Fire Sprinkler Connections: Are We Protecting the Vital Link?

By Larry Pigg
Executive Summary

To those tasked with public safety, asset protection, and minimizing fire loss, few tools are as significant as automatic fire sprinkler and standpipe systems. Water based fire protection systems are the life blood of any fire department’s ability to adequately protect the citizens and the infrastructure. The appliance that departments utilize to supply water to the system is called the Fire Department Connection (FDC). In a perfect situation, where quality components are installed properly, where there is no significant corrosion in the system, and when storage is kept within proper limits, fire protection systems will operate for many years without much outside assistance. Perfect situations rarely exist. In 2006, over 3000 people were killed in house fires alone. Most of these fatalities were in houses that were not sprinklered, but many did have smoke alarms that did not alert the victims. There were an additional 106 firefighters killed while on duty. The loss of contents, materials and time to affected businesses was estimated to be over 11 billion dollars. As with all of the parts of a modern sprinkler system, the FDC is vulnerable and subject to vandalism, theft, and deliberate acts of terrorism.

It is difficult to walk down the street of most cities in this country and not see open, vulnerable FDCs with everything from soda cans to the evening paper stuffed inside. The connection ‘swivels’, the threaded coupling attached typically to a siamese connection that mates the fire hose with the system are often missing. In large urban mixed-use occupancies where there are residences directly above service businesses like restaurants and dry-cleaners, missing FDC caps are putting people at some degree of risk. Missing caps are also seen in the institutions and facilities we have to protect the most vulnerable among us; schools, nursing homes and hospitals. In post 9/11 America, with the importance we place on vigilance and Homeland Security, you can go to the airports of many American cities and find open, vulnerable FDCs. If we see these vulnerabilities, those that would harm us see them too.

Either through theft, careless passersby that put items in the open FDC receptacles, or the occasional criminal that will use the FDC to introduce accelerants in an incendiary fire, the results can be devastating. While it goes unnoticed by most people, the reality is that there are not enough fire inspectors and code enforcement people to manage it 24 hours a day. A reliable, functioning FDC is the necessary portal that fire departments must have to successfully augment the fire sprinkler system in a catastrophic fire scenario.
Importance of the FDC

What is an FDC? Why is it so important? The Fire Department Connection (FDC) is the device used by the fire department to connect fire hose and augment the automatic fire sprinkler or standpipe system. FDCs come in various sizes typically from 1½" for residential systems and 2½" for most others, to 4" and 5" 'unidirectional’ “Storz” connections that can supply vast amounts of water if the installation requires. When a fire occurs, water is discharged from the sprinkler heads that have fusible links between the sprinkler head and the water supply in the connecting piping overhead in the ceiling. The fire department connection is used by the fire department to add to the water supply that is going to the sprinklers. In an active system where the heads have temperature links connected to each individual sprinkler head, the threshold for the need to supply pressure to the system is when twelve or more of the individual heads are activated. In passive Dry Standpipe systems, there is no water in the system, and all fire fighting water is supplied by the fire department through their pumpers. Given the potential for loss to both lives and property, the FDC becomes the vital link between the raging fire and the ability of the fire department to mitigate the event.

Historical Perspective

Every firefighter and code official understands the importance of Automatic Fire Sprinkler Systems. Fire sprinklers are widely recognized as the single most effective method for fighting the spread of fires in their early stages - before they can cause severe injury to people and damage to property. Data from the National Fire Protection Association (NFPA), the National Fire Sprinkler Association (NFSA), and American Fire Sprinkler Association (AFSA) are clear:

- Estimates suggest that 80% of all fires in fully sprinklered structures are suppressed by the activation of a single sprinkler head, and 90% by the activation of only two heads.

- NFPA research revealed that property damage in hotel fires was 78% less in structures with sprinklers than it was in structures without sprinklers.

- NFPA has no recorded incident where more than two people were killed in a structure fire when the facility was protected by a fully functional automatic sprinkler system, other than when there was a catastrophic explosion or injuries to firefighters and other emergency responders.
• Many fires can be suppressed with as little as 5-10 gallons of water causing minimal collateral water damage when compared to aggressive fire department attack evolutions and 100 + GPM hand lines.

• The odds of accidental discharge due to manufacturing defects are 1 in 16 million.

If a structure is not protected by fire sprinklers, the results can be catastrophic. Once the smoldering phase has completed and flames appear, any fire has changed from a relatively minor situation to a life-threatening event. Rapid flame and heat growth will follow with temperatures reaching 1500° F in minutes. The contents of the room will ignite, the structural integrity of the building itself will become compromised, and occupant lives are threatened. Within 3-5 minutes room temperatures may be high enough for “Flash-Over” to occur, igniting every combustible object in the room. At this point, all contents will be destroyed and human survivability is impossible. Significant smoke generation in excess of several thousand cubic feet per minute will occur, obscuring visibility while setting in motion conditions for the event to rapidly spread to adjoining structures. The danger does not stop when the fire department is called. The responding crews must enter the building, search for survivors and extinguish the fire. This scenario replays somewhere in America every day of the week, many times, with catastrophic results. In a sprinklered building the results are usually quite different.

Industry advocacy organization ConstuctionDeal.com recently published the following Q&A information regarding home fire sprinklers. “Fire sprinkler systems are set up to react to the temperature change within the room with the fire. So if you have a fire in a kitchen, the temperature will rise and trigger the sprinklers to come on in that room. If the fire were to spread, that change in temperature will allow more sprinklers to come on but only in the new location and not all across the building... most sprinkler applications do not have enough water pressure to turn on all the sprinkler nozzles at the same time. Smoke will set off a fire alarm, but residential and commercial sprinkler installations are set to turn on for temperature changes only. They’re usually set to go off between 155 and 165 degrees Fahrenheit.”

Given the overwhelming evidence substantiating the value of sprinkler systems, and the knowledge that the FDC may be the only way for fire crews to supply the system, what can fire professionals do to protect them and keep them serviceable?
Inherent Vulnerabilities

With the importance we place on automatic fire sprinklers it needs to be pointed out that while they can be tremendously effective, they do have weaknesses. Over time they are susceptible to corrosion, making delivery of water to original design specifications virtually impossible. They are vulnerable to effects of natural disasters like earthquakes, hurricanes, freezing and tornadoes. They are vulnerable to poor installation and maintenance. They are vulnerable to the quality of the individual component parts. All of these vulnerabilities magnify the importance of the ability of the fire department to connect to these systems and augment the pressure and water flow. It must be said, that ‘if’ a system is designed, installed, and maintained properly; storage is kept in accordance with the design parameters of the sprinkler system, and fire safe housekeeping practices are employed, the need for the fire department to pump to an FDC is greatly minimized. This is evident by the fact that most fires are controlled by one or two heads… long before the fire department arrives. The reality is that most systems, eventually, will become less efficient. They are not always installed to the highest level, with the most reliable components. A change of occupancy in a building will change the matrix of the proximity of combustibles and an ignition source (example: change of commodity storage and the introduction of propane forklifts). In many fire scenarios, the fire department is forced to hook up to the FDC and pump water into the system. The appliance, the FDC, is commonly the most vulnerable, ignored, and most often compromised component of the entire system.

Theft of Components

The theft of brass, aluminum, and other industrial metals is approaching epidemic proportions in America. Even a casual internet search on the subject of metal theft will reveal that law enforcement and asset protection professionals are acutely aware of the issue and are trying to identify ways to curb the negative trends. It affects the agricultural industry, transportation, telecommunications, the nation’s power grid, and even the recycling industry. The fact that copper production does not meet demand helps create a ‘black market’ impacting suppliers, users and recyclers while creating a cash flow source for the criminal element. Brass and copper theft is becoming increasingly common throughout the world. As copper approaches $4.00 a pound in 2008, compared to $.060 just five years ago... the theft market is growing past the point where police agencies can develop and train special task force groups to combat the thieves.
thieves. It has even been reported that new crime specific gangs have been created to steal just copper wire. Not long ago one of these gang members was electrocuted when he attempted to steal transmission line cable coming out of a power plant that was fully energized.

In 2008, Scotland Yard reports that large and small scale metal theft is the fastest growing crime in the UK and rates only behind terrorism as a threat to the transportation rail system. Items that have been reported stolen in the US and Europe include:

- Air Conditioning Equipment
- Catalytic Converters
- Manhole Covers
- Street Signs
- Farm Implements
- Irrigation Equipment
- Train/Light Rail Tracks
- Telecommunication Cable
- Electrical Grid Components
- Parking Meters

There is even an internet report that a man in Russia stole an entire small metal bridge to sell as scrap. New loss prevention organizations have formed. Some focus on iron and steel while others are concerned with non-ferrous metals like brass and aluminum. These new organizations have annual conferences where industry professionals and law enforcement can come together to discuss trends. Many states have passed legislation that mandates seller identification tracking, payment waiting periods, along with stiffer prison terms for the thieves.

**Fire Service Secret**

With all of the attention that this topic has received over the past few years, it is evident that this issue is only a small blip on the radar. From a monetary perspective this is true. It is all about loss prevention. There have been a few local TV reports and some good informational articles on fire specific web sites like FireHouse.com. In Florida, men who had previously been employed by a sprinkler installation company wore their former employer’s uniform to avoid suspicion as they went around stealing fire sprinkler connections. While under police surveillance, one man stole 19 in one day.
sell as scrap. Why is this? Are we hesitant to tip off potential thieves to a new cash market? They obviously know about it already. It is time the fire service take on this issue, and implement a multi-faceted approach of technology, legislation and enforcement to curb the threat. Theft of component parts is just part of the problem. There are several factors that can impact whether or not the fire department can supply the sprinkler or standpipe system. First you must understand the importance these connections play and the associated vulnerabilities. Walk down the street in most American downtowns and you see open, vulnerable sprinkler systems, one right after the other. In many cases the system components are stolen for scrap even before the structure is complete and occupied.

Related Issues

The theft of fire protection equipment has an impact that reaches beyond the cost of the metal itself. Spin-off issues and complications in a fire component scenario are:

• Loss of revenue during an interruption of productivity
• Potential business shutdown
• Replacement costs; including labor to inspect/backflush and re-install equipment
• Costs for additional security personnel or equipment to prevent reoccurrence
• Negative media attention
• Legal liabilities should catastrophic result occur
• Loss of life consequences

Impact Damage

It is not just about theft. Delivery trucks, commercial lawn mowers, or simply careless drivers are sometimes the cause of damage to sprinkler FDCs. In some applications bollards are required to keep fragile components from being impacted, other times they are not. Regardless of how the damage occurs, the end result is the same: the system may not work according to the intent of the designer should a fire occur.
Accumulated Debris

If an FDC is left open for an extended period of time, it becomes subject to the forces of nature, including dust, dirt, water, bugs, and birds constructing nests. The accumulated dirt and dust, when combined with humidity and rain can create a mud-slurry that will not pass through the piping. This is especially problematic because the accumulation happens so incrementally that it is not an obvious obstruction and may not be detected during a routine inspection. Once this happens, and if it is not caught and corrected during the inspection process, a potentially catastrophic scenario has been created. You will notice in the pictures on the left that the traditional breakaway caps had been reinstalled after the debris had been introduced into the system. The picture below shows the clog as it forced its way out during a mandatory backflush, shattering the breakaway caps from the inside out.

Negligence/ Criminal Acts

There are several categories of criminals that have their sights on the FDC. Any security plan must address the differences and motivators of each. These criminals include:

- VANDALS
- ARSONISTS
- THIEVES
- NARCOTIC/DRUG OFFENDERS
- DISGRUNTLED EMPLOYEES
- POLITICAL EXTREMISTS
- TERRORISTS

The crimes include theft of brass and individuals that would desire to clog the system to witness the outcome during a fire. As far back as the 1950 NFPA Inspection Manual, fire prevention professionals recognized the vulnerability of open FDCs by vandals. In the early ’50s the problem was blamed on children. In the 21st Century, the threat matrix has grown to include arson for profit and terrorist attacks. It must be stated that there is a significant difference in negligence, vandalism and purposeful sabotage. It seems that in many cities, open FDCs become a convenient trash receptacle by people walking down the street. It is not that they intend to sabotage the systems as much as they don’t want to be seen littering and they are ignorant to the fact that their thoughtless act could have a life threatening impact on the occupants of the building they just inadvertently compromised. While to most it appears to be more of a nuisance than anything, the fact is that in 2006 there were 3,245 civilians who lost their lives as the result of fire. If installed fire protection systems
are compromised or non-functional, the occupants, regardless of fire origin, are as vulnerable as they would be in a traditional non-sprinklered building. Vandalism may very well be attributed to kids out getting into mischief. They are not intending to harm anyone, but the end result is the same. Statistics from the *Insurance Information Institute* state that the leading cause of arson is vandalism, so the end result can be devastating. Consequently, since arson has one of the lowest arrest clearance rates, the crimes go unpunished. Sabotage is a form of vandalism but needs to be treated separately. Vandals are opportunistic and may be deterred by making components harder to steal. Conversely, people that engage in deliberate sabotage have pre-planned the mission, considered the risks, and are still willing to attack the facility and indirectly, the inhabitants. Sabotage may result from both political and economic motivations.

Sprinkler connections are vulnerable to individuals that would sabotage the system in an incendiary fire scenario (Arson). According to statistics from the *US Fire Administration*, in 2006 there were over 31,000 intentionally set fires that resulted in 305 fatalities. That is 305 arson murders. A single small rubber ball introduced into open FDC inlets can clog up the entire system. Then, once an accelerant had been ignited and numerous heads were going off, the fire department would not be able to assist the system by pumping through the FDC and the structure would burn unchecked until the crews were able to make a tactical and dangerous interior attack.

**Special Populations**

Nothing is more reflective of a society than how it treats its most vulnerable members. *Special Population* risk category people can include; elderly, children, and the disabled. They can also be travelers at airports, train, and subway stations, that is because they are away from home and their normal support systems, they are dependent on society and the local government to ensure their safety needs. In some respects, we are all members of some special group. In the context of public safety and survivability, special populations are those people that require additional consideration when planning for emergencies. It has been said that by the time you calculate all of the different groups that may be considered vulnerable during an emergency it becomes hard to find any individual that fits into none of the risk categories. The following is just a simple, partial list of facilities where it is vitally important to ensure that fire protection systems, including sprinkler FDCs are clear and operational.
“High Value” Targets

- Schools
- Hospitals
- Hotels
- Multiplex Movie Theaters
- Retirement Facilities
- Airports
- Assisted Living Centers
- Sports Arenas
- Malls
- Fire/Police Stations
- Ferry Terminals
- Prisons

Firefighter Safety

One issue that must be addressed is firefighter safety in a hazardous environment. Are we asking firefighters to enter a building which is on fire, with their pumpers supplying water to the system, in structures where the deck is stacked against them, or when there are un-expected delays?

OSHA addressed this topic on a global level in a 2006 report titled Fire Service Features of Buildings and Fire Protection Systems. The report states: “Fire service operations take place in stressful, time-sensitive environments. Delaying operations, even slightly, especially during the critical initial phase when the first arriving resources are committed, can adversely affect subsequent operations and the outcome. Delays caused by poorly located fire hydrants, confusing alarm information, ineffective communication systems, or inaccessible valves will have a ripple effect on the other portions of the operation. During these delays, the fire will be growing exponentially. Members of the fire service perform their functions during all times of the day or night, in any weather conditions, and frequently in unfamiliar environments. Their work environment is dangerous, mentally stressful, and physically exhausting. Decisions must often be made without an ideal amount of information, due to the many unknowns on the fire ground (such as what is on fire, how much is burning, where the fire is spreading, and where the occupants are located). These factors stack the deck against the safety of firefighters. Even simplifying the firefighters’ job in small ways will increase the level of safety for them, and thereby for building occupants. Design features that save time or personnel can make a great difference. Any feature that provides additional information regarding the fire, the building, or the occupants, as well as any method to speed the delivery of this information also helps.”
Mitigating the Risks

Any program implemented to address the concerns of protecting FDCs must be a multi-faceted endeavor that uses public education along with the proactive enforcement of the available codes and standards. At the end of the day, it is all about inspection and enforcement to secure the facilities and create a safer environment. It takes a commitment to ask the difficult questions, and take corrective action when it is deemed necessary.

Codes, Standards & FDC Protection

What do you do when you see open FDCs? Do you do anything at all? Do you simply tell the business owner to replace the missing caps? Is that enough? Most code experts agree that the NFPA standards and the fire code address the problem of open, unprotected FDCs. To many fire protection professionals, NFPA 25, Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems suggests that the best course of action is to make certain that when the caps are replaced, that the system is also purged and inspected for debris and be tagged as serviceable by a competent individual. If these are ‘yard pipe’ remote connections this means inspecting them from the connection, through the underground piping, through the back-flow devices, to the sprinkler check valve.

This scenario is problematic enough that the model codes now have an FDC provision for code officials to implement. Proposed language for NFPA 1, Uniform Fire Code states, The AHJ shall have the authority to require Locking Fire Department Connection (FDC) plugs or caps on all water-based fire protection systems. Similar verbiage has been in both the IFC and IBC since 2003. These provisionary code sections can help ensure that these vulnerable connections are secure and made resistant to accidental damage, vandalism and physical attack, and will be serviceable when responding engines arrive.

Proactive Steps

With the provisions of the code and the responsibility to protect both the property and citizens there are opportunities that can be taken that can minimize the risk. For the most part, day to day operational security is not expensive. It is about being vigilant. The following definitions, published in a Purdue University, Rural Security Planning report work well in the context of analyzing potential risks and likely incidents. It is a good baseline and starting point.
Threat + Vulnerability + Risk

- **Threat:** A person’s intent on stealing or destroying assets
- **Vulnerability:** An exploitable security deficiency
- **Risk:** Potential loss of (or damage to) assets

Once you have identified the need to protect and harden assets, the following tools can help you develop a plan.

- **Risk Assessment.** Generally recognized as one of the initial steps of risk and emergency management; it is the study of vulnerabilities and threats overlaid against the expected effectiveness of mitigation measures. It is the process of evaluating threats and vulnerabilities

- **Hazard Analysis.** The analysis or identification of the most likely hazards along with a description of the measures needed for their control.

- **Vulnerability Assessment.** This step is to simply take the first two and rank them in order of importance. (Example: If you don’t have a sea or river port, then you probably don’t have major concerns related to protecting ships and barges. If you do have FDCs with missing caps or brass, then you have a problem.)

Once these steps have been accomplished you can start down a path that will take corrective actions to meet the threat.

- **Implement Mitigation Plan.** Survey the open FDCs in your town. Set in motion a program that will help reduce costly service calls, and potentially save lives and property should a fire occur. Work with other businesses in your area to develop a watch group. Talk to your local emergency management official. Conduct a risk analysis to determine your level of vulnerability.

- **Enforce the Code.** With the code change being part of both the building code as well as the fire code, consult with your local building official and develop a plan that protects the structures during both initial construction phase that the building code covers and the long term maintenance of the structure that the fire code addresses.
• **Use the Power of the Legislature.** Consider passing a local ordinance that will address the issue for protecting the FDCs in your community and virtually eliminate the potential for abuse, accidental damage or malicious act.

• **Federal Assistance.** Consider applying for a federal grant to help combat the problem. Several communities across the country have successfully requested both inspection equipment and locking FDC plugs and caps.

• **Education.** Make public education part of the overall plan. Develop a reporting methodology that will allow citizens to alert the fire department when missing caps or brass is discovered so that corrective action can be taken.

The 21st century is offering new challenges to all public safety organizations. It is important for all of us to look for new solutions to emerging threats. The price of metal, coupled with declining production is creating a lucrative market for thieves. Are we protecting the vital link? In some instances we are, and in others we could do better. If we are to successfully manage this threat, it will take a concerted partnership of government and industry to focus on the issue and develop strategies that identify the risks and take corrective action. If you don’t take steps to enhance the survivability and service capability of the sprinkler/standpipe systems and the FDCs that supply them, who will?

**Three Case Studies**

The following case studies illustrate the potential negative scenarios that can result when clear unobstructed Fire Department Connections are not available to the responding fire units. These departments were willing to share their experiences in hopes that others will realize that if these conditions can exist in these, prevention-oriented departments, they may exist in any community, including yours.
Case Study 1

Franklin, Tennessee

Wrong Thread Pattern

In April 1999, the Franklin Fire Department in Franklin, Tennessee adopted a local ordinance requiring Locking Fire Department Connection (FDC) Caps.

Following the adoption of the ordinance, the Fire Marshal notified architects during the construction plans review for new construction and notified existing building owners of the requirements to retrofit the caps on existing systems along with a time table for compliance.

Soon thereafter, the Fire Marshal was asked to meet the building owner of a local industrial occupancy to secure the locking FDC caps. The existing metal “break-a-way” caps were removed and the staff attempted to install 2 ½” Locking FDC plugs.

It was discovered the thread provided on the FDC did not match the approved NST thread used by the Franklin Fire Department, a condition that existed for approximately 32 years.

By order of the Fire Marshal, the building owner immediately contacted his fire protection sprinkler contractor and the FDC was completely replaced with the approved thread pattern. The locking FDC plugs were installed.

According to Fire Marshal Robert Trotter (ret); “Had Franklin not adopted this local legislation to mandate the locking FDC caps, we may have never known about the conflict in hose thread pattern. The inability to hook-up to the FDC and support the fire sprinkler system could have resulted in tragic consequences including injuries, death, and significantly greater property losses.”
Case Study 2

Edina, Minnesota

Wellington Apartment Fire – Standpipe Clogged With Bird’s Nests

These photos are from an apartment fire in Edina, MN where attack nozzles were clogged and rendered unserviceable by debris introduced into the unprotected FDC openings. According to Fire Marshal Thomas Jenson, “The FDC was located about 15 feet from the building and the caps were missing. The amount of pipe between the FDC and the standpipe connection was an additional 250 feet with fire hose adding another 300 feet...the tennis ball and debris traveled 550 feet through pipe and attack lines before becoming jammed in the nozzle.”

Facts:

- Debris was introduced into unprotected Dry Standpipe connections.
- Tennis ball & bird nests traveled a total of 550 ft and clogged both the primary & backup fire lines
- Fire Crews were able to evacuate the building and then were forced to withdraw due to fire
- Apartment was a total loss and was eventually demolished
- All families were displaced
Case Study 3
Englewood, Colorado
Debris Clogging FDC

Marla Wilcox, Assistant Fire Marshal for Englewood Colorado’s Department of Safety Services noticed that there was trash stuffed in the FDC connections of a local big box store. Per the department’s policy, she requested the store clean out and re-secure the connection with locking FDC plugs. The store ordered the plugs and cleared the connection of all visible debris. After the store received their locking plugs, they contacted the fire prevention office to have the plugs installed and locked.

When firefighters arrived to install the plugs, it appeared the store had cleared the connection of the debris. But knowing that it had been stuffed with trash, the bureau decided to use a snake camera to ensure the connection didn’t have any debris further back. With the snake camera, they were able to see that debris was stuffed all the way back to the check valve. The debris consisted of a handful of rocks and an orange Titleist® golf ball – all debris that would negatively impact the performance of the connection if the department had to hook up their hoses during a fire. While it took some effort, the firefighters were able to remove all of the debris. Then, they locked the connection to prevent debris from being stuffed inside. “If the store had debris beyond our reach, we would have required them to back flush their system,” Wilcox said.

While most individuals mean no harm, stuffing rocks and other debris into FDC connections can negatively impact a connection’s usefulness for responding crews. It only takes a small handful of debris to negatively impact a department’s ability to fight a fire at the store.
FDC Anti-Theft Procedure Example

The following example illustrates steps that can be taken to make 2 ½” Siamese FDC connections less vulnerable to theft/attack. In today’s world, procedures such as these are necessary to ensure the FDC assembly is permanently secured to the pipe thread on the building.

**This procedure involves installing one or more 5/16-18 Allen set screws as well as a special permanent adhesive in order to secure FDC Brass to the pipe thread on the building. This will minimize the chance of theft.**

1. **Use Letter F** drill bit to drill a hole entirely through the brass adapter lip, approximately 1/2” from lip edge. One hole provides extra security. Three holes spaced 120° apart will provide much better security.

2. **Tap threads in the hole/s using a 5/16-18 thread tap.**

3. **Clean pipe threads thoroughly with solvent, wire brush, and dry completely.** No grease or oil can be present on the pipe threads in order for adhesive to work properly.

4. **Apply Permabond HM162 to both threads on adapter and threads on pipe. Coating should be thin, but needs to completely coat the threads.**

5. **Tighten and position FDC brass adapter on pipe.**

**NOTE:** To minimize potential of pipe being removed from outside, attach a clamp to secure pipe from the inside.

6. **Use 1/4” drill bit to spot drill through the set screw hole/s in adapter and into pipe approximately 1/16” deep. DO NOT OVERDRILL TOO DEEP AND PIERCE PIPE.**

7. **Clean drill holes of debris then place a small amount of remaining Permabond HM162 in hole and on set screws, then install set screws, securing firmly with a 5/32” Allen wrench.**

8. **After set screws have been secured, insert a ball bearing slightly larger than the Allen hole into the screw head and use punch to hammer into place. Alternatively, fill the screw head with a permanent epoxy material. This will virtually eliminate removal attempts.**

*Don’t let FDC brass fall victim to theft!*
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