SETTING THE RECORD STRAIGHT

Solvent cementing of CPVC fire sprinkler systems

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May 31, 2012

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In the last few years, a significant amount of erroneous and inaccurate information about the solvent welding process of CPVC has been circulated in the industry, particularly misinformation about CPVC fire sprinkler systems using a one-step cement. This has created confusion and unnecessary concerns but more importantly, it has created a lot of doubt about what is the right procedure for solvent cementing CPVC piping systems.

Weld-On, the pioneer of the solvent cement process in the early 1950's, has accumulated a tremendous amount of data regarding what does or doesn't harm a piping system. We believe that the industry can benefit from our experience, including over 20 years of forensic testing on plastic joints, in understanding what is the best solvent cementing procedure and what can be expected of a properly made solvent cement connection utilizing high quality cement, pipe and fittings. We hope that this paper helps to set the record straight for the industry and the owners, specifiers and installers who work with and rely on high quality CPVC fire sprinkler systems and their solvent cement connections.

An explanation of key Technical Aspects

First, let me highlight some relevant technical aspects that we have learned through our analysis of thousands of CPVC fire sprinkler piping system joints.

Effectiveness – Properly performed solvent cementing of quality CPVC fire sprinkler systems using premium cement will yield joints which will not only meet the performance standard of ASTM F-493 but in actuality exceed the strength, safety factor and meet the full life expectancy of the individual components being *welded* together. CPVC fire sprinkler systems have been a proven system ever since their introduction into the fire protection marketplace in 1984. Subsequently, well over one billion feet of CPVC fire sprinkler piping systems have been installed in over 60 countries.

Limitations – Just like any product/systems ever created by man, there are limitations and external factors that can and will compromise the integrity of a system. Fire sprinkler systems are not immune to this; however, the system component manufacturers (pipe, fitting, sprinkler heads and solvent cement) have put forth great efforts to identify any such factors and warn installers of what they are and how to avoid them. Cracking of CPVC pipe or fittings can occur due to stress created during the installation of the system; for example, by hangers attached too tightly to the pipe or pipe wedged into corners. Stress cracking can be accelerated by contact with specific chemicals such as certain thread sealants that contain ingredients which are incompatible with CPVC or certain surfactants (which are chemicals used to improve the effectiveness of products like detergents). These are some of the common concerns for CPVC fire sprinkler systems. While some have suggested that 'runs' or 'dribbles' of solvent cement can be themselves the cause of cracks in the pipe this is not accurate; what can occur in some cases is a <u>temporary</u> weakening of the mechanical properties of small areas of the fitting or pipe ID if exposed to excessive (uncured) amounts of cement. Such conditions can make these areas more susceptible to develop the problems brought on by the above mentioned stress cracking agents.

It should be noted that even in the most professional of installations small drips and runs of solvent cement may be present. As many years of experience have shown us, these small excess amounts do no harm and do not need to be removed to maintain the integrity of the system. On the other hand there are today no excuses to expose CPVC fire sprinkler systems to well-known stress inducing conditions/agents as the ones described above; detailed lists of many of these conditions/agents and ways to avoid them can be found in several publications as well as websites such as http://www.lubrizol.com/BuildingSolutions/FireSprinklerSystems.html

Blaming components, such as pipe and fittings, of CPVC fire sprinkler systems or approved solvent cements for failures due to known and easily avoidable conditions is akin to saying "since *a ¾" long nail would perforate a ½" thick tire but it would not have perforated a 1" thick tire, then the problem is the tire*." Tires, any tires (**), are not designed to be driven on nails, and the problem is the nail, not the tire. Of course we could buy thicker tires to prevent such an occurrence but then we get into the cost/benefit discussion and more importantly the 'intended use'.

Many years ago, I sold thermoplastic piping systems and back then the single most common objection I received was "what if a guy with a forklift runs into your plastic system?" After several such observations, it seemed obvious to me that the only thing that was needed in order for everyone to benefit from the many advantages of plastic over metal was either to educate (or imprison) these wild forklift drivers. It seems that we are now dealing with a similar mindset with regards to CPVC fire sprinkler systems and solvent cementing; with a little education regarding its proper use, the incredible advantages of CPVC fire sprinkler systems and the time-proven connection method of solvent cementing would become more obvious.

Solvent Cement Process – the right way

Speaking of 'proper use' I would like to now shift gears and focus on one of the great advantages of CPVC fire sprinkler systems-- its solvent cement connections. Some see this as a problem when in fact this is one of the strengths of these systems. Why a strength? It is a strength because, as previously stated, these systems are capable of consistently producing joints that are stronger than the components; moreover there are **very easy steps** that can be taken in order to significantly reduce cement runs and prevent the trapping of cement into the waterway, thus ensuring that the full potential of CPVC systems and a trouble-free life is consistently realized.

Listed below is the correct step-by-step process for solvent cementing; many of the CPVC system manufacturers have the exact same instructions in their installation manuals. However, I have tried to also provide some explanation as to the reasons why each step is important to a successful installation and how it minimizes runs and eliminates the possibility of excessive cement entering the waterway.

Cutting

> *CPVC pipe can be easily cut with a ratchet cutter, a wheel-type plastic tubing cutter, a power saw or a fine toothed saw. Tools used to cut CPVC must be designed for plastic use and must be in good condition in accordance with the tool manufacturer's recommendations. It is important to cut the pipe square. A square cut provides the surface of the pipe with maximum bonding area.*

NOTICE

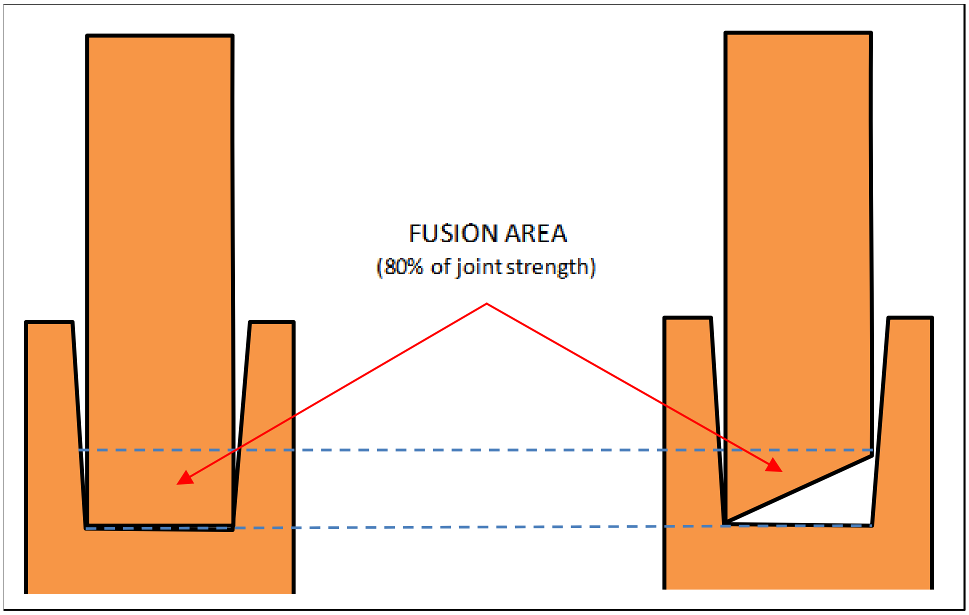
Avoid splitting the pipe when using ratchet cutters. Failure to do so may result in pipe failure or leakage.

- *Only use ratchet cutters that contain a sharp blade (blades dull quickly).*
- *Only use ratchet cutters at temperatures of 50°F (10°C) or warmer.*
- *Only use well-maintained, good quality ratchet cutters capable of consistently cutting the pipe squarely.*

If any indication of damage or cracking is evident at the pipe end, cut off at least 2 inches (50 mm) beyond any visible crack.

Why is cutting the pipe square so important? As stated in the instructions "A square cut provides the surface of the pipe with maximum bonding area." But what does that mean and how does it relate to the quality of my joint?

The figure below clearly shows that anything less than a square cut will not only greatly diminish the contact area between pipe an fitting but it will do so in the lower portion of the socket where 80% of the joint strength is developed.



Deburring & Beveling

Burrs and filings can prevent proper contact between pipe and fitting during assembly, and must be removed from the outside and the inside of the pipe. A chamfering/reaming tool or a file is suitable for this purpose. A slight bevel (approximately 10° to 15°) shall be placed at the end of the pipe to ease entry of the pipe into the socket. This will minimize the chance that the edges of the pipe will wipe solvent cement from the fitting socket during the insertion of the pipe.

The last sentence clearly defines the undesired result of a non-chamfered pipe end but does not explain why it is undesirable. There are actually three (3) separate reasons for not wanting the removal of cement from the socket during insertion. But before we list the reasons, let me also point out that in CPVC Fire Sprinkler systems we are dealing with a tapered socket and that a dimensionally proper fitting will have an ID which is smaller than the OD of that pipe towards the bottom of the socket (approx. 2/3 of the way down). This creates the '*interference*' which is such an important part of a high strength, long life expectancy connection.

On a side note, there are 3 types of possible fits between dry pipe and fittings. The most desirable is an 'interference fit', which is what I described above. The other acceptable fit is a 'net fit' which is a snug fit, signified by the dry pipe (before any cement is applied to it) encountering some resistance towards the bottom of the socket but which can still be bottomed out. The last possible fit is a 'loose fit', and this should never be used in a solvent cement system. This occurs when the dry pipe encounters no resistance all the way to the stop inside the socket.

So here are the three reasons for not wanting the removal of cement from the socket during insertion:

1. It is important to understand that the presence of solvent cement on the surface of the pipe OD and fitting ID will act as a lubricant; this allows full pipe insertion even in the presence of an interference fit. Removal of the cement will eliminate the necessary lubrication in the fusion or interference fit area. This in turn will almost certainly guarantee that the pipe is not fully inserted, thus missing the all-important fusion area.
2. Removal of the cement will also eliminate/shorten the exposure of the fitting wall to the softening agent which together with the radial pressure generated by the proper interference are the only reasons why fusion between pipe and fittings occur. A shortened exposure to the softening agents in the cement will result in a more superficial fusion, the consequence of which will vary greatly from decreased safety factor to shorter life expectancy.
3. But if the sharp edges of the pipe remove the cement, where does it go? Only one place – down into the waterway. Lack of a proper bevel is in fact one of the two reasons (the other being over cementing the fitting socket as described later) why cement 'runs' or 'puddles' are created. As we have seen before, although not the cause of cracking, these runs or puddles are to be avoided.

Solvent Cement Application

> *Using a clean, dry rag, wipe loose dirt and moisture from the fitting socket and pipe end. Moisture can slow the cure time and at this stage of assembly, excessive water can reduce joint strength.*

Why do we need to clean and dry pipe and fittings? Remember that we are performing a chemical fusion which is designed to work on CPVC compounds. Any impurities introduced in the chemical process between the cement ingredients and the polymer alters the chemical process which is never an improvement.

> *The pipe should enter the fitting socket easily one-third to two-thirds of the way. Contact between the pipe and fitting is essential in making a good joint. This contact allows the solvent cement (which is applied in the next step) to effectively join the pipe and fitting.*

Use a dauber that is properly sized for the pipe. For 3/4 inch (DN20) and 1 inch pipe, use a dauber that is 1/2 inch (12.7 mm) in size. For 1-1/4 inch (DN32) through 3 inch (DN80) pipe, use a dauber that is 3/4 inch (19 mm) in size.

This is much to do about dauber size--why? As we will see later, the other critical part of avoidance of runs and puddles is the amount of cement applied to the fitting socket. A dauber that is too large will simply deposit too much cement into the socket, and a dauber that is too small may not deposit enough cement or may allow for too much evaporation of the solvents before the joint is assembled.

Only use solvent cements that have been specifically formulated and listed/approved for use with CPVC fire sprinkler systems and approved by the pipe and fitting manufacturers.

No comment necessary here.

Vigorously apply a heavy, even coat of cement to the outside pipe end. Apply a medium coat to the fitting socket. Pipe sizes 1-1/4 inch (DN32mm) and above shall always receive a second cement application on the pipe end. FIRST APPLY CEMENT ON THE PIPE END, THEN IN THE FITTING SOCKET, AND, FINALLY, ON THE PIPE END AGAIN.

NOTICE

Too much solvent cement can cause clogged waterways or weaken the wall of the pipe or.

- *To prevent excess cement from entering the waterways apply a lighter coating of solvent cement to the inside of the fitting socket than the outside of the pipe.*
- *Wipe off excess cement on the outside of the joint. The solvents will evaporate, but the cured solvent cement inside the fitting will stay there.*

This seems fairly self-explanatory, but there are some key points here. However, before we go a little deeper into the statements made above let's revisit the difference between excess cement and a drip and the different effect each has on a CPVC fire sprinkler system. By excess cement we mean a large amount of partially-cured cement trapped inside the system. Depending on location, system geometry, sizes and a variety of other factors, this large amount of cement may not cure 100% for some period of time. If this happens, it is likely that the portion of the system (typically a fitting but could be pipe as well) in direct contact with the partially- cured cement may temporarily lose some of its mechanical properties. Under normal conditions, the solvents evaporate quickly and the material regains its original hardness and with it all of its mechanical properties, but trapped solvents can delay this process. A simultaneous application of stress such as compressive point loading (e.g. an over tightened hanger) or introduction of stress cracking agents, will likely affect the area in question to a greater extent. On the other hand, a drip or run poses no such risk since the solvents in such a small amount of cement will still evaporate as they require very little air contact/flow to evaporate, and they will have access to that even if trapped inside the system.

With that understood let's now dive into the details of this instruction. First, it says *Vigorously apply*--why 'vigorously'? It is because we are not gluing, but **welding**. In gluing, the glue needs only to be deposited in an even layer and be always present between the two parts, while in welding the success of our weld depends on the softening of a specific amount of material.
Because we are welding with chemicals rather than heat, we need the agents to penetrate into the wall of the pipe and fittings, and for this to occur the chemicals must dissolve and get past the hard outside

surface of the pipe and fittings, which are the areas where the material has been in contact with the tools and where it is 'sealed'. Additionally molding release and waxes are used during the manufacturing process. So, we must use a little elbow grease to vigorously remove the hard outside surface and any waxes or mold release agents.

The second item is the requirement of applying a *heavy coat* of cement on the pipe and a *medium coat* on the fitting and even going back to the pipe a second time depending on sizes. <u>This is the ingenuity of solvent cementing!</u>

Think about this; we are dealing with pipe and fittings that have ± tolerances, which means they will always be different. We are dealing with tapered sockets, which mean that the top, bottom and middle fit/gap between the pipe OD and fitting ID is different by design. So how do we make sure that we always use the exact right amount of cement, not too much or too little? Do we measure every fitting to pipe and plot the interstitial space and the interference and then through some complex mathematical equation determine the right volume of cement needed for each joint and each size, after which we section the pipe areas which should get more or less cement…….?

Well, that would be one way … or … we just put a big load of cement on the pipe (which we have properly cut square and beveled) so that whatever gap we have will be filled and also put a thin coating on the fitting socket so that we achieve softening of the walls but not enough material to be pushed into the waterway. And whatever excessive material we have deposited on the pipe will be pushed out during pipe insertion so that (a) it is not in the waterway (b) provides us with a very useful indicator that all gaps have been filled and (c) we can easily wipe off. BRILLIANT!

Assembly

> *After applying cement, immediately insert the pipe into the fitting socket, while rotating the pipe one-quarter turn until the pipe bottoms out at the fitting stop. Rotate the pipe as it is inserted into the fitting not after it has bottomed out in the fitting. Properly align the fitting for the installation at this time. Pipe must bottom to the stop. Hold the assembly for 30 seconds to ensure initial bonding.* ***A bead of solvent cement should be evident around the pipe and fitting juncture. If this bead is not continuous around the socket shoulder, it may indicate that insufficient cement was applied.*** *If insufficient cement is applied, the fitting must be cut out and discarded. Cement in excess of the bead should be wiped off with a rag.*

A few things here.

- First of all, the long definition of the word 'immediately' is 'make sure that the cement is still wet on both pipe and fitting as the pipe is inserted'. If the cement on either the pipe or fitting has dried, it means that it has cured; but if it has cured before full insertion, there will be no joint.
- Secondly, the ¼ turn or pipe rotation during insertion. To be sure, it is an excellent practice and it should be observed every time possible but <u>if conditions don't allow</u> it (e.g. I am inserting a 10ft pipe into an elbow which is already connected to 10ft of pipe) an excellent connection can still be achieved even without the turn The purpose of the rotation is to overcome a possible mistake during the application of cement. It is easy, for example, to apply more cement to the top portion of the pipe and less underneath, so rotating the pipe while inserting it will help redistribute the cement more evenly in the socket. However, if you do a good job during the cement application (particularly

if you know that it will be difficult or impossible to rotate the pipe during insertion) then the rotation is not necessary.

- Hold for 30 seconds after bottoming out. This is NOT an optional practice. Remember we are dealing with tapered sockets and interference fits. If you do not allow the bond to set without holding the pipe down, the shape of the socket will kick it out, enough in fact to clear most of the fusion area.

Set and Cure Times

> **NOTICE**
> *Inadequate curing of solvent cement joints may cause pipe failure or leakage.*
> *Solvent cement set and cure times are a function of pipe size, temperature, relative humidity, and tightness of fit.*

Cure times should be increased when moisture is present such as during cut-ins to live sprinkler lines. The assembly must be allowed to set, without any stress on the joint, for 1 to 5 minutes, depending on pipe size and temperature. Following the initial set period, the assembly can be handled carefully, ***avoiding significant stresses to the joint.***

The statements are very clear here but they can be enhanced by stating this: the full strength of the joint, the strength we talked about at the beginning of this article is achieved over time as the solvents completely evaporate out of the joint. The fusion is weak at first (Set Time) and breaking the bond is easy during this stage--any kind of force generated by weight, moving the parts, point loading, etc. will do just that. If the bond is broken as it cures, the curing process will continue but rather than the two parts (pipe and fitting) curing as on solid piece, they will cure as two separate pieces and that creates a leak path. But after just a few minutes (depending on conditions and sizes), the bond is strong enough for the parts to be carefully moved or hung. Only after the prescribed full cure time, the fusion bond is strong enough to handle pressure testing.
One thing to clarify is that the Set Time is a portion of the Cure Time; it is not in addition to it.

There are more details available (e.g. solvent welding in either cold or hot conditions) including Set and Cure Time charts and solvent welding tips for cold or hot conditions, but the purpose of this article was not to be an Instruction Manual. The purpose was to cut through the confusion surrounding both the techniques and the alleged dangers of solvent welding. The fact is that this is a very straight forward, time proven process with an astounding success rate. As is often the case, all that is needed are clear directions and a clear understanding of what the process is trying to accomplish.

<u>NOTE:</u> The author of this article makes no product warranties, and this article is not intended to be a comprehensive guide on how to install and weld CPVC pipe. Anyone using CPVC pipe should study and follow the manufacturers' literature and installation guides, including those from manufacturers of components and welding materials.

** Blaze Master is a registered trademark of The Lubrizol Corporation.*

*** Michelin will shortly introduce a combination flexible wheel/solid rubber tire which can't be punctured.*