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SEALING-FILLING GROUT INJECTIONS FOR TBM TUNNELS

BDC International and its subsidiary, BDC Poland, have been supplying high-quality cementation agents for drilling operations since their inception. Engineered for use under extreme geological and technical conditions, these agents—employed in the oil and gas industry—set the benchmark in quality and adhere to the most rigorous safety standards.

Years of experience in drilling fluid chemistry, gained through numerous engineering projects, have culminated in the development of a dedicated product line for injection applications in tunnel construction. Recently, the Polish market has become increasingly significant in this field, hosting major tunnel projects. These investments help address infrastructural backlogs, eliminate transportation isolation, and improve the capacity of roads, bypasses, and interchanges. Roads, bridges, and tunnels can be compared to the circulatory system of an economy—their development directly translates into the economic potential of both the country and the entire region.

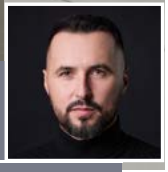
In this article, we present the challenges faced by tunnel engineers, with a particular focus on the importance of injection materials as fillers for the annular space created during TBM (Tunnel Boring Machine) operations. We will highlight the role of chemical agents in formulating appropriate grout compositions and their application, emphasizing the key role of the solutions offered by BDC.

Tunnel	Cutter Disc Diameter
Metro in Warsaw	6,3 m – 4 TBM cutterhead
Road tunnel under the Świna River (Świnoujście)	13,5 m
Railway tunnel in the radial route in Łódź	13 i 8 m – 2 TBM cutterhead
Railway tunnel along the Klęczany–Limanowa line	10 m
S19 Rzeszów South–Babica	15,2 m

TAB. 1. | List of exemplary TBM tunnel projects recently executed in Poland

TBM TECHNOLOGY – THE FOUNDATION OF MODERN TUNNELING

TBM tunneling technology enables work rates tailored to the substrate type. For in-



■ **SŁAWOMIR WŁODEK**
BDC Poland sp. z o.o.

stance, tunneling in sand versus rock may vary, with average advance rates ranging from 10 to 20 meters per day. By comparison, during the excavation of Warsaw Metro's Line II, a daily rate of 24 meters was achieved, with peak rates reaching up to 43 meters per day. However, a TBM is more than just a boring machine—it is an advanced technological system. In addition to excavating the tunnel, the TBM installs precast concrete segments that form a stable tunnel lining. During this process, an annular void is created between the precast segments and the surrounding ground; this space must be filled and sealed. To accomplish this, a specialized backfilling grout is used, typically based on a cement-bentonite mix.

APPLICATION OF BDC CHEMICAL AGENTS IN TBM TUNNEL INJECTIONS – THE BEMOWO METRO TUNNEL EXAMPLE

The Bemowo Metro Tunnel in Warsaw serves as an excellent example where bentonite materials supplied by BDC are an integral component of the grout used to fill the tunnel annulus. The selected product has undergone comprehensive compatibility testing with cement and other additives, ensuring its effectiveness and durability in such demanding applications.

KEY ADDITIVES OFFERED BY BDC

BDC supplies advanced chemical admixtures that significantly enhance the injection process and improve grout properties. In particular:

1. **Modiretard 05** – Retarding Admixture
   The primary function of this additive is to delay the hydration process of cement – a critical requirement in deep tunnels where the transport time of the mix from the batching plant to the application site can extend to several tens of hours. Typical hydration retardation ranges from 24 to 72 hours.

2. **Modiquick 02** – Activating Admixture
   This admixture facilitates nearly instantaneous setting of the mix upon injection into the tunnel lining. The gel time typically ranges between 10–15 seconds and can be adjusted through precise dosing. This rapid reaction ensures a watertight and durable annular fill (tubing).
   The dosage of Modiquick 02 depends on several parameters, including:
   - The class and composition of cement,
   - The cement content in the mix,
   - Ambient temperature,
   - The required setting time,
   - The targeted early strength.

Early strengths of the mix are usually measured after 24 hours (approximately 1–1.5 MPa), with ultimate strengths achieved after 28 days typically ranging from 2–3 MPa or more, depending on design specifications.

EXAMPLE BACKFILLING GROUT MIX DESIGN

- **Cement:** CEM I 42.5 R – 270–370 kg/m^3
- **Powdered Bentonite:** Swellgel PF – 20–50 kg/m^3
- **Water:** 750–850 dm^3/m^3
- **Modiretard 05**: 3–6 kg (depending on the required retardation time)
- **Modiquick 02**: 90–140 kg/m^3 (added to the mix of cement, bentonite, water, and Modiretard 05)

ROLE OF ADDITIVES IN MIX STABILIZATION AND FLUIDITY

The Swellgel PF additive stabilizes the mix by minimizing material segregation while maintaining optimal fluidity. A key parameter is the water bleeding rate, which typically measures:

- After 3 hours: 1–3%
- After 24 hours: 6–10%

The bleeding time is determined using a Marsh funnel and should fall within the range of 35–45 seconds. Maintaining fluidity for the required duration—usually 24, 48, or 72 hours—depends on the specific project requirements.

SUMMARY

The high-quality chemical additives provided by BDC—such as Modiretard 05 and Modiquick 02, in conjunction with bentonite Swellgel PF—not only deliver optimal grout parameters but also ensure the efficiency and safety of tunnel construction projects. Their application enables investments, such as the Bemowo Metro Tunnel, to be executed in accordance with the highest technical and technological standards.

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