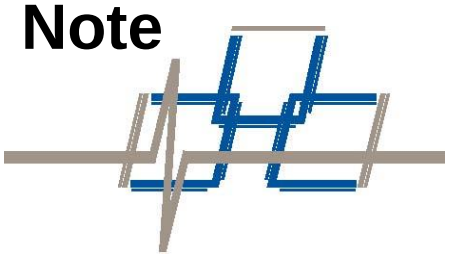
Culvert Protection

Application Note



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1. Introduction

The successful installation and operation of a Fiber SenSys® fiber optic security system are achieved by a thorough understanding of the security needs of the site to be protected as well as proper deployment of the sensor cable. For perimeters with accessible culverts running from outside to the inside of the secured area, securing the culvert grate is necessary. Culverts present a unique and covert access point for intruders, and the sensor must be installed correctly to ensure a high probability of detection. This application note will lead the reader through the site design and installation procedures for fiber optic sensor deployment on culvert grates.

Prior to installing the Alarm Processing Unit (APU) and deploying the sensor cable, the site must be assessed so all the security needs are met and all potential threats are accounted for. The entire perimeter needs to be secured, and the location of APUs planned for protecting each zone.

Fiber SenSys® recommends the following procedure for planning the installation of our fiber optic perimeter security systems:

1. **Assess:** Survey the site to be protected including all accessible culverts and record all information needed for the site design phase.

2. **Design:** Create a strategy for protecting the site. Planning location and number of zones should include an individual zone for each culvert grate.

3. **Install:** Proper deployment of the fiber optic sensor and correct installation of the Fiber SenSys® system.

4. **Tuning**: Once the sensor is properly installed, intrusion simulations should be performed and the system tuned to catch intrusions.

2. Site Assessment

Site assessment is used to evaluate the security needs of a site and to gather important information used for site design. This process involves the following:

- Collect the system requirements:
  - Level of security (high, medium, etc.)
  - Develop potential intruder profile
  - Types of security threats
  - Additional layers of security (cameras, lights, additional sensors, etc.)

- Survey the culvert and record:
  - Location of all culvert grates
  - Length and height of the culvert grate
  - Spacing of culvert grating
  - Culvert surroundings (fence, roads, openings, etc.)

2.1 Intrusion Types through Culverts

The culvert needs to be assessed for intrusion pathways. Culvert grating varies in structure, material grate spacing, and means of attachment. Possible intrusion attempts through culverts include the following:

1. Removing culvert grate attachments
2. Destroying and/or bending culvert grate
3. Cutting and removing portions of the culvert grate

A properly installed and tuned Fiber Defender® alarm processor will detect all relevant types of intrusion attempts on a culvert grate.

2.2 Nuisance Alarms

As part of the site assessment, consider possible non-threatening activity that could trigger an alarm. Water and debris flowing through the culvert, wind, and animals are potential sources of nuisance alarms. Encroaching vegetation may dampen or increase the vibration of the grate due to running water or heavy wind.

Before system installation, take all the necessary steps to prevent nuisance alarms by trimming encroaching or potentially encroaching vegetation and restricting wildlife. Nearby debris that may be carried with water should be removed and continually maintained. Due to the inherently rigid property of culvert grates, the wind is less likely to be an issue but should be adjusted for.

Figure 1: Excess debris in culverts should be removed. The debris may increase the Nuisance Alarm Rate(NAR) and also provides an intruder cover from visual identification.

In general, the culvert grate should be securely fastened and in good repair. A poorly secured grate will likely cause excessive nuisance alarms and will present a less challenging access point for intruders.

3. Deployment/Installation

3.1 General Rules

Culverts and culvert grates don't have a standard design so the installation can vary; however, the following guidelines apply to all culvert grates:

- Fiber and conduit should make vertical and horizontal passes covering entire surface with bend radius of 8" +/- 2". This means the distance between two pieces of sensor should be no more than 10" as shown in Figure 2. Kinks in the conduit or bends with a radius of 6" or less are not permitted when mounting conduit to a culvert grate. This will accelerate degradation of the conduit and fiber and decrease the probability of detection.
- If possible, the fiber and conduit should weave in and out of grating in at least one direction.
- The final installation pattern should be impossible to remove without cutting the sensor.
- The culvert grate should be impossible to bend or break without breaking or attenuating the fiber.
- Wire ties should be applied at least every 12" or 30cm. There cannot be too many wire ties, only too few as the cable inside the conduit is unrestrained.

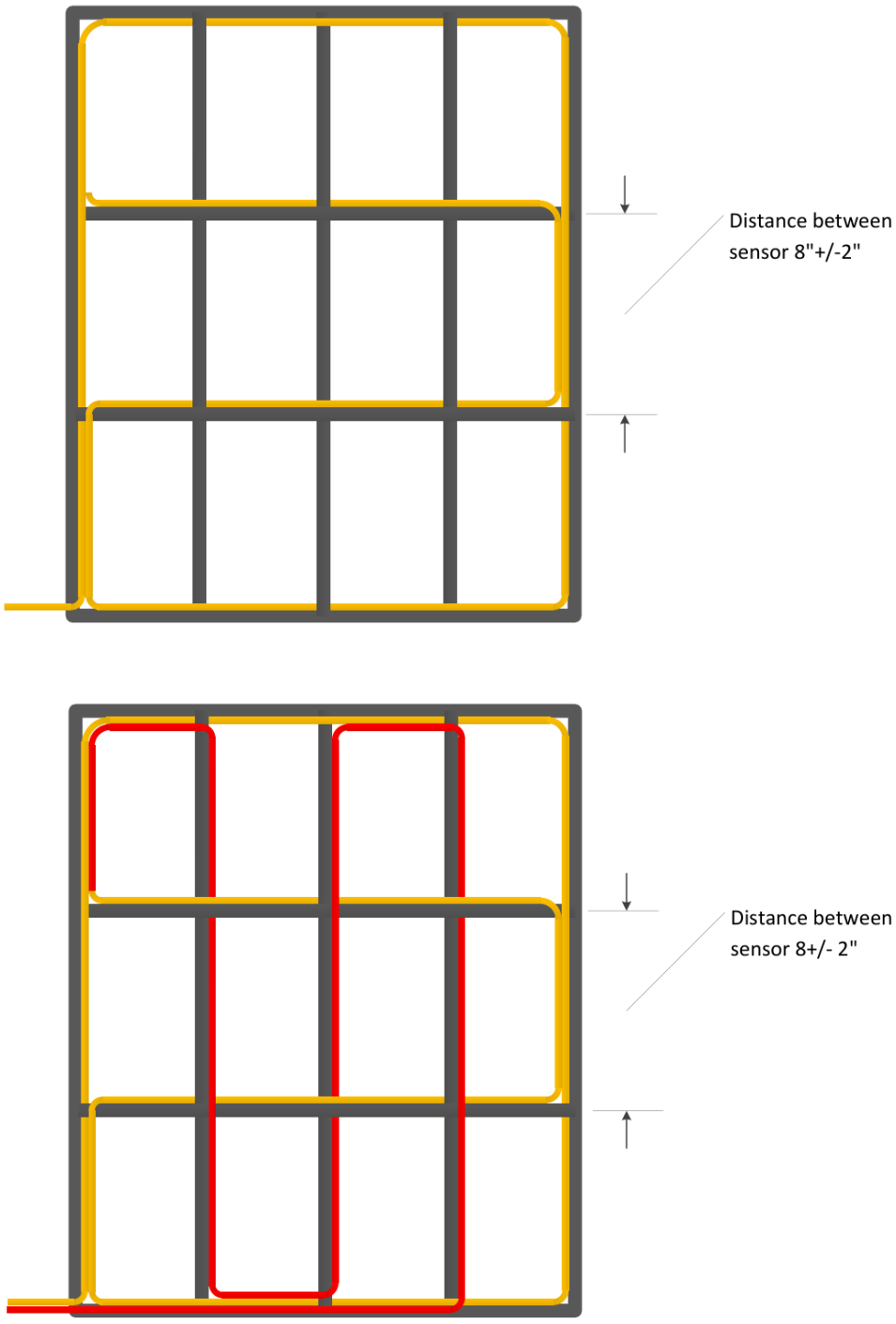

Figure 2: First wrap perimeter of culvert, weaving in and out of bars when possible, then weave horizontally, shown in the top image. Then continue to weave sensor vertically along each bar. Note sensor is close to grates to prevent excess debris from getting trapped.

A completed fiber optic installation is shown in Figure 3. The conduit should not kink when weaving in and out of culvert grate. If weaving causes kinks, consider skipping one or more bars

during weaving. Figure 3 shows vertical passes woven over and under the culvert grate; horizontal passes laid flat on top.

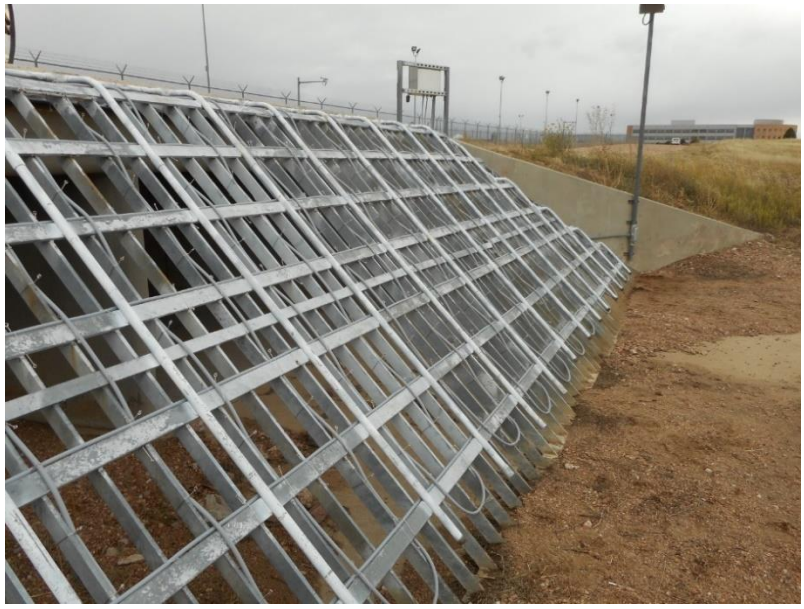

Figure 3: First horizontal passes are installed with loops 10” wide. The vertical passes were then installed weaving between grates. An intruder would have to cut or move a section of sensor to penetrate this culvert grate. Every bar is secured to the conduit.

Figure 4 shows an example where the weaving has caused kinks in the conduit degrading the material. For this application, weaving in the horizontal direction is not advised.

Figure 4: Example of an excessively small bend radius resulting in kinked conduit. This can impact fiber sensitivity and over time will degrade the conduit and fiber.

Figure 5: The above culvert requires the sensor to be deployed on all four sides of the grating. For this culvert, weaving would potentially result in kinks in the conduit and would have to be avoided. Installing on the protected side if possible would be preferable when weaving is not an option.

3.2 Special Case

A special case with recommended fiber install is included below to guide the reader.

Tunnel Grates

The example shown below in Figure 6 contains a culvert-like grate with doors through a tunnel. While it isn't possible for an intruder to climb over the grate, it would be possible to cut the bars and slide through. For this application, the sensing fiber has the same purpose as a culvert grate. The intruder would be forced to move or cut the sensor to penetrate the secured area. The fiber was run first in vertical loops (shown in Figure 6 center), weaving in and out of every other bar and avoiding the large gate and man gate. The fiber was then looped horizontally (Figure 6, far right) requiring at least one pass through each horizontal section. Door and gate, highlighted in the left image of Figure 6, are protected by installing sensor as their own zone so that unique parameters could be applied.

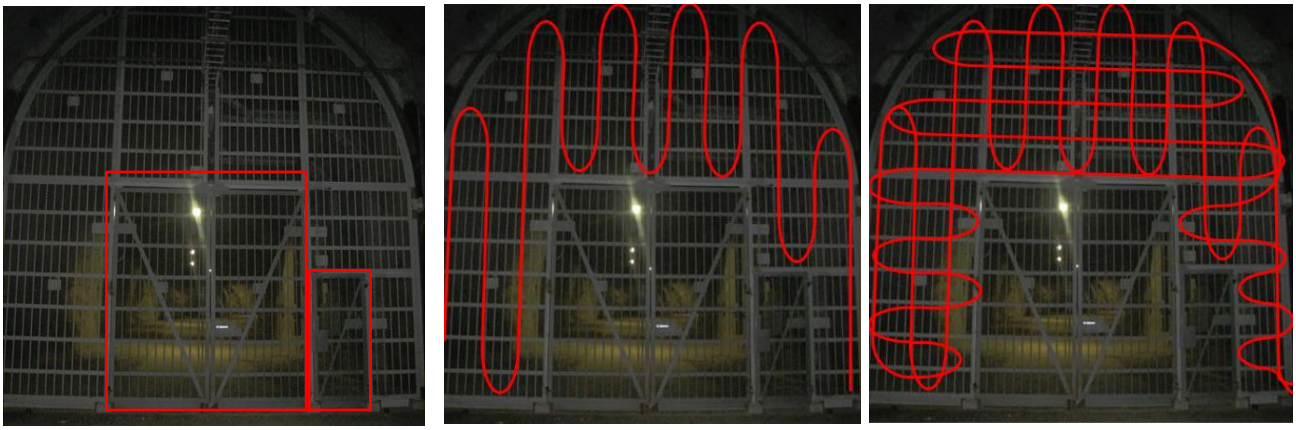

Figure 6: Culvert style grate inside tunnel. Location of gates and doors is highlighted on the left image shown above. These can be protected by fiber optic sensor. Center and right images above show correct conduit installation starting with the center image.

4. Tuning for culvert intrusions

The culvert zone is tuned by simulating intrusion attempts. A cut attempt can be simulated by drawing a piece of threaded rod as the test tool back and forth across the culvert grating. The rod should be a minimum of 8" long, with a 3/8" diameter and thread spacing of 16 threads/inch. A destructive intrusion attempt may be simulated by striking the culvert grate with a firm rubber hammer or mallet. Culvert deployment mediums are not tuned using the same techniques as fence deployments and do not resemble default fence parameters. An intruder would not attempt to climb a culvert grate; they would attempt to penetrate it.

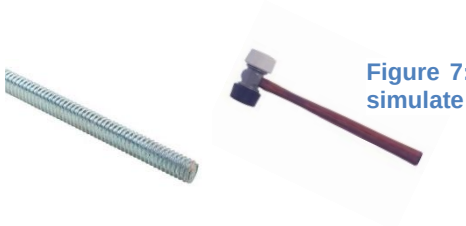

Figure 7: Threaded rod and rubber mallet used to simulate destructive testing.

NOTE: *The following section is not intended to be a comprehensive tutorial on tuning. Application Note AN-SM-008, Setting the Tuning Parameters, contains detailed tuning instructions and can be provided by contacting support at support@fibersensys.com or (503) 726-4455.*

Basic steps for tuning:

1. Disable Processor #2.
2. Simulate a saw cut using the threaded rod for 5-10 seconds, and record it while viewing the signal in RealTime mode.
3. Review the signal in Replay and Modeler modes. Adjust the Sensitivity as needed by only 1-2 points at a time.

4. After Sensitivity is satisfactory, record a new signal from a new saw simulation. Adjust the gain, level of signal and low frequency on Processor 1 to ensure you get a single alarm. The saw intrusion should generate an alarm within 5 seconds of the simulation. If alarms too soon, the system is tuned too hot. If it takes too long, it may not catch an intruder.
5. Simulate a destructive test using a hammer or mallet. Verify that there is sufficient signal to detect the intrusion.
6. View signal from the test tool on Replay and Modeler and adjust Processor 1 level of signal and low frequency.
7. Conduct a probability of detection (PD) test consisting of 20 saw tests and 20 hammer tests.

NOTE: *A culvert zone can be tuned to catch other types of intrusions. However, tuning a zone to be overly sensitive, referred to as a "hot" zone, causes it to be more susceptible to nuisance alarms.*

Settings	Default	
Gain (1-50)	20	20
Sensitivity (1-500)	10	10
Processor #1		
Enabled	Yes	Yes
Signal (1-40 dB)	10	10
Low Frequency (10-600 Hz)	200	200
High Frequency (10-600 Hz)	600	600
Duration of Signal (1-25 sec/10)	3	3
Tolerance (1-10 dB)	5	5
Event Count (1-100)	3	3
Event Window (1-200 sec/10)	50	50
Event Mask (1-100 sec/10)	2	2
Processor #2		
Enabled	Yes	No
Signal (1-40 dB)	10	10
Low Frequency (10-600 Hz)	300	300
High Frequency (10-600 Hz)	600	600
Duration of Signal (1-25 sec/10)	1	1
Tolerance (1-10 dB)	3	3
Event Count (1-100)	5	5
Event Window (1-200 sec/10)	80	80
Event Mask (1-100 sec/10)	7	7

Figure 8: Parameter set for culvert applications. Signal size and frequency vary greatly with culvert size and construction. Start with processor 2 disabled and default parameters on processor 1.

Initial parameters can be found in Figure 8. Processor 2 has been disabled. Processor 1 has default parameters remaining. Depending on the size and construction of the culvert default parameters may be too sensitive or too insensitive. Processor 2 is disabled because a hammer strike has such a large signal it will be captured on both processors. Processor 1 has been tuned to capture saw cuts and will always alarm with a hammer strike.

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