Development Of An Optical Fibre Cable Overblowing System

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Abstract

Over the last few years there has been an increase in the level of interest and activity in the optical fibre cable overblowing installation process. In 2016 a paper was presented at the IWCS [1] which showed that this process was possible in small diameter sub-ducts. This practice of overblowing a small diameter 72 fibre cable into a reduced diameter sub-duct already containing an optical fibre cable is now a proven practice. Refinements to the installation practice and Connectivity have since been developed to enhance the existing practice.

Equipment, cable and installation processes have now been developed to enable higher fibre count cables to be overblown into larger diameter sub-ducts

This installation process involves installing a small diameter, high density fibre cable into a sub-duct that already contains an existing in-service cable. The key benefits with this practice are:

1. Cost.
2. Speed.
3. Reduction in third party inconvenience.
4. Minimising environmental impact.

In order to maximise the benefits of overblowing a system approach has been developed which includes:

- Fibre Cable Design.
- Sub-duct Design.
- Sub-duct & Cable Options.
    - Fibre Count
    - Fill Factor
- Installation Equipment.
    - Blowing Head
    - Y Connector
- Installation Process.
    - Lubrication.
- Connectivity.
- Training.

This paper will detail the development of an overblowing system which covers a wide range of sub-ducts.

1. Introduction

Over the last few years there has been an increase in the level of interest and activity in the overblowing installation process. In 2016 a paper was presented at the IWCS [1] which showed that this process was possible in small sub-ducts.

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A more detailed description of these benefits is covered in section 9.

The result of this work was proven in extensive installation trials and one UK network provider took the decision to equip a significant number of installation teams with the equipment required to undertake the process. This installation practice is now used extensively throughout the UK with a high level of success. It has also been trialled in Italy in a 25/20mm sub-duct which was successful and resulted in an extremely positive reaction from the customer.

A decision was made to look at the equipment and Connectivity involved in the process and to see where it could be made more operator friendly.

The obvious question then came up 'what fibre count cables could be overblown into larger sub-ducts'? The original design of cables suitable for overblowing was extended from 96f maximum to 144f incorporating 12f per tube, this has since been extended to include a 432f version. A new range of cables was developed incorporating 24f per tube with a capacity up to 288f.

2. Cable Design

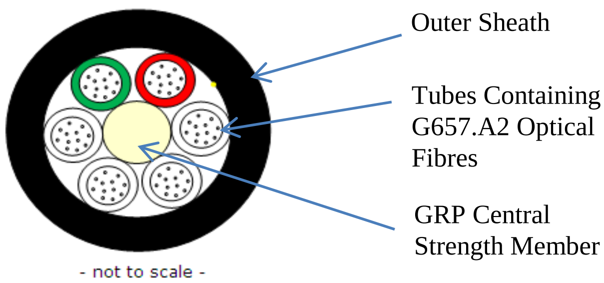

Figure 1. 72f Cable Design

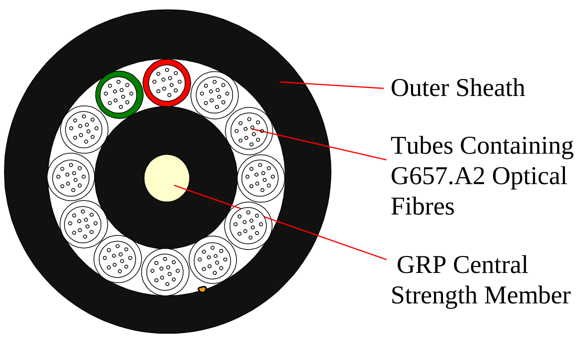

Figure 2. up to 144f Cable Design

Figures 1 and 2 show the typical design of the cables that are suitable for overblowing systems. The use of a conventional multi-loose tube design gives the optimal installation performance due to it having a neutral bend performance. Tables 1 and 2 indicate the key cable parameters that influence the cable selection and ability to install an overblown cable.

Table 1. 12f/tube Cable Parameters

	72f	96f	144f	432f
Diameter	5.0mm	5.8mm	7.5mm	12.8mm
Weight	23kg/km	33kg/km	53kg/km	135kg/km

Table 2. 24f/tube Cable Parameters

	144f	192f	288f
Diameter	6.6mm	7.9mm	10.6mm
Weight	44kg/km	60kg/km	100kg/km

3. Sub-duct Design.

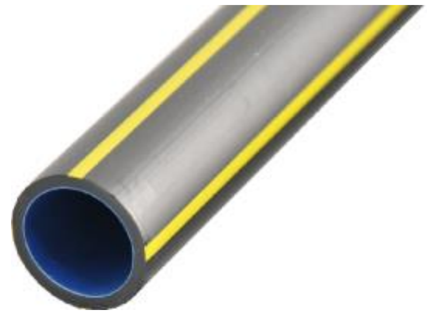

Figure 3. Sub-duct Design

The high-density polyethylene sub-duct (figure 3) that is typically installed by customers has the dimensions detailed in table 3.

Table 3. Sub-duct Parameters

Overall Diameter	40mm	32mm	25mm
Inner Diameter	32mm	26mm	20mm
Bore Configuration	Smooth with low friction liner		

Figure 4. Cables In A 25/20mm Sub-duct.

4. Cable/Sub-duct Options

Tables 4 to 6 show what the options are for increasing the fibre capacity in an existing sub-duct route. In general, the amount of free space within the sub-duct is defined as:

Sub-duct ID – In-situ cable – 2mm = maximum cable diameter.

This allows for 1mm radial clearance around the overblown cable.

As can be seen from tables 4 to 6 the fill factors for the system are all below 50%. This compares favourably with the recommended maximum fill factor for a blown cable system at 70%. This suggests that it may be able to overblow a second cable at a later date.

Table 4. 40/32mm Sub-duct

In-situ Cable OD	Free Space	Maximum Fibre Count 12f/tube	Fill Factor	Maximum Fibre Count 24f/tube	Fill Factor
13mm	17mm	432f	33%	288f	28%
14mm	16mm		35%		30%
15mm	15mm		38%		33%
16mm	14mm		41%		36%
17mm	13mm		44%		39%
18mm	12mm	144f	37%		43%
19mm	11mm		41%		46%
20mm	10mm		45%	192f	45%

Table 5. 32/26mm Sub-duct.

In-situ Cable OD	Free Space	Maximum Fibre Count 12f/tube	Fill Factor	Maximum Fibre Count 24f/tube	Fill Factor
13mm	11mm	144f	33%	288f	42%
14mm	10mm		37%	192f	38%
15mm	9mm		42%		43%
16mm	8mm		46%		47%
17mm	7mm	96f	48%	144f	49%
18mm	6mm		53%	n/a	n/a
19mm	5mm	72f	57%	n/a	n/a

Table 6. 25/20mm Sub-duct.

In-situ Cable OD	Free Space	Maximum Fibre Count 12f/tube	Fill Factor	Maximum Fibre Count 24f/tube	Fill Factor
13mm	5mm	72f	49%	n/a	n/a

Future developments with new cable designs suggest that it could be possible to develop cables up to 864f which would be suitable for overblowing into a 40/32mm sub-duct.

5. Installation Equipment

5.1 Blowing Head

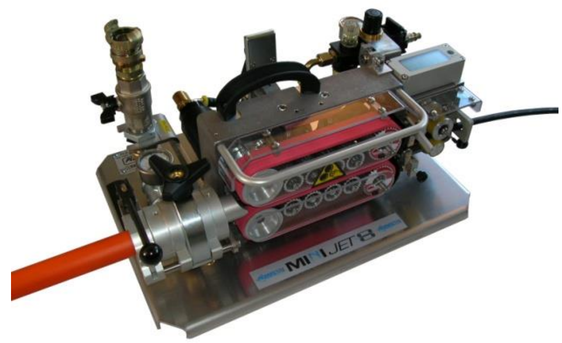

Figure 5. Cable Blowing Machine

Figure 5 shows a typical Cable Blowing Machine. The design of the machine must ensure that in the event of a sudden stop the overblown cable does not get damaged and does not exit the machine between the cable drive belts and the air-box. In order to determine this a ‘Crash Test’ is undertaken. This involves installing the overblowing cable into a 10m sample of sub-duct, containing a sample of the cable that is to be overblown. As the end of the sub-duct is blocked this will simulate a blockage. A series of tests are undertaken, with increasing levels of Push Force, until the overblown cable is damaged.

The overblowing installation process speed is typically 40m/min and in order to achieve that speed the air pressure to the air motor is approximately 2.5 bar. However, when undertaking a ‘Crash Test’ the maximum air pressure applied to the overblown cable is 3.0 bars. This means that in order to achieve an installation speed of 40m/min there is a reduction in Push Force being applied to the overblown cable. This will have a significant effect on the maximum installation distance that can be achieved. In order to resolve this problem an airflow valve is introduced into the compressed air system between the pressure regulator and the air motor (figure 6). Since the air pressure being applied to an air motor determines the torque and the airflow being applied to the air motor determines the speed this enables the maximum push force to be set at 3.0 bar but the speed control can be adjusted to achieve the required 40m/min.

Figure 6. Airflow/Speed Control

5.2 Overblowing ‘Y’ Connector

The overblowing ‘Y’ Connector (figure 7, 8 & 9) has the ability to handle sub-duct sizes from 25mm to 40mm diameter by the use of replaceable inserts. The sealing around the in-line cable and jumper mini-duct is accomplished with the use of rubber seals with differing bore sizes. In the event of the overblown cable being greater than 9mm an alternative jumper mini-duct seal assembly can be used.

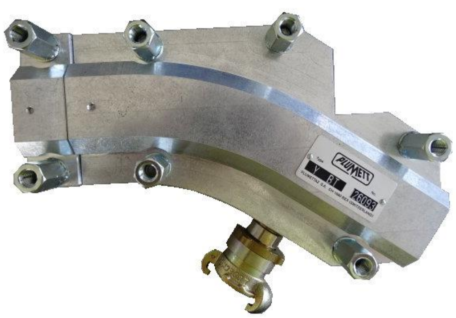

Figure 7. Overblowing Head

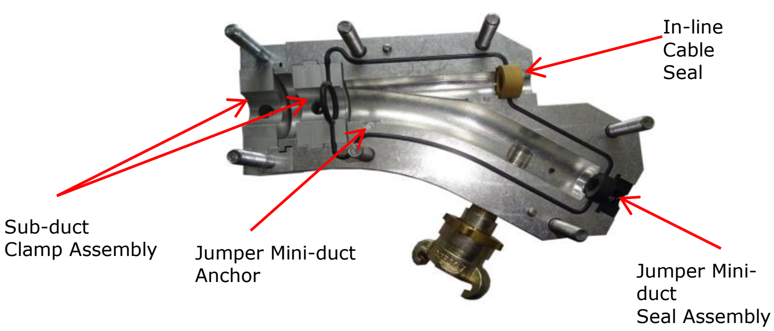

Figure 8. Overblowing Head – Internal Arrangement

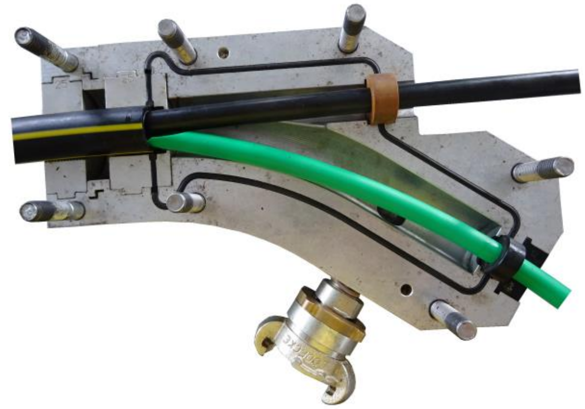

Figure 9. Overblowing Head – Internal Configuration

6. Lubrication

In any blown cable or fibre installation, the coefficient of friction is one of the most important factors [2]. At present the normal installation practice for overblowing involves cutting a section out of the sub-duct containing the cable. An amount of a suitable wet lubricant is then poured into the sub-duct and a mini-duct is then used to connect the cable blowing machine to the overblowing head. Compressed air is then used to distribute the lubricant along the route [1]. However, it has been shown that this method is not reliable [2] so an alternative method of applying lubricant to the cable and route is being investigated. This may be the subject of a patent application so will be discussed as and when permitted.

7. Installation Process

7.1 Connectivity

In order to maximize the cost effectiveness of this installation process it is important to minimise the number of engineers required to operate the process. At the same time the operation must comply with local Health & Safety regulations. In the UK it is not permissible to have an open ended sub-duct, which allows the compressed air to vent freely. To resolve this issue an air guard (figure 10) was developed which allowed the compressed air to vent freely but at the same time caught any debris that was blown through by the air. This has widely used throughout the UK for blown cable applications since 1999. When the cable reaches the end of this device the blowing head will stop feeding the cable, providing the blowing head is set up correctly.

Figure 10. Air Guard

The issue with the overblowing process is that it is not possible to attach this device onto a sub-duct that already contains a cable. This issue was resolved by developing a 'Cable Deflector' (figure 11) which deflects the compressed air and cable into a short section of sub-duct with an air guard fitted on the end.

Figure 11. Cable Deflector

The design of the insert (figure 12) ensures that the cable does not 'hang up' in the deflector and that there is no reduction in the level of compressed air passing through the route.

Figure 12. Cable Deflector Internal Arrangement

7.2 Centre-blowing

There are two main installation practices used in the field:

1. Point to Point.
2. Centre Blowing.

Typical installation distances of up to 1000m have been achieved using the point to point practice in 25/20mm sub-duct. The process of centre-blowing enables the length of installed cable to be double that of point to point blowing. Connectivity and installation practices have been developed to enable a coil of protected cable to be provided within a jointing chamber. At a later date, this cable can be used within a suitable 'loop through' optical fibre joint to provide optical fibre for customer drops.

8. Post Installation Connectivity

Upon completion of the overblown cable installation it is important that the mini-cable is protected between the exit of the sub-duct and the optical fibre joint. This is achieved by 'over-sleeving' the cable with a section of heavy duty 14/10mm mini-duct (figure 13). This will protect the cable from damage caused by crushing and kinking.

Figure 13. 14/10mm Heavy Duty Mini-duct

At the end of the sub-duct a 'Swept T' (figure 14) closure is configured around the sub-duct such that the mini-duct and sub-duct are located in the correct manner. This closure is rated to IP 41. In order to prevent any water from entering the optical fibre joint via the mini-duct a gas/water block connector (figure 15) is positioned in the mini-duct between the Swept 'T' closure and the optical fibre joint. To prevent water from entering the sub-duct a suitable flexible compound is forced around the cables within the sub-duct.

Figure 14. Swept 'T' Closure

Figure 15. Gas/Water Block Connector Configuration

For 25mm sub-ducts this Swept 'T' Closure has now been replaced by a purpose built, sealed unit (figure 16) with the following benefits:

1. Reduced Size.
2. Improved water resistance, now 1m head of water for 24 hours.
3. Simpler installation, fewer components.
4. Eliminates the requirement for flexible sealing compound.
5. Cost reduction.
6. Multi-functional (figure 17).

Figure 16. Sealed Swept 'T' As Drop Joint

Figure 17. Sealed Swept 'T' As A Sub-duct Seal

9. Benefits

The Overblown Cable System provides many attractive benefits over a traditional approach to an optical fibre cable infrastructure upgrade installation. These benefits are to the Network Provider, Customer, General Public and the Environment.

It was initially thought that this process would be used at 'pinch points' within networks however, due to the high success rate it is being trialled throughout the networks and there are even plans to trial it as a method for increasing the fibre counts within the network backbone routes.

Table 7. List Of Benefits.

Factor	Overblown System	Traditional Approach
Description	**Overblown cable is installed by air into occupied pre-installed duct network.**	**Additional duct network is installed. Cable is installed into new ducts by blowing or winching.**
Lead time to install	Standard for blow installation into pre-installed duct. Typically: 1-30 days.	Civil work approval required for duct installation. Typically: 90-120 days.
Installation time	Duct pre-installed. System approach. Typically: 1-3hrs.	Civil work required. Standard blow installation. Typically: 7-21 days.
Installation requirements Equipment requirement	Standard for blown installation. Typically: completed at side of road. No effect. Overblown system: standard blowing equipment, overblow head and connectivity.	Standard for blown installation and civil works. Typically: Road/ Bridge closures and traffic management. Civil trenching equipment, traffic management and standard blowing equipment.
Connectivity	Compatible with standard connectivity joints and splicing techniques. Connectivity improves duct cable management.	Standard connectivity equipment and splicing techniques. Integration of new installed duct networks complicates connectivity.
Training and Personnel	Standard Blown cable installation training plus Overblown system training. Typically: 1 team.	Civil, traffic management and Installation team. Typically: Multiple teams/skills required.
Environmental	Limited equipment requirement - Minor Energy/ greenhouse/ ozone affect. Duct pre-installed, immediate environment not affected. Limited visibility in environment for installation. No waste products created or to be removed.	Major equipment requirement - Major Energy/ greenhouse/ ozone affect. Duct to be installed, immediate environment highly affected during installation. High visibility in environment for installation. Waste products and materials created and to be removed.

Factor	Overblown System	Traditional Approach
Social	High speed cable installation. Minor effect on local environment/traffic/ aesthetic.	Long duration cable installation. Major effect on local environment/traffic/ aesthetic during installation.
Political	High speed, high flexibility, low cost and optimized fibre rollout. Customers/businesses connected rapidly.	Low speed, high flexibility, high cost fibre rollout. Customers/businesses connected slowly.
Economic	Low cost, high speed fibre installation connecting many customers/businesses. New chargeable services supplied rapidly.	High cost, low speed fibre installation connecting few customers/businesses. New chargeable services supplied slowly.
End-customer perception	Customers/businesses connected rapidly and effectively with minor negative visibility and affect.	Customers/businesses connected slowly with extensive negative visibility and affect.

10. Training

A 1.5 day, theoretical and practical, training course has been developed to train installers in the use of the Prysmian Group Overblowing System. This course details the cables, equipment, installation practices and support documentation that fit together to produce the Overblowing System.

11. Conclusion

It has been shown that by using a system approach the practice of overblowing small high density fibre optic cables into existing routes is an extremely easy and attractive option giving the network provider impressive cost, time and environmental savings.

12. Acknowledgments

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13. References

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[2] R. Sutehall, M. Davies "Installation of Mini-Cables: Factors that Influence the Installation Performance of Mini-cables" IWCS 2010.

14. Authors

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