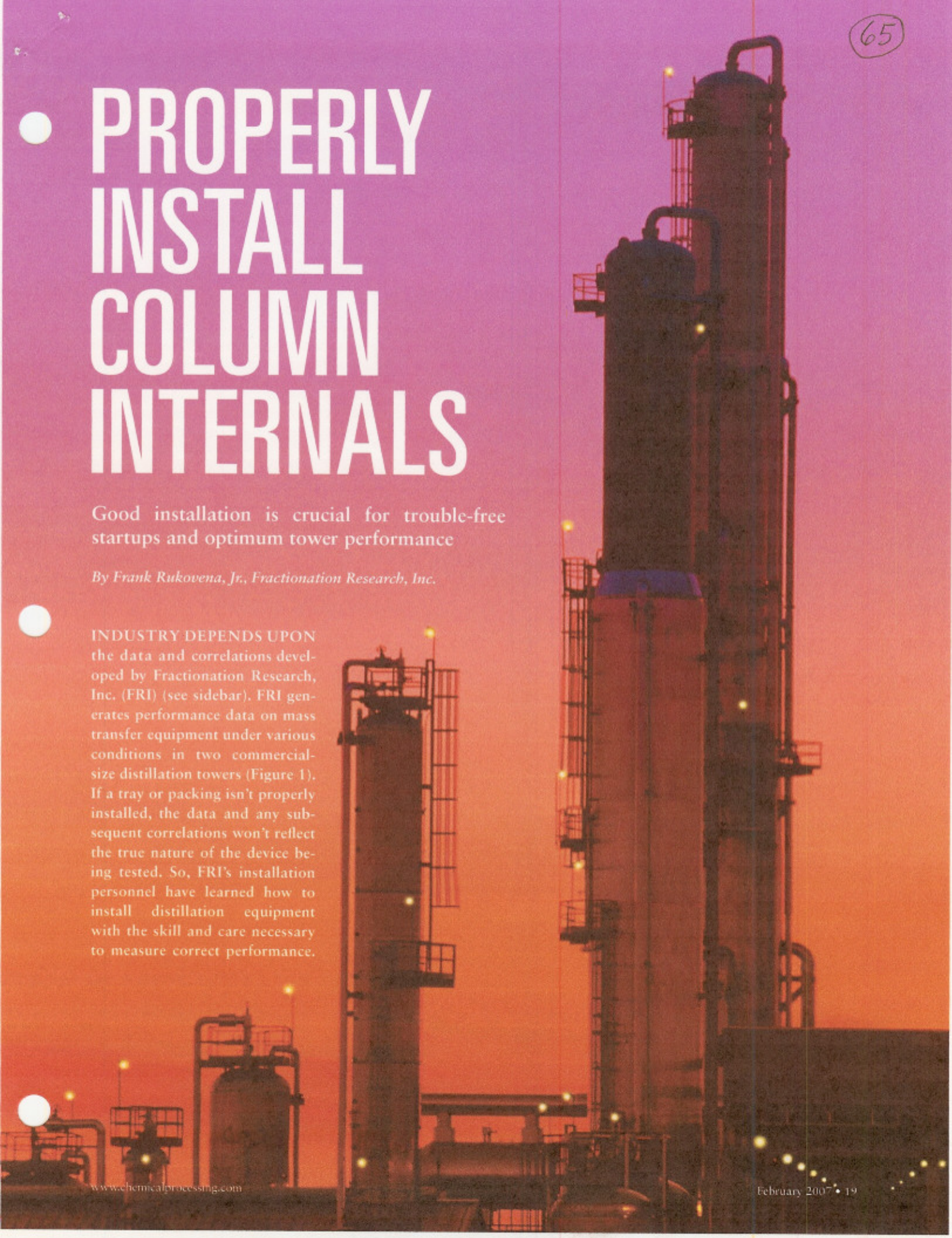
INDUSTRY DEPENDS UPON the data and correlations developed by Fractionation Research, Inc. (FRI) (see sidebar). FRI generates performance data on mass transfer equipment under various conditions in two commercial-size distillation towers (Figure 1). If a tray or packing isn't properly installed, the data and any subsequent correlations won't reflect the true nature of the device being tested. So, FRI's installation personnel have learned how to install distillation equipment with the skill and care necessary to measure correct performance.



>> **Pilot plant**

Figure 1. FRI has both high- and low-pressure commercial-size distillation columns.

In this article, we share some of that practical knowledge. It will help you make sure that the tower you are erecting will work as expected. The advice also applies to absorbers and strippers.

First, unless you or your installers are familiar with installing trays and packing, it is best to have the equipment vendor's representative on hand during the equipment installation. At a minimum, the representative should be present to inspect critical items as they are installed.

Now let's look at what should be done both before and during installation.

Pre-installation activities

For a new tower, start at the fabrication shop. There, check:

- tower internal diameter, especially around nozzles and manways;
- tangent-to-tangent measurement;
- roundness;
- location of wall clips;
- location of support rings;
- levelness of clips and rings; and
- removal of scale and dirt

After erection, check:

- tower roundness (large diameter towers can become elliptical);
- tower vertical-ness; and
- for scale and dirt (especially for packed towers with small-orifice liquid distributors).

A tower that is out-of-round by more than that allowed for by the trays' and internals' designs can make their installation difficult. It's best to find this out before starting installation. Out-of-roundness occurs especially in the area of the manways and nozzles. Be prepared to do field modifications to some of the hardware during installation.

For an existing tower, do the same pre-installation checks. Tower roundness can change during years of operations and it's best to know this during the equipment specifying stage.

Installation for packed towers

When dealing with packing, whether random or structured, you must pay close attention to the installation of five key elements:

1. support plate;
2. packing;
3. packing retainer;
4. distributor; and
5. feed pipe.

Support plate. Random packing support plates normally are multi-beam-type units (Figure 2) and usually are set on a continuous support ring. It's important that the support beams fit the ring correctly so they don't fall off the ring during vapor flow surges. If an upset is possible, it's a good practice to clamp the support plate to the support ring. Because the top of the random packing bed can be leveled to maintain the specified clearance between the top of the packing and the liquid distributor, levelness of the ring isn't critical; so, normal construction tolerances are acceptable.

Tower roundness can change during years of operations and it's best to know this during the equipment specifying stage.

Structured-packing support grids usually are flat-bar-type units (Figure 3). The support grid may be set on a ring or attached to wall clips. Take care to make sure the ring is level to within vendor specifications — if it isn't level, this error carries all the way to the top of the bed, which may interfere with liquid distributor installation above the bed. If the support grid is set on a ring, consider clamping it to the ring if severe vapor surges are possible.

FRACTIONATION RESEARCH, INC.

FRI is a non-profit organization that for more than 50 years has focused on research and evaluation of trays and packings. It generates data in its two commercial-size distillation towers. (The low-pressure column has 4-ft. and 8-ft. diameter sections. The high-pressure column is 4 ft. in diameter. The test distillation conditions range from full vacuum to 500 psia. Typical test fluids include p-xylene/o-xylene, cyclohexane/n-heptane, and iso-butane/n-butane.) These data are used to develop and improve design correlations. Many vendors have trusted FRI to test their products and all of FRI's members depend on FRI's data and correlations to design their towers. Membership is open to any company that uses, designs or supplies direct-contact mass-transfer equipment. See www.fri.org for the list of members and other information about FRI.

Random packing. Metal random packing normally is poured into a tower from boxes or bags. The vertical distance a metal packing can be poured is about 20 ft. However, the exact distance depends upon the packing shape and the gauge of material from which it is made; so, always check with the vendor. Don't crush the packing into the support plate. A good practice is to lower the first packing onto the support until the plate is covered with a foot or more of packing. Take care not to introduce dirt and particulates into the tower during installation because they may plug up the liquid distributors after startup.

Also, make sure to evenly fill the tower. The creation of void spaces in the packed bed or at the packing/tower-wall interface can lower the apparent packing efficiency. The packing can be leveled as you go by spreading the packing around as it is poured or by using brooms and rakes to level it. It's best not to walk on the packing to install it. If unavoidable, use boards to spread the weight of the person. Check with the packing supplier about the proper way to stand or walk on the random packing.

Plastic random packing can be handled in much the same manner as metal. However, you must make allowances for the material. The allowable drop height can change with the ambient temperature because a plastic material's brittleness increases with decreasing temperature. Plastic packing also has a lower upper operating temperature limit than metal packing. Consult the supplier about temperature limitations of the plastic being used and how that affects drop height, general handling, and operating temperature.

Providing a manway or nozzle above the support plate of each packed bed in the tower can ease packing removal. While the packing can be scooped out from the top, this is slow and labor intensive. Vacuuming the packing out of a tower is another option, particularly for large towers. It's the fastest way to remove the packing but can pose the risk of damaging the packing, depending on its shape and gauge. In most cases the damage is slight and the packing can be reused. Consult with the packing supplier before using the vacuum method, though.

Structured packing. Metal structured packing comes in blocks that are normally sized to allow installation through a manway. It's very helpful to lay out each layer of structured packing before installing it into the tower to make sure the configuration is correctly understood. For large towers where this isn't practical, it nevertheless is worthwhile to take the time to lay out one layer of each layer design outside of the tower to check it has the correct dimensions. This also helps in understanding how the layers are to be rotated. Take care not to introduce dirt and particulates into the tower during installation as they may plug up the liquid distributors after startup.

The first layer on the support grid must be correctly oriented to obtain proper support. Rotate subsequent layers per the vendor's instructions. The orientation from one layer to the next is usually 90°. Place the bundles of packing so they don't have space between them and so they correctly meet the tower wall. If the bundles have a wall wiper, it should touch the wall. Some vendors may supply extra sheets of structured packing to fill any gaps that occur between bundles. Check the bed height occasionally as the bed is built up to see if the height is as expected for the number of layers installed. Especially for large installations it's better to find out sooner rather than later whether the installed bed is going to come to the correct height.

It's good practice not to walk directly on structured packing. Use sheets of plywood or other methods for spreading the load of the person. Consult the packing supplier about how to move around on the surface of the structured packing during installation.

To help spot a poor installation, ask yourself: "Does the installed packing allow liquid or vapor to short circuit

>> **Random-packing support plate**

Figure 2. This unit typifies the multi-beam design for mounting upon a support ring.

>> **Structured-packing support plate**

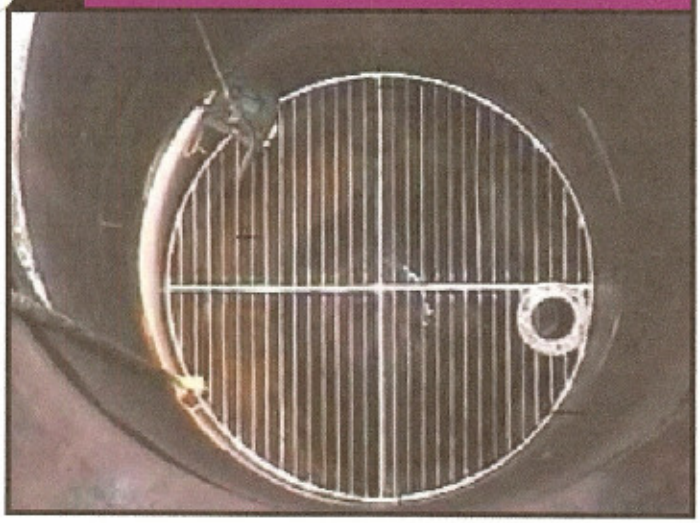


Figure 3. Structured packing commonly rests upon a flat-bar-style support.

between packing bundles or between packing bundles and the tower wall, or does it cause liquid and vapor to channel and bypass one and other?"

Packing retainer. A packing retainer is a device that holds the random or structured packing in place during upset conditions. (Figures 4 and 5.) Two conditions can move the packing around in a tower. One is a vapor surge and the other is a high liquid level in the bottom of the tower so high that liquid enters the vapor inlet or even the bottom of the packed bed.

A vapor surge can fluidize the random packing and blow it into the liquid distributor and, in the extreme case, dislodge the support plate. A high liquid level can knock the support plate off its ledge and damage packing even if the support plate isn't displaced. If either condition can exist in your tower, it's best to use a packing retainer and attach the support plate to the support ring or wall clips.

The packing retainer may be separate from or integral with the liquid distributor. The structural elements of the retainer should never interfere with the liquid leaving the liquid distributor and cause splashing. Watch out for this when installing separate retainers.

Liquid distributors. Correctly designing and installing a liquid distributor is critical to obtaining the best performance from the packed tower. The distributor's purpose is to provide an even flow of liquid across the entire top of the packed bed. We will limit discussion to properly designed gravity head distributors and will cover only those installation items that can affect the distributor's performance.

There are three basic types of gravity orifice liquid distributors: pan (Figure 6), trough arm (Figure 7), and deck. The performance of all of these distributors can be negatively affected by being installed:

- with poorly sealed joints;
- out of level;
- with construction dirt left in the tower; and
- with poorly located feed-pipe discharges.

Industrial-size liquid distributors come in sections small enough to pass through a manway and are assembled in the tower with gasketed joints. Take care to ensure that the joints are sealed. It's possible to have leaks in low-flow distributors with small orifices where a single leak flow rate can exceed the orifice flow. (See References 1 and 2 on the effects on performance of orifice layout patterns.) Whenever possible, we recommend water testing the distributor after assembly [3]. FRI installation personnel find it very useful to become familiar with a liquid distributor by laying it out before starting installation. This is especially true for distributors made up of many pieces. Be sure to check the liquid orifice size before installing the distributor.

Because the flow of liquid through an orifice is square root function of the liquid height above the orifice, doubling the liquid level causes a 41% increase in liquid flow. A liquid distributor designed for a minimum liquid rate at a 1-in. head has a 12% larger flow-rate on one side of the distributor than the other if it's ¼ in. out of level from one side to the other. A way to minimize the effect of out-of-levelness at the minimum required flow rate is to increase the liquid head to 2-in. Leveling a distributor to a tight tolerance is difficult. It's best to make sure that the liquid distributor has a built-in leveling mechanism. FRI's orifice pan distributors are hung on rods, with the length of the rods adjusted to hang the distributor the correct distance above the packing and assure levelness. With trough arm distributors, the individual arms aren't exactly level with each other, so making sure they are level on average is the best that can be done, but keep in

>> **Random-packing retainer grid**

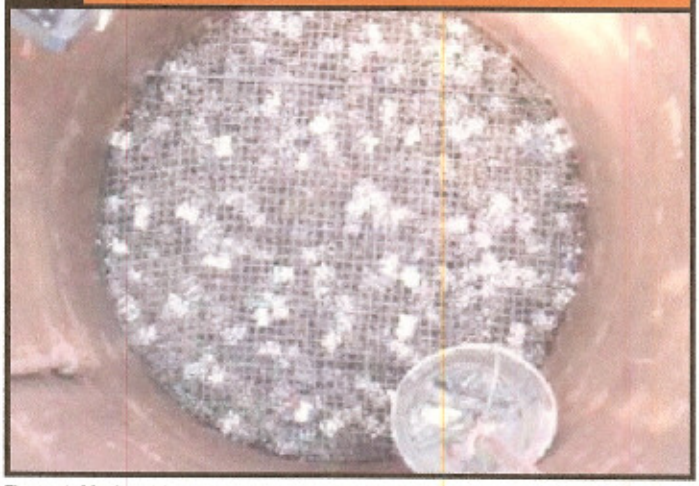


Figure 4. Mesh retainer prevents pieces of random packing from moving around during an upset.

mind the effect of head variation on the flow through the liquid orifice. Any un-levelness can reduce tower performance especially at low flow rates.

Construction dirt left in the tower can plug up the orifices. This is especially true if the orifices are in the bottom of the liquid pool. The flow unevenness caused by dirt-plugged orifices can lower tower efficiency if the number of plugged orifices isn't small and random. Plugged orifices also depress tower capacity by

Be careful not to introduce dirt into the tower during equipment installation, and inspect and clean the liquid distributor before closing the tower.

decreasing the capacity of the liquid distributor. FRI's crews are careful not to introduce dirt into the tower during equipment installation and they inspect and clean the liquid distributor before closing the tower. Always check the cleanliness of the piping leading into the tower and clean the line if necessary. (References 4, 5 and 6 cover the effect of plugged liquid distributor orifices, and their impact on performance.)

Unlike trough arm and pan liquid distributors, deck distributors are supported and sealed to the 360° tray ring. The tower wall retains the liquid on the distributor instead of the wall of a pan or trough arm. So, it's essential that the deck distributor panels be sealed to the ring as well as to one another with gasketing. The leaking of a deck distributor at the tray ring allows liquid to flow

>> **Structured-packing retainer**

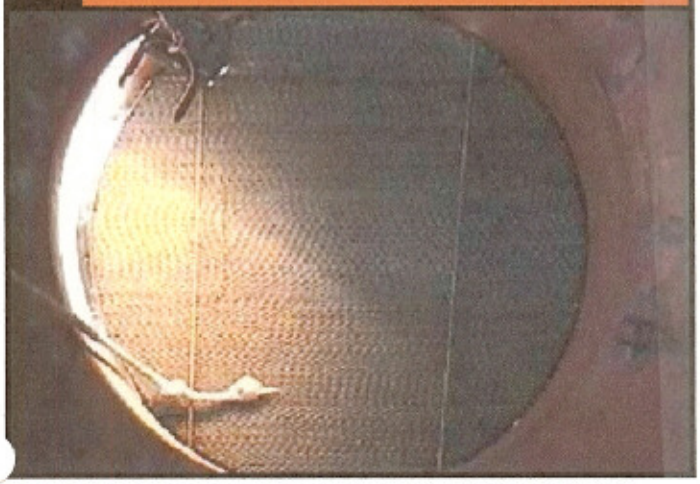


Figure 5. Bars keep structured packing in place when a column upset occurs.

>> Tube drip pan distributor

Figure 6. This FRI pan distributor design is commonly used for packing tests.

>> Trough arm distributor

Figure 7. Unit undergoes flow testing before installation.

down the tower wall, totally bypassing the packed bed below and resulting in poor apparent packing efficiency.

Feed pipes. Reflux or feed introduced onto a liquid distributor via a feed pipe must not splash, upset the liquid pool or impinge directly onto the distributor orifices. Any of these occurrences can increase the liquid flow variation out of the distributor and decrease tower efficiency. Also make sure that the liquid leaving the feedpipe is discharged at least 1 in. below the top of the gas-riser discharge to prevent the liquid being fed onto the distributor from entering the gas riser or the vapor leaving the gas riser from entraining the liquid up the tower. Ensure that the liquid is single phase and doesn't flash as it enters the tower — otherwise, a flashing-feed liquid distributor is required. The liquid velocities in the feed pipe should be kept low in the range of 3 ft/sec to 5 ft/sec. Reference 7 covers this and other parameters of a good liquid feed-pipe design.

Total collector tray. These trays are used for a number of reasons in a tower, but we will limit our discussion to their use with liquid distributors. In this case the liquid passing down the tower is totally collected and then fed to the distributor below. This is done to have a totally mixed liquid entering the distributor or to collect all of the liquid raining from the bed above (including liquid that may be running down the tower wall) to make sure it enters the liquid distributor below. When a total collector is used above a trough arm or pan distributor, it's critical that it is very well sealed with gasketing or seal-welded because any leaking liquid can entirely miss the liquid distributor below and lower the apparent packing efficiency due to the maldistribution the leaking creates. FRI crews have successfully gasketed total collectors in the 4-ft.-diameter section of our column but have been less successful in the 8-ft.-diameter section. In addition to making sure that the tray panels are gasketed correctly at the tray ring and between panels, ensure that the bolt holes at the tray clamp are sealed.

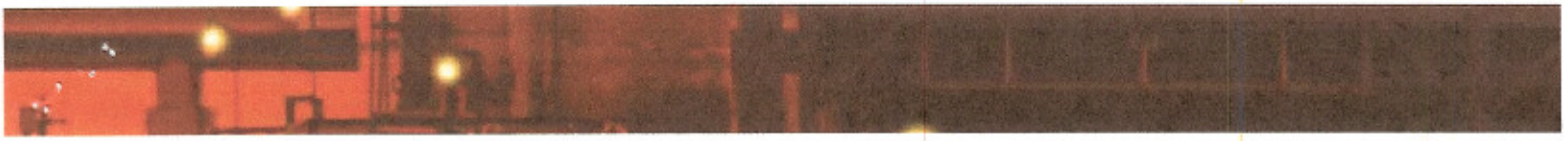
Tips for trays

Much of what has been covered in this article also applies to trays. FRI's crew has put in many different types of trays and always starts by installing the expandable tray rings to make sure they are level and sealed at the wall with gasketing. It's essential that the tray ring be sealed so the liquid on the tray does not leak down to the tray below. In commercial towers, except for those with cartridge trays [8], tray rings usually are seal-welded to the tower wall and don't require gasketing. For both normal and cartridge trays, it is important that the trays are level, so liquid flows evenly across the tray deck — otherwise the tray efficiency and capacity will suffer.

It also is very useful to lay out the trays outside the tower before starting installation to make sure of fit-up and how the trays are to be assembled (Figure 8). Be prepared to make minor adjustments during installation.

>> Valve tray pre-installation lay out

Figure 8. Laying out tray provides a check on fit-up and clarifies its assembly.



In addition, it's critical that the downcomer outlet clearance and tray weirs are set to the specified height and leveled. The valves on the valve tray deck must be free to move and the valve legs must be the correct length and spread properly so the valve isn't blown out of the deck by the vapor. Check sieve-tray orifice size and deck thickness to confirm that they match the design values.

A key preliminary

We haven't mentioned everything that needs to be considered during installation of mass-transfer trays and packing, but following the recommendations here will help you have an easier startup. Then, should you run into trouble, the care you took in installation will allow you to eliminate much speculation about what could be wrong and find the real problem sooner. It's also very helpful for future reference to photograph the equipment installation as it happens. **CP**

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