Tube fittings must provide leak tight operation. The choice of fitting technologies usually depends on pressures, temperatures and media. However, their design can prove to be an Achilles heel. When applications demand very high reliability, or involve pressures beyond the scope of industry standard compression fittings, the choices become limited, and the cost of the fitting itself can be a tiny fraction compared with the cost of installation.

This is the application focus of a new tube connection system. Designed as an alternative to welded and cone and thread fittings, the technology introduces ‘push fit’ assembly into the high performance tube fitting arena, providing the means to reduce assembly times by up to 100 fold (Figure 1).

The new fitting design, known as Phastite, will initially be available for instrumentation tube bore sizes. It is designed to withstand pressures up to 1360 bar (20 000 psi). In the oil and gas sector, an increasing variety of applications are falling within this size and pressure category, ranging from pump driven high pressure hydraulics, through deepwater oil and gas drilling operations, to subsea equipment and ROVs. Often, applications are of an instrumentation nature for the transfer of fluids or gases.

Before looking in detail at the fitting, this article will review currently available designs and the problems they face, particularly focusing on rigid steel tubing, which involves stainless steel fittings in the so called ‘medium pressure’ region, working up to approximately 1000 bar/15 000 psi.

Existing fitting systems
At lower pressures, advances in flexible hose technology in some instances compete with metal tubing. When employed for offshore duty, for example, hoses are known to safely

Steve Mullen, Parker Instrumentation, UK, details a new, rapid assembly concept for tube fittings that can change the economics of liquid or gas applications demanding high integrity and/or high pressure operation.
involve pressures up to approximately 400 bar. Nevertheless, they are limited when a longer run of tubing is required, as well as when there is any likelihood of pressure surges occurring above 400 bar. This is when stainless steel tubing becomes essential.

The marketplace for stainless steel tube fittings (flared and flareless) abounds with different manufacturers’ products, many of them long established. Arguments, no doubt, will be heard of how existing all metal single and twin ferrule products perform satisfactorily further down the pressure scale at between 400 - 500 bar.

In general, twin ferrule fittings with the simple and familiar compression assembly principle (‘one and quarter turns’ to assemble) can be specified for pressures up to 6000 psi (414 bar), depending on the tubing size selected. Beyond this point, less convenient fitting technologies are typically used, usually welded or cone and thread, depending on the need or difficulty of maintenance and the pressures involved.

So, why change something that is tried and tested? The main reason has to be to achieve faster assembly. It is here that the new design of fitting comes into its own.

Cone and thread connections

The cone and thread connection principle is often employed when high pressure operation is required, up to 15 000 psi and above (cone and thread systems are available for operation up to 150 000 psi, but the majority of the market tends to be in the ‘medium pressure’ arena with pressures up to approximately 15 000 - 20 000 psi).

With a cone and thread interface, tubing does not simply abut into a fitting, but enters a countersunk arrangement, which demands that the tube end is chamfered or ‘coned’. For a good joint, these angled ends must be precision made (usually onsite), with a fine surface finish. The end of the tubing must then be threaded (again, often in the field) to allow the tubing to be assembled hard against the joint.

The ‘price’ that users of these fittings pay lies largely in assembly. It can take half an hour or more to perform the coning and threading operations, and requires a set of tools (vice, coning tool, dies etc). These assembly operations are often carried out without any formal quality control or tooling inspection procedures that would help to ensure accurate and measured surface finishes are achieved.

Threaded fittings in general can be prone to problems when subjected to changing pressure and temperature. Leakage can occur because they are torque sensitive; i.e., over tightening can distort the threads and cause a path for leakage to occur. Threads are also liable to loosen when exposed to vibration, and this in particular can be an issue for cone and thread fittings, due to their parallel threads. It is not unknown for cone and thread fittings to require tightening after equipment is transported to site, for example, and as a result, many users choose to fit an anti-vibration accessory as standard.

Vibration fatigue

The reliability of tubing systems with threaded connections is uncertain when faced with vibration induced fatigue. For every three and a half corrosion related pipeline system failures there is typically one vibration induced failure. An investigation participated in by the HSE, oil companies and associated engineering contractors brought to publication a set of guidelines. These outline the different vibration mechanisms and their effect on small bore connections. They also include an assessment methodology for failure and possible design solutions for best practice.

Phastite is particularly good at dealing with vibration prone environments. In testing to verify compliance with BS 4368 for example (which calls for 20 million vibration cycles at between 23 - 47 Hz, some 238 hours of testing in total), Phastite fittings were left on the rig until destruction. The fittings still retained their seal even in excess of 400 hours, and at this point, the test frequency was increased way beyond the range of the standard and the fittings continued to operate for another 40 hours.

This advanced performance stems from the novel design of Phastite’s sealing mechanism, which has a series of peaks that create a compression seal (Figure 5) without weakening.
the tubing surface. The peaks ‘coin’ or smooth the surface of the tubing in a way that retains all of the tubing’s strength. In contrast, cone and thread systems must cut a thread into the tubing, reducing a fitting’s ability to deal with vibration and stress. Flexure/fatigue load tests have demonstrated that cone and thread systems perform markedly less well than conventional compression fitting systems for example. Phastite’s novel compression sealing mechanism is believed to enhance this advantage even further.

**Welded connections**
When welded connections form part of a tubing system, long term permanency is usually what a designer is aiming for. Effectively, when the fittings are in the same material as the tubing, they become an integral part of the system. Although the aim is laudable, as with cone and thread systems, there is a considerable price to be paid in terms of the worker skill and equipment required, and the time to fabricate each joint. Installers of welded fittings also face extra difficulties. When working on oil and gas sites, ‘hot work’ permits are often needed, involving administration and safety procedure work, all of which adds to the cost of the field work. Among other restrictions, floor sweeping and the purging of flammable vapours may be necessary; spark and slag catchers must be suspended below any elevated operation, and sparks must be prevented from travelling to other unprotected areas. As welding produces hot sparks, the area should be inspected one hour after work is completed. In addition, smoke detectors in the vicinity of the work area have to be switched off and then on again later. Fire fighting equipment must be on hand. All of this takes time to implement, and multiplies the cost of the job.

**Rework factor**
In both welded and cone and thread fitting applications, most users consider a certain degree of rework to be part of the process. The rates vary according to the skill levels and application conditions at each site, and the equipment available. Based on feedback from major users, it is the author’s view that for both welded and cone and thread fittings, rework represents 5 - 10% of total installation time.

**Rapid assembly**
What the Phastite fitting sets out to achieve is to reduce considerably this assembly time, and at the same time, provide a simple method of making a connection. This is enabled by a small hydraulically operated tool, which accompanies the fittings. Phastite fittings are supplied in a single piece, ready to apply form. No preassembly work is needed and the tubing does not require preparation, providing it is clean and undamaged. Each fitting end comprises a collar and body. Figure 2 shows a straight union comprising a body and two collars; the collars are preassembled during manufacture. The portable tooling associated with the fittings (Figure 3) operates hydraulically via a pump. A set of clip-in inserts allows it to be quickly configured to suit different sizes of fitting. It can be positioned to work closely against panels and bulkheads, thus avoiding having to bend the tubing to engage the tool.

After placing the fitting in the tooling, each tube end is then slid into the fitting. The tooling applies hydraulic pressure to the collar(s) of the fitting, thus forcing the tubes further into the body until a stop is reached. As the collars are moved inwards, they force the profiles of the
internal sleeve to bite into the tubing, thus providing a high
pressure, leak tight seal.

The designed for purpose nature of the tool assures
users of correct, right first time assembly. The assembly time
itself is measured in seconds, and requires no consumables.

A key advantage for end users is that the does not
require any formal operator training. The simplicity of the
procedure, involving a ‘push fit to dead stop’ operation,
is such that it can be acquired in minutes. The relative
operations and costs compared with welded and cone and
thread fittings are illustrated in Figure 4.

An additional point to consider in terms of cost is the
ability to use thinner wall tubing, due to Phastite’s multiple
profiles providing excellent sealing without any detrimental
effect on the tubing (Figure 5). (Cone and thread fittings
require thicker wall tubing sizes because of the thread
cutting required.)

The associated saving, in both weight and cost, could
be very beneficial when installing gas services. If the
tubing savings were translated into reduced weight, for an
offshore platform (where each ton of topside equipment
might cost US$ 80,000 in superstructure), the savings can
be enormous. A typical platform might have 250,000 ft of
tubing. A large percentage of that might be used for gas
service, depending on the type of platform.

Application opportunities
Currently, a number of major fittings users are evaluating
Phastite. Among them are two of the world’s largest
producers of oil, a defence contractor in the marine industry
and an offshore equipment manufacturer.

Marine applications provide a useful illustration of
the potential savings. Large vessels require thousands of
tube runs with several fittings; these are often welded and
installed in-situ. Due to being close fitted against panels
and bulkheads, tubing has to be levered away in order to
weld the fitting, imposing stresses. If testing using non-
destructive x-ray inspection or dye penetrant is then
required (as it would be for a ship), it adds considerable
cost to an already lengthy installation process. Phastite
allows such tubing joints to be assembled in-situ without
moving the tubing, in a few seconds. No testing apart from
the normal system pressure test following assembly is
required.

One of the standards for tubing in the marine defence
field is that it must be capable of withstanding a deformation
of 60 mm without leakage, when pressurised to 160 bar
(2320 psi). This test offers a useful illustration of the strength
of the new fitting. As part of the development programme
for Phastite, a tube run has been deformed under pressure
to five times this standard (300 mm) without leakage
(Figure 6). It was then subjected to increasing pressure until
destruction, with the tubing itself bursting before the joint (at
2200 bar/31,908 psi). As illustrated in Figure 5, the design
of the fitting allows for cavities to accept deformation of the
tubing under the action of the multiple profiles, providing
an extremely strong grip that is both leak tight and actively
stops the tubing blowing out under pressure.

Reference
1. Guidelines for the Avoidance of Vibration Induced Fatigue in Process