TECHNICAL REPORT

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Pipe/Specialties Team

Mechanical Coupling Testing for Smooth Walled HDPE Conduit

Introduction

The joining of lengths of telecommunication ducting is an important, but often overlooked aspect of a network system because this joint can be a potential weak point. If the ducts are not joined together effectively, there is a high probability that what was meant to be protected by the ducting is exposed.

Figure 1 – Duct Installation using Mechanical Couplers

There are many different mechanical couplings currently being used to join smooth walled HDPE conduit in the field today. The purpose of this testing was to provide a side by side comparison of commercially available couplings and establish compliance with the Bellcore GR-356 Generic Requirements for Optical Cable Innerduct and Accessories testing protocol requirements.

These requirements include water tightness (external pressure test), an internal pressure test, a pull out test, and chemical/corrosion resistance. Each of these tests can be related to a real world situation to which HDPE ducting systems are exposed to in the field. Additional comments were added for each type of coupling used such as "ease of installation" or if special tools were required for installation.

In order to test the forgiveness of the couplings to various installation conditions additional testing was performed on samples where the ducting was only partially installed into the coupling (approximately 50% of the thread-length of the coupling). The concept being simulation of "less than ideal" installation conditions, where either the duct was not fully installed into the coupler or the duct was not cut at a 90° angle, which in either case would prevent the full utilization of the threads.

It was seen that some samples that passed the original "proper installation" testing, failed when only partially installed. This indicates that some couplers are more robust in providing a secure joint under less than optimal conditions due to their design.

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Couplers Evaluated

The couplers most widely used in the field were chosen for this study and consisted of 5 commercially available couplers from 4 different manufacturers (see Figure 2). These included the following:

- Central Plastic's HDPE Electrofusion Coupling also used for pressure pipe applications
- Group Timberline's Condu-Grip, a plastic thread-on coupler with a rubber gasket
- Jack Moon's anodized aluminum thread-on coupler
- Lozon's SealLock plastic thread-on One Piece coupler
- Lozon's SealLock Two Piece, a plastic thread-on, snap-together coupler

All couplers tested were used to join 1¼" duct provided by Quail Pipe of Kingman, Arizona.

Figure 2 – Couplers Tested

From left to right:
Group Timberline Condu-Grip
Jack Moon Aluminum
Lozon Seal-lock One Piece
Lozon Seal-lock Two Piece

Not pictured – Central Plastics Electrofusion Coupler

Testing and Requirements

Chemical and Corrosion Resistance

This test is important due to the potential for chemical interactions between some soils and the couplings. Alkaline soils are particularly harsh environments for some materials and are found in abundance across the southern US. Typically, alkaline soils will contain limestone, gypsum, dolomite, or have been stabilized with lime such as along roadways and railroads.

The following requirements are taken directly from the Bellcore GR-356 *Generic Requirements for Optical Cable Innerduct and Accessories* testing protocol requirements:

> Section R5-3 – Non-metallic couplers used in direct buried or underground applications shall meet Environmental Stress Cracking and Hydrocarbon Resistance requirements.
>
> Section R5-4 – Metal couplers used for joining sections of innerduct shall be made of corrosion resistant metal.

Couplers in use in the field are constructed from a variety of materials, including plastics and metals. Some of these materials are more inert and impervious to attack than other materials are due to their inherent properties. The chemical and corrosion resistance for each coupler was evaluated based on the published chemical reactivity of the materials used to manufacture the coupling. Comments are made in Table 1 of the Testing Results section for each coupler.

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Internal Pressure Test

This test can be linked to blowing cable through the duct. Internal pressure tightness is an important property because it impacts how easily cable can be installed into the HDPE ducting system. If the joints leak and cannot hold a reasonable amount of pressure then both the blowing lengths and the installation efficiency are reduced, which increases project costs.

The following requirement is taken directly from the Bellcore GR-356 Specifications:

> Section R5-5 – Innerduct couplers intended for use with high speed air blowing systems for placing optical cable in innerduct shall be capable of being pressurized to 125psi at 23°C for 5 minutes.

Each coupling was used to join two 1 - 2 foot long sections of smooth walled HDPE duct with HDPE end caps fused to each open end (Figure 3) and testing was conducted in Solvay's Pipe Testing Laboratory (Figure 4) at 200 psi. While insertion of cable in the field can take considerably longer and often at higher internal pressures than the Bellcore proposed 5 minutes at 125 psi, the testing conducted in this report provides some insight into each coupling's overall capability.

The coupler passed this test if no air leaks were observed during the 5-minute test duration. The results are summarized in Tables 1 and 2 for each coupler.

Figure 3 – Coupler Installed with Duct and Ready for Pressure Testing

Figure 4 – Internal Pressure Testing – Leaking Coupler

Water Tightness (External Pressure Test)

This test can be related to water or ground moisture surrounding a buried duct. This is another important performance criteria because it is expected that what is inside the duct (fiber optic cables, wire, etc.) will be protected from water and soil contact. In addition, many of the ducting systems installed today will not be used for several years and may be considered useless if water or soil sediment has seeped into the duct since initial installation.

The following requirements are taken directly from the Bellcore GR-356 Generic Requirements for Optical Cable Innerduct and Accessories testing protocol requirements:

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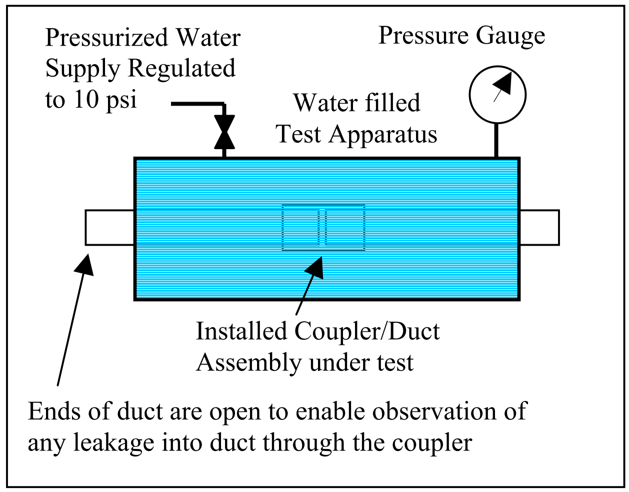
> Section R5-6 Innerduct compression type couplers used in direct burial applications or manholes shall provide a water resistant seal capable of withstanding a 20 foot head of water (approximately 5 psi) for 7 days.

Each coupling was used to join two 1 - 2 foot long sections of smooth walled HDPE duct and this assembly was placed into the test apparatus. The test apparatus was constructed at Solvay Polymers' Technical Center and is pictured in Figure 5. A slightly higher test pressure of 10 psi was chosen, as it was readily available and easy to maintain.

Samples were tested until water began to leak into the conduit (See Figure 6). The specimen passed if no leakage was detected during the 7 days of testing. The results for each coupler are summarized in Tables 1 and 2.

Figure 5 – Water Tightness Test Apparatus with Specimen Under Test Conditions

Figure 6 – Sketch of Water Tightness Test Apparatus



Pull Out Resistance (Tensile Strength)

The Bellcore requirement applies only to duct systems which are intended to be pulled during installation (i.e. directional drilling), however this test can also be correlated to soil stability, compaction, or thermal expansion and contraction, which can impose similar forces on the ducting system.

The following requirement is taken directly from the Bellcore GR-356 Specifications:

> Section R5-7 – Innerduct pulling type couplers used for non-corrugated innerduct, shall have a pullout resistance equal to the minimum working pull strength (of the actual innerduct product).

Figure 7 shows the tensile testing conducted at

Figure 7 – Pull Out Resistance Tensile Test

CSR Polypipe in Gainsville, TX on an Instron model 4202 with a 2000 lb_f maximum load. The test pull speed was set at ½ inch/minute and the test was stopped at the first drop in tensile load, either due to full pull out or slipping of the threads (partial pull out). For 1 ¼" SDR 11 duct, the Bellcore requirement for minimum pulling strength is 1500 lbf and was a "guideline" for this study.

The Bellcore requirement focuses only on pulling type couplers, this testing was useful to gain a perspective as to which coupler(s) could perform well when faced with harsh installation situations, sub-optimal soil conditions, and thermal cycles, all of which can impart significant tensile loads on a duct system. Results of the Pull out testing are summarized in Tables 1 and 2.

Coupler Size

The actual dimensions of the couplers can be a factor in some applications, especially if they are used in pulling and plowing applications.

> Section R5-8 – Innerduct pulling type couplers shall not unduly increase the outside dimensions of the innerduct/coupler arrangement.

This was not an important consideration in this study since all of the couplers studied were of similar dimensions and any exceptions were noted in the comment field located in the Testing Results in Table 1.

Improper Installation

The Bellcore testing protocol assumes that the coupler is properly installed and threaded fully onto the duct (Figure 8). However, in order to test the forgiveness of the couplings to various "real world" installation conditions additional testing was performed on samples where the ducting was only partially installed into the coupling (approximately 50% of the thread-length of the coupling).

The concept was to simulate "less than ideal" installation conditions, where either the duct was not fully installed into the coupler or the duct was not cut at a 90° angle, which in either case would prevent the full utilization of the threads (see Figure 9). With an incorrectly cut duct, the duct could be installed to the internal stops of the coupler, but only a portion of the thread-length is utilized.

Figure 8 – Sketch of Properly Installed Coupler

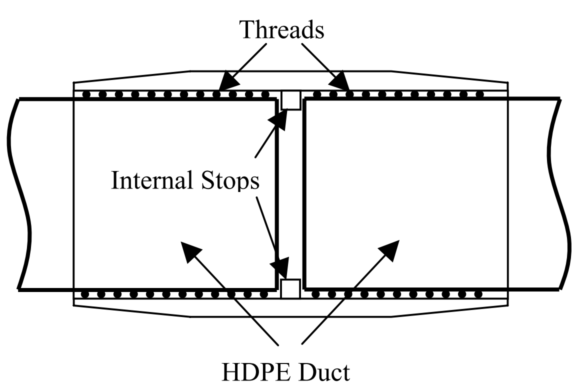


Figure 9 – Sketch of Incorrectly Installed Coupler Conduit is only Inserted 50% or Less than 90° Cut Angle

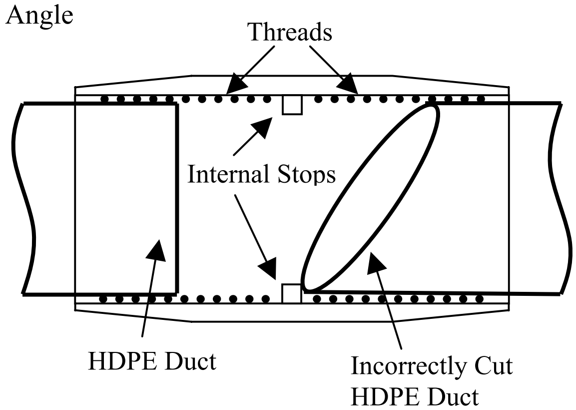


Table 1 summarizes the testing results for couplers that were fully and correctly installed and Table 2 are for improperly installed couplers.

Testing Results

Tables 1 and 2 summarize the testing results and comments made for each of the couplers tested in this study. Table 1 is for couplers that were fully and correctly installed and Table 2 is for couplers that were incorrectly installed.

1. Central Plastics Electro-fusion HDPE

The Electro-fusion HDPE fittings also passed the tests, but drawbacks for this system are related to the installation. Special equipment is needed and installation time is increased to insure proper cool-down after fusion and removal of electrical plugs extending away from coupler. Care must be taken to insure that the conduit is completely installed into the coupler during fusion and that the fusion zone is free from contamination.

2. Group Timberline Condu-Grip

The Condu-Grip passed nearly all evaluation categories for both correct and incorrect installation testing. It is made from corrosion resistant and durable polymer material, the rubber gaskets provide a water/air tight seal even when not fully installed, no special equipment is required for installation, and the thread design provides superior pull out resistance. Although the "improperly installed" Condu-Grip did not surpass the 1500 lb_f pull out test (Table 2), the test results suggest that it performs better under these laboratory conditions than the other couplers in this test.

3. Lozon SealLock One Piece

Depending on the application and field conditions (soil pH and stability) the Lozon SealLock One Piece coupler could be used. Ease of installation was very good, however care must be taken to insure that 100% of the threads are used to obtain a sufficient water/air tight seal. Pull out strength was lower than the other couplers evaluated even when fully installed.

4. Lozon SealLock Two Piece

The Lozon Two Piece SealLock coupler did not pass several areas of testing including the Internal Pressure, External Pressure (water tightness) and Pull-out Strength tests. The Chemical and Corrosion Resistance is also an area of concern as the material used in the manufacture of this coupling may not react well in alkaline soils. Therefore it is recommended that careful consideration of the intended application be given prior to using this coupling.

5. Jack Moon Aluminum

The Jack Moon Aluminum coupler did not pass several areas of testing including the Internal Pressure and External Pressure (water tightness) tests. The Chemical and Corrosion Resistance is also an area of concern as the material used in the manufacture of this coupling may not react well in alkaline soils. Therefore it is recommended that careful consideration of the intended application be given prior to using this coupling.

Conclusion

The joining of lengths of telecommunication ducting is an important, but often forgotten aspect of a network system because this joint can be a potential weak point. If the ducts are not joined together effectively, there is a high probability that what was meant to be protected by the ducting is exposed.

There are many different mechanical couplings currently being used to join smooth walled HDPE conduit in the field today. The purpose of this testing was to provide a side by side comparison of commercially available couplings and establish compliance with the Bellcore GR-356 Generic Requirements for Optical Cable Innerduct and Accessories testing protocol requirements.

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It was seen that some samples that passed the original “proper installation” testing, failed when only partially installed. This indicates that some couplers are more robust in providing a secure joint under less than optimal conditions due to their design.

Based on these test results, the Group Timberline Condu-Grip appeared to offer an optimal combination of technical performance and ease of installation. The Central Plastics Electrofusion fitting and Lozon One Piece SealLock couplers performed sufficiently in many areas, but each had some shortcomings such as special installation equipment required or corrosion resistance issues. The Jack Moon Aluminum and Lozon Two Piece SealLock couplers did not pass several areas of testing and therefore may not be well suited for some applications.

Table 1: Full and correct installation of coupling onto conduit

Requirement	**Central Plastics Electro-fusion Coupling**	**Group Timberline Condu-Grip**	**Jack Moon Aluminum Coupling**	**Lozon One Piece**	**Lozon Two Piece - Snap Together**
Chemical and Corrosion Resistance	Excellent HDPE is as good as duct material	Excellent Polymer material is impervious to soil corrosion	Marginal Aluminum can corrode in alkaline soils	Marginal Polyacetal is susceptible to stress cracking in alkaline soils	Marginal Polyacetal is susceptible to stress cracking in alkaline soils
External Pressure "Water-tightness" Test **10 psi, 23°C, 7 days**	Passed Held full pressure for duration of test	Passed Held full pressure for duration of test	Failed Leak detected immediately	Passed Held full pressure for duration of test	Failed Leak detected immediately
Internal Pressure **200 psi at 23°C** **for 5 minutes**	Passed Held full pressure for duration of test	Passed Held full pressure for duration of test	Failed Leak detected immediately	Passed Held full pressure for duration of test	Failed Leak detected immediately
Pull Out Strength **>1¼" duct tensile strength (1500 lb_f)**	Passed >1800 lb_f Test discontinued	Passed 1902 lb_f Full Pullout	Passed 1675 lb_f Full Pullout	Failed 438 lb_f Threads Slipped	Failed 581 lb_f Threads Slipped
Coupler Size – Outside Diameter **For coupling 1¼" duct**	2-1/4 inch OD Electric plugs extend away from coupler that may require removal.	2 inch OD	2 inch OD Low profile	2 inch OD	2 inch OD
Ease of Use Comments	Special equipment required for installation. Easy to fully install.	Good – required more torque to fully install. Only coupler with rubber gaskets.	Very Good – not difficult to thread on fully. Metal threads can be sharp.	Very Good – not difficult to thread on fully.	Excellent – easy to fully install and couple two parts together.

Table 2: Improper Installation by only inserting conduit 50% into coupling

Requirement	**Central Plastics Electro-fusion Coupling**	**Group Timberline Condu-Grip**	**Jack Moon Aluminum Coupling**	**Lozon One Piece**	**Lozon Two Piece - Snap Together**
External Pressure “Water-tightness” Test 10 psi, 23°C, 7 days	Passed Held full pressure for duration of test	Passed Held full pressure for duration of test	Failed Leak detected immediately	Failed Leak detected immediately	Failed Leak detected immediately
Internal Pressure 200 psi at 23°C for 5 minutes	Passed Held full pressure for duration of test	Passed Held full pressure for duration of test	Failed Leak detected immediately	Failed Leak detected immediately	Failed Leak detected immediately
Pull Out Strength >1¼” duct tensile strength (1500 psi)	Not Tested	Failed 1231 lb_f Full Pullout	Failed 265 lb_f Full Pullout	Failed 552 lb_f Threads Slipped	Failed 209 lb_f Threads Slipped