The city of Copenhagen and the Ø restadsselskabet organization, responsible for the first part of this important project, have chosen a fully automatic Mini Metro, as a new transport system in the city and the surrounding suburbs. When completely finished, this new line will have a total of 22 km. The first phase will mainly consist in boring about 16 km under the center of the city of which 14 km are bored with two tunnelling machines.

The COMET Construction Group, the contractor for this first phase, has chosen two Earth Pressure Balanced Machines from MÜHLHÄUSER to perform these works.

THE REALIZATION

THE GLOBAL PROJECT:

This first metro line, which is part of the transport network system in the Amager Island, where Copenhagen international airport is located, is done in three different phases:

Phase 1: Ø restad line, from Norreport then it divides in two branches, one to Vestmager with an underground part until Island Brygge, and one to Lergravsparken (1999).

Phase 2: Extension of the line onto the north from Norreport to Vanlose (2001).

Phase 3: Extension of the line to the south from Lergravsparken to the airport (2003).

Tunnelling works

Two mono track tubes are excavated by two MÜHLHÄUSERS’ tunnelling machines. Each one bores approximately 7,300 meters in several sections, that obliges to dismount and reset-up the machines twice during the works. The final linings of the tunnels, with an inner diameter of 4.9 m, is of a universal concrete precast type, with 5 elements and one key for each ring.
THE TUNNELLING MACHINES

Two EPBs (Earth Pressure Balanced) machines with foam and bentonite injection have been chosen. These machines have been designed to be operated also in an open mode, using the screw for mucking out. Since hard rock zones and abrasives flint formations are expected during the drives, the cutter head and the screw system of each machine have been particularly protected against wear and abrasion by the mean of wear plates.

CHARACTERISTICS OF THE MACHINES

THRUST:
- Total thrust: 28,600 kN (20 x 1,430 kN)
- Boring stroke: 2.20 m

ARTICULATED SHIELD:
- Diameter of the shield: 5.71 m
- Length of the shield: 9.3 m
- Weight of the shield: 350 t

BACK-UP SYSTEM:
- 9 fully equipped gantries + 1 table for segments handling
  Equipments for:
  - shield operation and muck-out
  - lining installation
  - foam and bentonite injection
  - back grouting

CUTTERHEAD:
- Equipped with 40 disk cutters of 17"
- Head protected with wear plates
- Hydraulic motorization of 1,360 kW (7 motors)
- Rotation speed: 0 to 5.1 rpm
- Nominal torque: 3,800 kN.m
- Unseizing torque: 4,800 kN.m

THE TUNNELLING MACHINES

GEOLOGY OF THE TUNNELS

Most part of the drives is in limestone of hardness of 20 to 50 MPa. Zones with hard rocks up to 200 MPa and important abrasive flint layers of 45 cm to 75 cm thickness are also encountered. Some boulders are situated along the drives. Water presence is possible at certain locations with a pressure up to 3.5 bars.