Bondstrand piping systems
in fire hazardous areas

Bondstrand glassfiber reinforced epoxy (GRE) piping products are widely used for underground and above ground fire water systems. For above ground systems, the fire response of the material itself, how the composite pipe behaves when exposed to fire, is an important issue in the decision to specify Bondstrand GRE piping.

The most common applications where the fire resistance of Bondstrand piping is important are for fire mains (ring mains on platforms and above ground), sprinkler systems, dry deluge systems and foam lines, since these are used to fight the fire itself. Also important, however, are other applications like cooling water lines, vents, drainage and flow lines where the fluids being transferred may be critical.

In all these applications, Bondstrand GRE pipe is primarily chosen because of its corrosion resistance. Especially for fire water systems, corrosion does not only limit the life time of steel and metal firewater piping, but corrosion scale and salt encrustation causes plugging of the nozzles and sprinkler heads, creating an unacceptable risk for safety. With Bondstrand GRE pipe systems, designed for 25 or more years of continuous service at pressures up to 50 bar, none of these corrosion related lifecycle or operational problems occur.

The fire resistance of Bondstrand GRE pipe systems are tested and approved for many applications in marine industries (ship building), offshore structures (platforms, FPSO's, MODU's, etc), industrial installations such as refineries, (petro) chemical plants, storage facilities and tank farms and also in other applications such as tunnels, ports and jetties and at airports. The behavior of an epoxy based glassfiber composite pipe in fire is different than a steel or metal pipe: in this bulletin we try to explain the differences and advantages of using Bondstrand GRE pipe in areas and applications where fire exposure presents a serious hazard.

Behavior and endurance of Bondstrand pipe systems in fire conditions

Bondstrand GRE pipe systems have a surprisingly high resistance to fire. This endurance is caused by the composite structure of the material. The combination of low thermal conductivity, low thermal capacitance, and the endothermic decomposition of the resin matrix material makes the material very resistant to fire. As the resin component of the matrix is burned on the outside of the pipe, a carbonaceous ceramic-type layer (char) will form, still reinforced with fiberglass, which effectively isolates the rest of the pipe, slowing down the burning process.
The final endurance of Bondstrand GRE pipe depends also on the type of fire: the intensity (heat flux) and the type of fuel (which defines the temperature of the fire).

The operational situation of the piping has also an important influence on the endurance of the pipe system in fire:

- Pipe in dry condition
- Pipe filled with stagnant water
- Pipe with flowing water

Fire testing of GRE pipe in dry condition

If GRE pipe, in dry condition, is exposed to a fire, the pipe wall generally needs to be protected from the fire by an external coating (unless exposure is very short). In the fire, the outer protective layers will form a carbonaceous ceramic-type layer (char) which effectively isolates the structural wall of the pipe and which slows down further the excessive heating. If after a certain time (typically 5 minutes in qualification testing) the pipe is filled with water under pressure, the situation stabilizes due to the cooling effect and further degradation stops. Depending on the intensity of the fire, the time exposed while dry and the wall thickness, the pipe may ultimately even start to weep, but also then the functionality of the pipe system is intact. Due to a combination of the insulation properties, low thermal capacitance and the elasticity of the composite pipe, it is resistant to the temperature and stress shocks related to the abrupt starting water flow (such as when a deluge valve opens quickly). Several tests have shown that metal pipes may burst in a similar situation due to the thermal and pressure shocks which occur due to explosive steam formation when water hits the red hot metal. There are several official tests determining a minimum time that the pipe system should remain fully intact in dry condition (so-called wet-dry tests): see the reference to IMO below. The protective layers referred to above are made of highly filled epoxy or thermoplastic material, such as used for Bondstrand 2000M-WD and Bondstrand 2000M-FP.

Effect of fire on GRE pipes filled with water

A water filled pipe exposed to fire will last a lot longer due to the cooling effect or “heat sink” of the water in the pipe, again in combination with the low heat conductivity of the composite pipe material. Bondstrand pipe material has passed tests which required fire endurance times ranging from 15 to more than 60 min.

The most realistic situation will be that immediately or shortly after the start of the fire (within 1 minute) there will be flowing water in the piping. This will increase the cooling effect as compared to stagnant water. For almost all real-life fire conditions, a water filled epoxy based composite pipe, without additional protection layer, will be able to withstand design pressure after 60 min or more fire exposure.

The IMO (International Maritime Organization) has developed the most clearly defined set of criteria for endurance in fire for pipes on vessels *(for more details see ‘There’s no Smoke without Fire’, NOV Fiber Glass Systems publication TB-2 and www.imo.org).*

Other factors

Other factors related to the response of GRE pipe to fire conditions are flame spread, smoke emission and smoke toxicity:

- Flame spread: a measure of the extent, under prescribed conditions, to which a pipe becomes a self sustaining source of fire, meaning that the flames will continue to spread from an ignition source. In this, GRE pipe is considered to be self-extinguishing (it requires an external heat source to continue burning) and in this performs very well compared to polyester, vinyl ester and thermoplastic pipe materials. Special additives may be added to the pipe resin matrix which can further improve this performance, but these additives may increase costs dramatically, increase the toxicity of the smoke emitted and may also affect the mechanical properties of the product.
- Smoke emissions and smoke toxicity. The optical density and toxicity of smoke emitting from the GRE pipe under fire exposure can be measured. This will typically be done with high and low radiant energy levels to see the effects of burning as well as smouldering conditions. For certain circumstances, such as in enclosed spaces like living quarters and control rooms, the results may not be acceptable. Special solutions then will be required, like applying an intumescent coating or using GRE pipe made with special resins (Bondstrand PSX).

Characterization of different types of fire

Below table summarizes the main fire tests as defined and used in the industry.

- Impinging flame - with a heat flux of 113.6 kW/m2 (IMO A.753 (18) - Level 3)
- Jet fire - gas fire with heat flux of min 300 kW/m2 and defined gas velocity.
- Surface flammability: furnace test including smoke and toxicity analysis
- Hydrocarbon Fire - furnace test at 1100 C°

Table 1: Type Approvals for Bondstrand GRE pipe systems

Fire condition	Description	Bondstrand Series
IMO A.753(18)L3 Standard Level 3 fire test for steel vessels, Modu's and platforms	30 min wet, stagnant water, impinging flame, propane, 113.6 kW/m2	2000M 7000M 2400 TT 2400C TT 3400 TT 3400C TT PSX-L3 PSX-JF
IMO A.753 (18) L3 WD modified level 3 fire test acc. to USCG PFM 1-98	5 min dry + 25 min wet, impinging flame, 113.6 kW/m2	2000M-WD 7000M-WD 2400-WD
Jet Fire	5 min dry + 15 min wet, heat flux > 300 kW/m2	2000M-FP 7000M-FP 2400-FP 2400C-FP PSX-JF Or Bondstrand pipe spools with a Favuseal or Pitt-Char protection layer.
IMO L3 - Extended 60 min	60 min wet, impinging flame, 113.6 kW/m2	2000M 7000M 2400 TT 3400 TT PSX-L3

Note: Bondstrand GRE pipe systems have been certified or have Type Approvals of almost any certification body, including ABS, USCG, BV, DNV, Lloyds, NKK, RINA

Additional tests have been developed to define the surface flammability (flame spread), smoke emission and smoke toxicity, like the IMO A.653(16). Bondstrand PSX-L3 will pass this testing, Also standard Bondstrand pipe with a coating of a certified intumescing paint system will be able to pass this test.

Note: Bondstrand 2000M and 7000M with Quick-Lock joints are not suitable for dynamically operated fire water systems subject to extreme water hammer in diameters above 6 inch (DN150). For such fire water systems, NOV Fiber Glass Systems advises to use Bondstrand pipe systems with Taper/Taper joints.

Summary

Bondstrand solutions for piping in applications and zones with fire hazards

For on board floating offshore structures (FPSO's, Modu's, etc) the specifications and solutions for fire water systems with Bondstrand materials are clearly defined:

- Fire fighting sprinkler systems according to IMO A.753 (18) Level 3 in wet condition: standard Bondstrand 2000M, 7000M, 2400, 2400C, 3400, 3400C and PSX-L3
- For sprinkler systems in enclosed areas such as living quarters and control rooms, piping should perform in accordance with IMO A.653(16) for smoke emissions and smoke toxicity: Bondstrand PSX-L3; or a standard Bondstrand with a certified intumescing paint system applied.
- Dry deluge systems not in zones where jet fires can occur: Bondstrand 2000M-WD, 7000M-WD, 2400-WD, 2400C-WD and PSX-JF.
- Dry deluge systems in jet fire zones will require either Bondstrand PSX-JF or standard Bondstrand with a pre-fabricated protection layer: Bondstrand 2000M-FP, 7000M-FP, 2400-FP or 2400C-FP. Alternatively pre-fabricated spools can be protected with a sufficiently thick layer of Favuseal or Pitt-Char. NOV Fiber Glass Systems will supply such or advise on the application.

On offshore platforms and other offshore structures, the jet fire zones are normally clearly and strictly defined. The (relatively expensive) fire protected solutions are only required for (dry) deluge systems within these zones, and should not be unnecessarily specified in other areas.

In other industries and applications, the specifications and rules as set by IMO, and the generally accepted solutions in offshore industries as described above, can be used as guideline on how to apply the different Bondstrand solutions. Typical industrial applications include above ground fire water and other suspended systems, fire fighting and foam lines as often used in tank yards, etc.

The above described certified specifications are not the technical limits of the Bondstrand piping systems.

- In the standard wet Level 3 fire tests the endurance of Bondstrand pipe systems will be (much) longer than the 30 minutes test requirement.
- Foam extinguishing lines could be considered as dry deluge systems.

For all applications in areas with fire hazards and/or specifications regarding the performance of the piping in fire, please contact NOV Fiber Glass Systems. Our engineers will advise on the best solution in Bondstrand GRE pipe systems.

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ENG1150 supersedes FP 1033 November 2012