Marina Piping Systems from Dock to Shore

Many marinas use rubber hose to connect the floating dock to the shore piping. Piping experts Andy Youngs and Terry Stinson point out the leaks in this common practice and discuss what can be done about them.

Catching up with today’s technology
With experience in designing and installing piping systems for more than 100 marina fueling facilities, we feel strongly that the piping system merits special attention and discussion. Especially in areas with severe periodic variation in water surface levels, such as reservoirs or oceans, the design of the marina piping system is critical to the long-term economic and environmental success of the site. These systems need to be durable, permeation-resistant, flexible, fire-resistant, crush-proof, easy to install and (last but not least) economical.

A clumsy excuse
Marina owners (not all, but many, in our experience) often place little value on the environmental security of the marina fueling system. After all, many claim clumsy boaters spill more fuel into the water than the worst fueling system. But, many of the existing marina installations can easily put well in excess of 200 gallons per year of fuel into the water through permeation alone.

An NPV (Net Present Value) analysis generally shows the benefit of the more expensive special marina piping systems now on the market, when system longevity and fuel loss are taken into account. Thus, permeation, pollution and system life are particularly important considerations for proper system design, and often justify the higher cost of more suitable piping systems.

Current Environmental Protection Agency (EPA), state and local regulations are very clear as to what is acceptable for the underground portion of any marina fueling system. Thus underground storage tank (UST) systems or aboveground storage tank (AST) systems with buried piping to the shore are almost always done in the conventional manner used in service stations and other land-based fueling facilities.

However, when the pipe hits the shore, things can really get different—especially where changes in water level are expected and the dispenser is on a floating dock (see Figure 1). The conventional practice is to put an “oil-resistant elastomeric (rubber) hose” as a flexible connector between the shore and the dock.
In many instances, these hoses are well in excess of 100 feet long. Nitrile rubber (also referred to as Buna rubber, Buna-N or butadiene-acrylonitrile rubber), tank truck hose and curb pump hose are the two most popular styles of rubber hoses used for this application. These items are commonly used, and well accepted by most regulatory authorities.

The problems with use of rubber hose to connect the floating dock to the shore piping are primarily three-fold: excessive permeation, poor damage resistance and poor life cycle. Let’s take a closer look.

**Figure 1:**
*Example of a piping system on a floating dock. Artwork courtesy of Total Containment, Inc. and modified for publication by R. Dunbar, PE&T.*

**Where the rubber meets the “road”**

Over the years, we have tested a variety of hoses to find out their permeation properties. Commercially available nitrile rubber-based hoses for curb pumps and tank trucks have been found, at equilibrium, to permeate 100 to 200 percent of their contained volume every month under normal temperatures. In the hot sun, this could go as high as 500 percent of the contained volume every month.

A two-inch diameter hose contains approximately 0.16 gallons per foot. A 100-foot length of two-inch diameter hose will permeate 200 to 400 gallons every year under normal temperatures, and up to 1,000 gallons if exposed to elevated temperatures along its entire length. Permeation rates increase in pressure fueling systems and decrease in suction fueling systems. This permeation level is, of course, costly in terms of both lost fuel and environmental impacts.

The most commonly used hoses are based on nitrile rubber, which has a poor life cycle, especially when exposed to atmospheric ozone and UV radiation. Military uses of nitrile rubber strictly limit this material to one-, three-, five- or 10-year life cycles, depending on the quality of the compound and its level of atmospheric exposure. Rubber hose used in marinas normally cracks and checks* within the first year, and is prone to embrittlement and failure after three years. Rubber hose should always be replaced prior to its fifth year of service, and should be periodically examined and replaced when noticeably cracked and checked on the surface.

* Checking is a condition in which the rubber begins to exhibit “spiderweb” hairline cracks on the surface. These cracks become wider over time, ultimately providing a source for failure of the unit.

Tank truck hose is much more durable than curb pump hose, but all rubber hose is fairly easily damaged by contact with sharp edges, rocks and boat propellers. Coupled with the poor life cycle of the rubber, the poor resistance to impact damage and cuts make it necessary to frequently examine and replace rubber hose used to connect shore piping and floating docks.
With all of these problems, why in the world is the practice of using rubber hose for this application accepted by installers, owners and regulators? The answer is that, in spite of its shortcomings, rubber hose was (up until the last few years) the only reasonably effective product available for the areas where the water level would change substantially over the course of a day or season.

Better alternatives now exist; but the regulatory protocol has yet to catch up with the technology, and the new systems cost much more initially than rubber hose (although they cost less when a proper NPV analysis is done).

So what’s the alternative?
Several suppliers of underground flexible piping have developed systems specifically designed for use in marinas. Some systems are designed only for use on top of or under the dock, with specific warranty exclusion for the flexible portion between the shore and the dock. Others are designed for use in this flexible section, as well as on or under the dock.

At this time, there is no specific UL protocol for marina piping, and most regulators do not readily accept other third-party test reports. Therefore, obtaining local regulatory approval for these improved piping systems is not always easy.

Many regulators, while recognizing and admitting to the superiority of several of the new systems, do not allow their use due to the lack of a clear third-party testing standard or protocol. The specifier and installer should be aware of this. But rather than letting it deter one from using a superior system, this potential problem can serve as a reminder to obtain approvals from local regulators prior to ordering product and beginning construction. Suppliers of these advanced piping materials will normally be more than happy to provide assistance in obtaining needed approvals.

Any piping used in any portion of the piping system between the tank and dispenser should meet UL 971 Standard for NonMetallic Underground Piping for Flammable Liquids or the protocol used for aboveground flexible connectors for gasoline use [protocol is based on portions of UL 536 (Metallic Flexible Hose) and UL 842 (Valves) and involves pressure, cycle and fire testing].

These UL standards provide guidelines for products that will contain fuels under pressure, and have appropriate testing criteria for permeation, attachment of end fittings, temperature and chemical exposure. UL 971-listed flexible piping is typically specified by nearly every designer of marina-specific piping systems.

Piping that will only be used at the dock is often UL 971 piping, and may be co-axially secondarily contained. This piping may be placed in a structurally durable, water- and UV-resistant chase, or duct, either on top of or under the dock (see Photo 2). The use of low melting piping materials has
been common for years, and is often accepted by local regulatory bodies. Fire codes generally only allow their use at points in the piping system where flexibility is needed or where these materials can be protected from the effects of a fire. (The fire codes assume that the piping on each section of the floating pier is metal, with hose being allowed where transitions are made from one section to another.)

Photo 3: A flexible secondary piping is commonly used to contain a primary flexible connector in the presence of fluctuating water levels, such as on floating docks. Courtesy of S. Bravo Systems, Inc.

Sumps and entry fittings
Several firms supply products designed specifically for use in marinas. Most are derived from products used for UST piping installations and have been modified for durability, fire protection or corrosion resistance. Special areas of design consideration for marina sumps, entry fittings and accessories include water tightness; durability; corrosion resistance; flexibility; and fire resistance.

For fire resistance and corrosion resistance, most sumps designed specifically for marina use are fiberglass-clad steel (see Photo 4).

Fiberglass sumps are acceptable in areas where the fire rating is not an issue. Polyethylene sumps are generally unacceptable for marina applications due to poor UV resistance and excessive creep (cold flow) under the more severe loads seen in these installations. As in underground piping systems, the purpose of the marina dispenser sump is to provide an area to capture and monitor fuel leaks from the dispenser, while protecting piping connections from corrosion.

Anchoring and strain relief of the flexible portion of a marina piping system is of paramount importance when considering piping failures. Another key element is the entry of the pipe to the marina dispenser sump. The entry fittings used in marinas need to be of a construction that is strong and beefy, and yet able to provide sufficient flexibility to accommodate the constant motion of the dock.

Keeping leaking fuel in the sump and water outside the sump is especially difficult in a marina application. Most marina entry fittings are double-sided (also referred to as secondarily contained), to provide dual seals on the pipe. A new innovation in entry fittings is the filled boot, wherein a specially constructed double-sided boot is filled with a gel or sealant to provide the maximum in strength and environmental security while maintaining flexibility for angled pipe entries (See Figure 2).

Figure 2: Sealant-filled, double-ended entry fitting appropriate for use in marine environments. Courtesy of Weaver Manufacturing, L.L.C.

Photo 5: Whether installed underneath or alongside the dock, the piping should be supported every three to four feet. Courtesy of APT, Inc.
System design concerns
Whenever there is a floating dock situation wherein flexible hose or piping is used to accommodate change in water levels, a grave danger of piping failure exists if the pipe is not properly attached and strain-relieved (see Photo 5). Several of the early flexible piping marinas failed, as did a number of their rubber hose counterparts, due to fatigue failures at the fittings due to improper anchoring.

Most of the flexible piping and rubber hose systems used, even the metallic ducted systems, float or have neutral buoyancy. Because of this, the tendency is to forget that, like an astronaut in zero-G, the pipe still has the same mass and, therefore, considerable inertia. If not properly anchored and strain-relieved, the ocean wave-action or repeated rise and fall of levels in a reservoir will quickly fatigue the pipe to failure right at the fitting attachment point (see Photo 6).

Photo 6: Install pipe supports as close to the dispenser sump as possible to avoid over-stressing the entry boots. Courtesy of APT, Inc.

Another area of concern is the entry point to sumps. Due to the constant presence of water and movement of the pipe and dock, use of double-sided or secondarily contained entry fittings, at a minimum, is essential. The technology available for flexible filled bulkhead fittings provides the highest levels of environmental security and longest system life.

Marina fueling systems offer a unique challenge to regulators, designers, specifiers and installers. Proper selection of environmentally sound, durable materials will provide, over the life of the system, a cost-effective alternative for the marina owner. The selection and proper installation of the proper piping system is one of the most important pieces in providing the marina owner with a safe, trouble-free and non-polluting marine fueling location.

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