

**VENAUS**

*Società Consortile a r.l.*

**VENAUS SOCIETA' CONSORTILE A R.L.**

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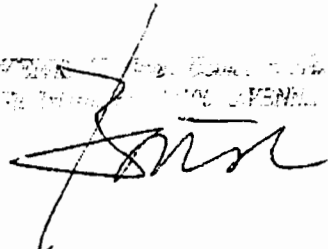
Ravenna, li 10 MAG 2005

OGGETTO: Contratto Nr. 1 del 05-05-2005  
Commessa VENAUS - Progettazione e realizzazione cunicolo esplorativo  
Cod. 003974

Con la presente siamo a trasmettervi la proposta contrattuale costituita da :

- Contract agreement
- Allegati:  
Drawing P3514  
Drawing P3532  
Delivery schedule

Distinti saluti

Stampa illeggibile  


**CONTRACT AGREEMENT**

**REF. VENAUS N. 1 - date May 2nd, 2005**

**REF. ROBBINS N. 021505-MB**

BY AND BETWEEN

**VENAUS SOCIETA' CONSORTILE a.r.l.**

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&

**THE ROBBINS COMPANY**

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For the supply of :

**A ROBBINS TBM High Performance, Hard Rock  
Tunnel Boring Machine 6.3m Diameter, Backup System,  
and Associated Equipment**

**for the “Galleria di Venaus” Project - Italy**



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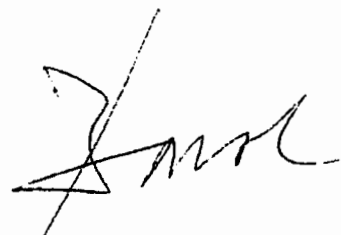


## 1. OBJECT OF THE CONTRACT

### 1.1 Object.

Robbins will supply the H.P. (High Performance) TBM 1812-299-3 complete of back-up system for boring the 7/10 km length, 6,3 m diameter tunnel of the "Galleria di Venaus" Project in Italy, refurbished and modified as per attached preliminary drawing P3514- P3532 and specifications in Annex A.

The TBM shall comply with CEN European Standard , EN 815 and The Robbins Company shall provide to the Buyer all necessary CE certificate of conformity

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**2. H.P. (High Performance) HARD ROCK TBM 1812-299-3 - DESCRIPTION**

**TABLE 2-1**

**TECHNICAL SPECIFICATIONS**

Machine Diameter (new cutters)	6.30m
Main Bearing	High capacity three axis
Cutters – Back loading	Series 17” Wedge Lock
Number of Disc Cutters	41
Cutter configuration	4 center cutters
	33 face and gauge
Overbore capacity	100 mm diameter
	(gage cutter shims & cutterhead support lifting)
	200 mm diameter
	(add n.2 gage cutters, gage cutter shims and cutterhead support lifting)
Maximum Recommended Individual Cutter Load	250 KN
Cutterhead	
Maximum Operating Cutterhead Thrust - Recommended	10,250 KN
Maximum Machine Thrust	14,200 KN
Cutterhead Drive - VFD	
Cutterhead Drive	VFD
	Elec. Motor/Gear Reducers/Hydraulic clutches
Cutterhead Power	7 x 315 kW = 2,205 kW
Cutterhead Speed (Approx.)	0-11.4 rpm
Cutterhead torque	2,711 kNm (0-7.8 rpm)
Cutterhead torque	1,854 kNm (7.8-11,4 rpm)
Thrust Cylinder Stroke	1,800mm
Hydraulic System	111 kW
System Operating Pressure at Maximum Recommended Chd. Thrust	315 bar
System Rated Pressure	345 bar
Electrical System	
Main Drive Motors	690V, 3 Phase, 50 Hz
Electric Motors of Hyd. & Lube System	690V/50 Hz
Field device (e.g. press. Switches, Solenoid valves, etc.)	24 V DC
TBM Lighting	220V, 24V 50 Hz
Transformers	2 x 1700 kVA(15/0.69 KV) and 1 x 1000 kVA (15/0.4 KV)
Primary Voltage	15,000V, 50 Hz
Secondary Voltage	690V, drive motors 690V, hydraulic pump motors
Conveyor Capacity (approx.) (belt width)	350 m <sup>3</sup> /hr. 762mm
TBM and Backup Weight (approx.)	380 tons
Minimum tunnel radius	500m
Proposal Drawing – TBM & Backup	P3514 and P3532

## 2.2 Component Description

### 2.2.1 General Description

The Robbins tunneling machine described is a rotary rock boring machine designed to transform a rock face into conveyor sized chips at efficient production rates. The machine consists of three main structural components: (1) the cutterhead; (2) the cutterhead support with main beam; and (3) the gripper and thrust assembly. Other primary components include electrical drive motors with gear reducers and torque limiting devices, main bearing and seal assembly, lubrication and seal lubrication systems, dust shields, operator station and controls, cutterhead water spray, muck buckets and conveyors, and electrical and hydraulic systems. Together these components form an integral machine that is capable of rock excavation, ground control, and transfer of broken rock to the muck removal system.

### 2.2.2 Cutterhead

The five (5) piece cutterhead is mounted to a shaft ("bearing adapter") which passes through the main bearing and is thus attached to the ring gear. Cutterhead torque is supplied via the ring gear, while cutterhead thrust is provided via the shaft.

The flat cutterhead is a complex heavy weldment. The cutterhead contains cutter housings designed for mounting of Robbins' 431 mm (17 inch) Back loading, Wedge Lock™ cutters. The cutter housings have hardened seats into which the cutters are mounted, providing long life. Cutters are retained by two bolts and wedges, which provide secure mounting.

The cutterhead exposure at the periphery is kept to a minimum to provide the smallest possible surface for loose rock to act against. This provides for the minimum cutterhead drag.

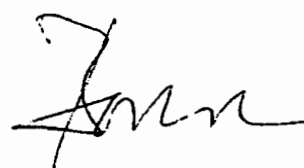
The muck buckets, which pick up the broken rock, are designed with a low profile to reduce the possibility of "pulling" in loose rock from the crown. However, the buckets are designed with a large capacity and smooth throat in order to handle the large amount of broken rock produced in high speed tunneling. The bucket lips are Robbins proprietary design, bolt-on lips. The lips are made of abrasion resistant material. The cutterhead has through-holes and the bucket lips contain the threaded hole. To mount the lip, a bolt is passed through the cutterhead and threads into the lip. With this design, at each change of the lip a new threaded hole is provided. The lips are easy to change and therefore downtime is minimal to maintain the buckets. Improperly maintained buckets lead to excessive cutter wear (high cutter cost and more downtime for cutter changes), so it is very important to have an easily maintainable bucket.

The cutterhead is supported by a large diameter three-axis cylindrical roller bearing. The cutterhead is driven by electric motor / gear reducer unit driving through a common large ring-gear. The cut rock falls to the invert where it is scooped up by the low profile buckets built into the head. The buckets contain the muck until it is in the overhead position, where it is dumped out into the muck chute and onto the machine conveyor.

### 2.2.3 Cutters

The Robbins 6.3 m TBM will be equipped for use with quantity 41 x 431mm (17 inch) heavy-duty backloading cutters.

The TBM will be equipped with a flushing water system which will allow to cool the cutterhead before the cutter change operations.



#### 2.2.4 Over cutting system

The excavated diameter of the tunnel with new cutters is Ø 6,300 mm. The tunnel bore can be over excavated by shimming of the last gage cutters and the invert support to a maximum diameter of Ø 6,400 mm. No other changes are required if the diameter of over cut tunnel is less than or equal to Ø6,400 mm.

For excavated diameters larger than Ø 6,400 mm n.2 additional housings are supplied for over cutting as described in section 4.10. This system allows the tunnel diameter to be over cut up to Ø 6,500 mm.

#### 2.2.5 Cutterhead Dust Control and Water Spray System

A steel dust curtain maintains a seal between the bored diameter and the cutterhead support in the area directly behind the head. Dust generated at the face is trapped in the cutterhead area and sucked out from muck dump area through a vent duct in the main beam. The ventilation ducting extends from the TBM to the backup-mounted dust scrubber. (The dust scrubber is provided as a part of the backup system.)

Dust control is enhanced by a network of nozzles and pipes that spray a water pattern from the cutterhead and roof/side supports onto the rock face. There are additional nozzles in the muck chute / TBM conveyor area to further dampen dust circulation. The water mist assists in preventing the dust particles from becoming airborne. Actual flow to the face is variable and may be turned off should ground conditions dictate. Nozzles are mounted in large steel blocks and are oriented to avoid plugging and damage from muck. Plumbing on the cutterhead is via rubber hose, as hard steel plumbing tends to crack under the vibration stress at the cutterhead. All plumbing is shrouded by heavy steel angles to prevent damage.

#### 2.2.6 Cutterhead Support & Mainbeam: The Gripper / Thrust System

The cutterhead support and mainbeam are the backbone of the TBM and provide mounting points for all other components. The cutterhead support is a precision, highly machined component. Both structures are thick-plate weldments. The mainbeam and the cutterhead support are connected together by a heavy bolted flange joint.

#### 2.2.7 Cutterhead Support

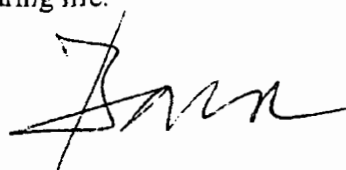
The outside diameter of the main bearing is mounted within the forward side of the cutterhead support. The cutterhead is mounted to a shaft ("bearing adapter") which passes through the inside diameter of the main bearing. The ring gear is mounted on the aft end of the shaft.

VFD Electric motor + hydraulic clutch + gear reducer units (Main Drive Units) mount through large diameter bores in the cutterhead support. The gear reducer output pinions engage the ring gear. The main drive units are accessible and serviceable from the rear of the cutterhead support.

The periphery of the cutterhead support provides the mounting for the various support shields that stabilize the cutterhead during boring:

#### 2.2.8 Roof Support

An expandable roof support is maintained in full contact with the ground to minimize vibration. The roof support is hydraulically adjustable and is located as close to the cutterhead as possible. Cutterhead stabilization is important for repeatable cutter tracking (elimination of excessive cutterhead vibration / movement.). A stable cutterhead with consistent and repeatable cutter tracking, enhances TBM performance, and extends cutter and main bearing life.



The roof support structure extends past the rear of the cutterhead support to give a protected area for workers on the TBM. The aft end of the roof support is fitted with "fingers" which, when properly supported with roof bolts and/or ring beams, act to give further protection to ground support installation workers.

#### 2.2.9 Vertical Front Support

The vertical front support (sometimes referred to as the "front shoe") is located at the invert under the cutterhead support. The vertical front support is mounted directly to the cutterhead support via a large bolt flange with a shear key perpendicular to the tunnel axis.

The vertical front support acts as the pivot fulcrum point for vertical steering of the TBM.

The vertical front support moves with the TBM during boring and acts as a scraper for any muck in the invert. Muck that passes behind the cutterhead pushes ahead of the front shoe. Special back scoops located on the backside of the cutterhead, pick up the muck from the area behind the cutterhead and deposit it in the muck conveying system. The geometry of the design is such that the height of the muck collected behind the head is maintained well below the outer main bearing seals.

#### 2.2.10 Side Supports

Side supports are fitted to each side of the cutterhead support. Each side support is positioned by the side support cylinder. Once positioned, a wedge actuated by the wedge cylinder rigidly locks the side support in position. This system provides a solid load path from the cutterhead support to the tunnel wall. The side supports act with the roof support in stabilizing the cutterhead.

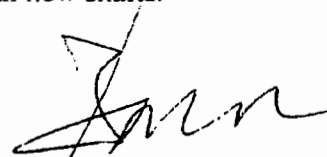
The side supports act as the pivot fulcrum point for horizontal steering of the TBM. When negotiating short radius curves, the side supports may be used to force the cutterhead left or right, assisting the normal gripper steering system.

#### 2.2.11 Main Bearing and Bull Gear

Thrust and radial loads from the TBM cutterhead are passed to the machine structure and hydraulic cylinders to the gripper shoes, and thence to the tunnel wall. All cutterhead thrust and radial loads pass through a precision manufactured main bearing. The TBM main bearing is a large diameter, three axis cylindrical roller bearing.

The main bearing and gear are lubricated via a dry sump, constant circulation system. Oil being supplied to the bearing and gear are passed through cartridge type filter elements. Oil returning from the bearing / gear cavity is passed first through a magnetic strainer, then through cartridge type filter elements. Both supply and return cartridge filters are mounted in tandem with switchover valves, which allow maintenance of filter elements during operation of the machine. Lubricant flow is monitored. Insufficient lubricant flow will result in automatic shutdown of the equipment.

The main bearing and gear cavity is protected against contaminants with a special sealing system. Both the inner and outer sealing system consists of a series of large cross-section, high deflection lip seals. The lip seals are mounted within the bores of machined parts with the lips extending inward. The shafts against which the seal lips ride are covered (shrink fit), with a very high tensile strength, abrasion resistant alloy steel band. The alloy steel band provides maximum shaft life, and can be replaced during rebuilding between projects for far less cost than new shafts.





In the unlikely event of a main bearing or seal failure, the critical components can be changed from within the tunnel. A small drill and blast cavern near the heading is typically required for changing of the main bearing.

#### 2.2.12 Cutterhead Drive Unit

The cutterhead drive motors will consist of 7 x 315 kW water-cooled, standard induction motors with adjustable frequency converter. The frequency converters use flux vector control technology.

Motors are controlled from a dust and water protected control cabinet (IP55 rating).

#### 2.2.13 Main Beam & Gripper Carrier

The cutterhead support is mounted to the forward end of the mainbeam. Some distances aft are clevises for mounting the forward, moving end of the thrust cylinders. At the aft end of the mainbeam, one on each side, are the "grripper carrier ways". The gripper carrier is mounted to the mainbeam via the carrier ways, which allow the gripper carrier to move fore and aft relative to the mainbeam.

The gripper cylinder / gripper carrier remains stationary during boring, and the mainbeam slides through the gripper carrier on the carrier ways. During re-grip, the mainbeam remains stationary and the gripper cylinder + gripper carrier moves forward along the carrier ways.

The gripper cylinder is trunion mounted within the gripper carrier, resulting in the "floating gripper" design originated by Robbins. The floating gripper cylinder allows the TBM to be continuously steered, resulting in a machine, which maintains line and grade accuracy and is also much easier to operate than other designs.

#### 2.2.14 Rear Support System

Support cylinders are located in the rear section and support the weight of the machine during the re-gripping cycle or when the machine is not in use by raising and lowering the rear support legs. The rear support system will be provided with interlocks to prevent boring unless the rear supports are retracted from tunnel invert.

#### 2.2.15 Muck Conveyor

The tunnel machine is provided with a troughed belt-conveyor, which transfers the muck from inside the cutting head back through the main beam to the rear of the machine. Here the muck is transferred to the backup muck handling equipment for removal from the tunnel. The TBM conveyor system has a capacity of 350 m<sup>3</sup>/hr broken rock.

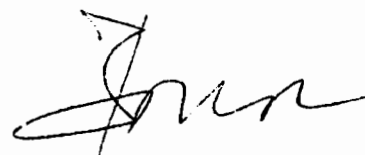
Two conveyor cylinders are provided to maintain tension on the conveyor belt during operation.

Two conveyor retract cylinders are provided so that the conveyor can be retracted to allow access by workers through the mainbeam to the cutterhead, or through the cutterhead to the face.

#### 2.2.16 Hydraulic System

Major hydraulic circuits include the gripper, thrust, steering/torque cylinders, and the conveyor drive system. Double-ended electric motors drive pumps at each end of the motors. Both high pressure / low volume and low pressure / high volume pumps are incorporated. Fixed and variable volume pumps are used depending on circuit requirements.

Hydraulic logic components may be cartridge and/or sub-plate mounted..



Hydraulic oil is filtered when leaving the reservoir, before going to the pumps for delivery to the various cylinders and hydraulic motors. Low pressure return oil is filtered upon return to the tank. Both supply and return filters are fitted in tandem with valves to allow maintenance of filters while the machine is operating.

Near-zero pressure return lines (case drains) are plumbed directly to tank with no restrictions.

When fire resistant hydraulic oil (such as "Condat 68") is to be used, a closed loop oil polishing circuit can be provided (Kidney Loop filtering system). This is required for these oil types as they tend to readily absorb water, which, in addition to usual water/oil problems, causes these oils to become corrosive to hydraulic component parts.

#### 2.2.17 Electrical system.

Two 1700 kVA transformers to convert 15,000 V primary voltage to 690 V, 3 Phases, 50 Hz are provided on the TBM.

One 1000 kVA transformer to convert 15,000V primary voltage to 400V, 3 phases, 50 Hz is provided for the back-up system.

The system shall meet the EMC and low voltage Directive of EC for usage in Europe.

Auxiliary motors shall be 400VAC, 50 Hz.

High voltage disconnects for 400 volt transformer shall be acceptable for operation with methane present.

The controls and lighting will be 24 VDC, 115VAC, 230 VAC, 50 Hz. Lighting fixtures will be provided and mounted to give a good visibility for operation and servicing.

The lighting service will operate if radon detector shuts down TBM power.

Lighting System: The TBM will be equipped with a lighting system to provide adequate general illumination around the machine and specific lighting for primary work areas. One-third (1/3rd) of all light fixtures will be battery backup type, emergency lights with 1-hour battery powered illumination in emergency.

#### 2.2.18 Control System and Indicating Devices

A Programmable Logic Controller (PLC) will be supplied to augment the original hard-wired control system of the TBM. The PLC will provide data logging abilities, key high level interlocking, and supervision of the VFD drive system.

#### 2.2.19 L1\* Working Zone Equipment

- Two (2) roof drills positioners.
- Erector system for 400 mm and 1400 mm wide panels.
- Wire mesh placement system
- Probe drill positioner system for 360°



### 3. BACKUP SYSTEM -DESCRIPTION

The Robbins backup will be composed by a series of platforms and decks, plus a conveyor discharging to a continuous conveyor system.

The platforms are steel structures rolling on the invert segment.

The decks are steel structures riding on the main rail.

The rail installation area is located between the platforms and the rolling deck #1.

The platform are defined as "L2 WORKING ZONE". They are used for ground' support and ground monitoring system.

The decks are used to incorporate all the TBM, back-up equipment as described in the present contract and back-up ancillary equipment supplied by the J.V.

The system is designed for use with a continuous conveyor for muck haulage.

#### 3.1 Tow System

Two (2) each towing cylinders are provided. The backup is continuously pulled forward via the first platform. Pin connections at both ends of the first platform assist in negotiating the curves.

#### 3.2 "L2\* WORKING ZONE"

All the platforms include a "double track" section for transport of the segments and other material forward, as well the hopper and the invert conveyor to transport the muck.

The platforms are suitable to meet the 500 m minimum radius.

In addition they will incorporate the following equipment:

##### 3.2.1 Radial Drill

- Space and positioner only.

##### 3.2.2 Man Bucket

One (1) hydraulically operated man bucket to allow access to the crown for rock sealing or access to the rock bolts.

##### 3.2.3 Shotcrete System

- Space only.

##### 3.3.3 Core Drilling/Ground Monitoring

- Space only.

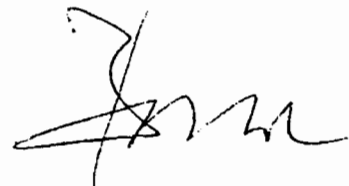
#### 3.3 Segment Hoist / Movement

Five (no.5) 6T capacity segment hoists systems will be provided to transport the segment from the unloading point on the rolling decks to the installation point at the rear of the TBM.

##### 3.3.1 Segment Handling

The segment are moved from the rolling decks through the L2\* working area and forward for placement under the TBM just aft of the cutterhead support. Included in the segment handling system is the following:

1. The segment handling system will require 5 each 6 ton hoists, and one segment shuttle car, as follows:



- a. 1 each 6 ton hoist at the segment unloading area. This hoist travels laterally to unload the segments from the supply car and place them in the segment storage area on either side of the first backup deck.
- b. 2 each 6 ton hoists to transport the segments from the storage area on the side to the segment shuttle car on the L2 work platform.
- c. 1 each 6 ton hoist mounted to the bottom of the TBM conveyor extension to unload the shuttle car and lower the segment to the invert.
- d. 1 each 6 ton hoist mounted under the TBM to transport the segment forward to the area behind cutterhead support.

### 3.3.2 Material Handling

Material such as cutters, rock bolts, wire mesh, steel beams, etc is brought into the tunnel on flat cars to the backup area. At the backup area, material is lifted off the car by hoist and transferred to the storage area on deck # 1. From this location the hoists and transport system used for the segments is used to move the material forward to the appropriate work area.

### 3.4 Tunnel De-Watering

Robbins will provide settling tank on the backup. A pump (supplied by the contractor) will pump dirty water into this tank, which contains baffles and semi-clean water will pump out. The tank will have easy to open clean-out doors at bottom of baffles. Material is raked out easily and shoveled into muck cars. Tank capacity will be 5 cu m.

A 100 mm de-watering pipe is included from the track laying area to the rear of the backup, from where the water is discharged.

### 3.5 Rail Installation Area

A 15 m area is provided in front of the Deck #1 laying of the track. A segment handling hoist is provided for this purpose.

The backup is designed to pass a 1.4 wide segment with adequate clearance.

### 3.6 Rolling Decks

Rolling decks are supplied for housing TBM power equipment, ancillary equipment, bridge/loading conveyor, ventilation, cable reel and accessory equipment.

Steel Structure Rolling Decks :

Track gauge (main line)        900 mm

Curve radius, min.            500 m

### 3.7 Conveyors

Included are:

1. Invert conveyor mounted in the L2\* work rolling platforms.
2. Bridge/backup conveyor from the rolling platform to the backup gantries transfer conveyor.
3. Transfer conveyor from the backup conveyor to mainline continuous conveyor hopper.

### 3.8 Dust Suppression

A dry type dust scrubber system with fan and two silencers along with the necessary rigid ducting from the TBM to the scrubber location on the backup is supplied. Dust scrubber to have 600m<sup>3</sup>/minute capacity.



### 3.9 Fresh Air Ventilation

Fresh air vent line is carried forward the rail installation area, from where a smaller vent line continues to the forward end of the skids.

A storage cassette is suitable for 100m of flexible ducting (2000 mm diameter).

A lifting device will provide the lifting and locating of the vent line storage cassette in the working position.

There is significant overlap of the dust scrubber air vent line and the fresh air vent line.

### 3.10 Electrical System

Backup electrical system consists of the necessary power and control circuits for:

- Conveyors
- Lighting
- Dust scrubber
- Buster Fans
- Vent duct cassette lifting mechanism
- Segment and materials handling hoist
- Materials handling hoist and jib cranes on skids (not shown on drawing)
- All L2\* power packs
- Wet shotcrete pump for L1\* and L2\* and robot lance for L2\*
- Air compressors
- Safety container
- Industrial water system and dewatering system
- Cooling ventilation system.
- Others back-up equipment in accordance with the buyer.

Lighting shall be provided to provide a good working environment. One-third (1/3<sup>rd</sup>) of all lights shall be of the battery backup, emergency type with minimum 1 hour battery lighting life.

All electrical enclosures shall be minimum IP55.

### 3.11 Industrial Water System

A 4.0 cubic meter fresh water tank with inlet float valve and supply water pump and a hose reel with 50 m capacity of 75 mm flexible hose are foreseen.

### 3.12 Compressed Air

Two (2) air compressors, 11 m<sup>3</sup> - 7.5 bar compressors, plus 50 mm diameter compressed air pipe, along the length of the backup are foreseen.

### 3.13 Electric Generator.

An electric generator 100 kVA will be installed on the back-up.

### 3.14 High Voltage Cable Reel

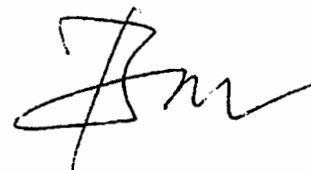
A high voltage cable reel with capacity of 280m of flexible high voltage cable is foreseen.

### 3.15 Safety Container and Lunchroom

Including, first aid station, drinkable water and breathing masks. Suitable for 12 people.

### 3.16 Workshop Area

Workshop area for general repairs, which includes benches, shelves, lighting, vise, power outlets, etc.



### **3.17 Shotcrete Storage Area**

Storage area for n.2 shotcrete containers, coming by the rolling unit, to be available on the back-up along with the pump to transfer the shotcrete material to the shotcrete unit.

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#### 4. SCOPE OF SUPPLY

The following specifications are for the supply of the TBM systems for the Galleria Venaus tunnel project.

- TBM

##### 4.1 Back and Front Loading Cutterhead

- 4.1.1 Center section (NEW)  
Outer segments. (REFURBISHED)

###### A. Boring Diameter

Boring diameter with new cutters	6300 mm
Over boring capability (shimming)	100 mm diameter (gage cutter shims & cutterhead support lifting) 200 mm diameter (add n.2 gage cutters, gage cutter shims and cutterhead support lifting)
Maximum boring diameter	6500 mm

###### B. Cutters

Type:	17" wedge lock cutters
Nominal thrust:	250 kN per cutter
Total:	41 cutters (NEW)
Center:	4 x 17" double cutters
Face and gauge	33 x 17" single cutters

- 4.1.2 Structure (NEW center section (1 piece) and REFURBISHED outer segments (4 pieces))

The structure shall include the following:

- Rear loading cutterhead – (5) five piece design
- Boring in one direction only
- Strong and rigid structure
- Distance from rock face to cutterhead structure = 120 mm
- All areas exposed to wear are easy to exchange or covered with efficient wear protection
- Wedge lock system to fix cutters with self-locking seats
- A method of transport and lifting device for change out of cutter discs to be incorporated in the design.
- Cutterhead rotation: mucking in one direction
- Jog station to turn cutterhead with V.F.D. drive in 2 directions
- Min. two normally closed manholes to access the face
- Peripheral area smooth and free of protrusions or recesses to avoid taking loose rock from the crown
- 8 muck buckets with sufficient opening and grill bars
- bucket lips of one (1) piece design and bolted for easy change from inside the cutterhead
- Overbore: 100 mm diameter (gage cutter shims & cutterhead support lifting); 200 mm diameter (add n.2 gage cutters, gage cutter shims and cutterhead support lifting).  
Complete kit for overbore as per drawing P3532 will be supplied.

#### 4.1.3 Dust Control

Water spray system (water spray nozzles at the front of the cutterhead)

Muck chute nozzles changeable from inside the cutterhead

Large water pipes installed in the roof and side/roof support to inject water to the tunnel face.

Dry dust scrubber system (REFURBISHED)

### 4.2 **Main Bearing, Cutterhead Support, Side Support, Roof Shield**

#### 4.2.1 3-axis Main Bearing (REFURBISHED)

The main bearing will be refurbished and certified by the manufacturer.

- Spare main bearing will be on consignment stock ex-works Solon.

Main bearing: L10 life >10,000 hours.

The bearing cavity is slightly pressurized to prevent ingress of foreign material.

Main bearing can be exchanged from within the tunnel without any additional excavation except niches to bring bearing to the front

#### 4.2.2 Seals and wear bands(NEW)

Seals, large cross section, high deflection lip, to be replaceable in situ without major disassembly works.

Wear bands high strength, abrasion resistant alloy steel.

Radial seals with replaceable wear bands, outer seals flushed with grease

#### 4.2.3 Bull gear (NEW)

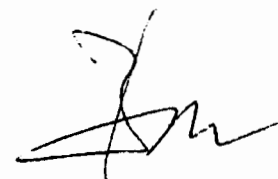
- Bull gear, together with pinions fixed onto the outer shaft of the main reducers will be supplied new.

#### 4.2.4 Dust Shield (REFURBISHED AND MODIFIED)

- Made of steel plates and rubber dust seals
- Space to be provided for mounting the target of the guidance system

#### 4.2.5 Cutterhead support, Side Supports, Vertical Front Support, and Roof Shield (REFURBISHED AND MODIFIED)

- Sufficient power and stroke of side supports and vertical front supports shoe to steer TBM in difficult ground conditions without any changes on the system.
- Room for one self priming pump in the invert section (by others) with easy maintenance of pumps and piping to be considered.
- Cutterhead support structure: thick plate construction. Precision machined to accommodate the main bearing, ring gear and main drive units.
- Roof shield provided with fingers for rock support and protection of personnel. Extensible roof support is maintained in full contact with ground to minimize vibration of TBM
- Side supports fitted to each side of the cutterhead support. Rigidly locked in position by a wedge mechanism to stabilize the cutterhead. Acts as the pivot fulcrum point for horizontal steering of the TBM
- Vertical front support: mounted directly to bottom of cutterhead support via a large bolt flange with a shear key perpendicular to tunnel axis. Acts as pivot fulcrum point for vertical steering of TBM





#### 4.3 Initial Dress of Cutters (NEW)

Initial dress of 41 cutters will consist of 4 center cutters, 33 face / gage cutters, all 17" (431mm) . The initial dress may be mounted on the machine or shipped separately as desired by the customer or as required to meet weight or dimension limits. Shims for overbore capacity as mentioned in item 4.1.2 included.

#### 4.4 Main Beam, Gripper, Torque and Propel System (REFURBISHED AND MODIFIED)

##### 4.4.1 General

- Effective boring stroke: 1.8 m

##### 4.4.2 Main Beam (REFURBISHED)

- One piece with bolt flanges for connection to the cutterhead support and the rear section.

##### 4.4.3 Gripper System (REFURBISHED AND MODIFIED)

The gripper system is composed of Gripper carrier, gripper shoes, gripper cylinder and torque cylinders, which will be designed to work with 400 mm and 1400 mm rock support panels.(drawings of panels supplied from VENAUS).

Gripper cylinder (REFURBISHED) : Single barrel, double rod. Trunion mounted within the gripper carrier. Floating gripper cylinder arrangement allows the TBM to be continuously steered to maintain line and grade accuracy and for ease of operation.

Gripping force 16,370 kN per pad x 2 pads = 32,740 kN total

##### Gripper carrier (REFURBISHED)

Accommodates the trunion mounted gripper cylinder and the torque cylinder.

Horizontal steering is accomplished by side movement of the gripper cylinder.

Vertical steering is accomplished by action of torque cylinders which also react the cutterhead torque

Torque cylinders qty 4 (REFURBISHED)

Carrier way (REFURBISHED)

Regrip time hydraulically max. 3.3 min

##### 4.4.4 Propel Cylinders (REFURBISHED)

Recommended thrust force 11,600 kN

Stroke 1,830 mm

Number of cylinders 4

##### 4.4.5 Rear Section and Rear Lift Legs (REFURBISHED)

- Adequate retraction for cleaning under TBM and to allow transportation and passage of 1,4 m invert segment..

##### 4.4.6 Tow System (REFURBISHED AND MODIFIED)

- Two (2) each towing cylinders are provided. The backup is continuously pulled forward via the first deck in L2 zone . Pin connections at both ends of the first platform assist in negotiating the curves.



- Backup can be pulled with tow cylinders independently from the TBM movement during boring or during stationary position, to allow the TBM move backwards.

#### 4.5 Cutterhead Drive (REFURBISHED)

##### 4.5.1 General

Sufficient power for high advance rates.

Nominal torque: 2711 kNm @ (0-7,8 RPM)  
1854 kNm @ (7,8 – 11,4 RPM)

Cutterhead speed: 0 to 11,4 R.P.M.

##### 4.5.2 Main Motors (REFURBISHED)

- Number of motors 7 units, 315 kW water cooled, induction motors
- Motors are suitable for frequency converters
- Water-cooled three phase motors
- Protection : IP 67.

##### 4.5.3 Hydraulic clutches. (REFURBISHED)

Clutches are permanently engaged for VF controlled drives.

Clutches are set to act as the torque limiting device to protect the gearboxes against the high inertia of electric motors.

##### 4.5.4 Gear Reducers (REFURBISHED) and Pinions (NEW).

They are two stage planetary gear reducers water cooled supplied with new pinions.

##### 4.5.5 VFD System (REFURBISHED)

One unit per main motor, suitable for continuous total power of 315 kW.

VFD cabinet protection rating IP55

VF drives are equipped with closed loop heat removal system

All necessary protective measures included in the design and layout of the system including consideration given to: Adequate cooling incorporated in the design

Component change-out can be easily performed

Appropriate cables to be utilized in the design

VFD drive cables to be segregated from other cables due to induced earth currents


Control devices in particular earth leakage units need to be able to operate effectively in close proximity to the VFD drive systems

An effective filtering system is to be installed to protect against induced harmonics

#### 4.6 Hydraulic and Lube System

##### 4.6.1 Hydraulic System (REFURBISHED AND MODIFIED)

- System high pressure: 315 bar
- Design pressure of components: min. 345 bar (where applicable)
- Suitable for the use of fire resistant and hydraulic fluid
- Oil cooling system sufficient to keep oil temperatures in correct range not exceeding 60 degrees Celsius
- All refilling points are to incorporate a filtering system



- Filtration of oil leaving the reservoir, before going to the pumps and filtration of low pressure return oil to the tank
- Supply and return filters in tandem with valves to allow maintenance of filters while the machine is operating
- Hydraulic logic components are cartridge and/or sub-plate mounted
- Storage place to be provided on backup decks for two standard oil drums

#### 4.6.2 Lube System (REFURBISHED AND MODIFIED)

- Complete lube oil system for main bearing filtration with magnetic filter, pressure, and return filtration
- Oil cooling system sufficient to keep oil temperatures in correct range not exceeding 60 degrees Celsius
- Sampling points for systematic oil sampling to be provided

#### 4.7 Electrical System (REFURBISHED AND UPDATED)

##### General

- The TBM shall have all electrical equipment to conform to European Standards.
- Where practical, provision will be made to physically protect cables.
- All transformers shall be dry type configuration.
- All wiring shall be made exclusively from copper core wires or cables.
- To reduce current intake during startup, motors shall be sequential where possible or by other means employed. Supply phases shall also remain balanced.
- Electrical enclosures shall be sturdy construction with a minimum environmental protection rating of IP55..
- All electrical components shall be clearly marked.
- Cable ducting shall not be used as a base for indication tabs.
- Cables shall be labeled
- Electrical enclosures shall have protection installed to guard against running water.

##### 4.7.1 High Voltage General Requirements

- Electrical supply to the TBM will be 15,000 Volts 50 Hz
- All 15kv high voltage connections shall utilize stress-relieving kits to reduce the risk of insulation breakdown.
- Provision for earthing of outgoing 15kV circuits shall be provided. This earthing shall be designed as either integral with its main circuit breaker or interlocked both mechanically and electrically. Earthing out points need to be easily visible.

##### 4.7.2 Main Transformers (NEW)

Type                                      dry transformers  
Primary voltage                        15 kV

##### 4.7.3 Cable Reel (NEW)

Cable reel capacity    280 m

Capacity                                15 kV

Flex cable not included. (features of the cable will be communicated from the VENAUS)



#### 4.7.4 Low Voltage Energy Supply on TBM and Backup

- On six (6) locations a 400-volt supply enclosure shall be provided (exact locations to be confirmed).
- Access to this enclosure is to be available to all with protected entries provided for external equipment to be plugged in at the bottom of the enclosure.
- A space should be allowed for to house a 600Amp fixed welding set in the workshop area.

#### 4.7.5 Lighting

The fixed lighting installation shall comprise normal lighting and emergency lighting employing self-contained units.

On each module and on the machine, lighting shall be distributed by two circuits (220 V / 24 V) generated at different LV transformers and protected locally by 30mA differential circuit breakers.

The degree of protection for all lighting appliances is IP 55 minimum.

The minimum lighting intensity, depending on the particular area, is:

- Work areas: > 200 lux
- Highly lit areas: > 300 lux
- Pedestrian access areas: > 120 lux
- Other areas: > 100 lux

### **4.8 L1\* Working Zone EQUIPMENT**

#### 4.8.1 Mesh Handling System (NEW)

The wire mesh handling system consists of three major components. The first is a jib crane (capacity suitable for one panel, CE certified) that is used to raise the panels from the invert of the tunnel to on top of the main beam. The second component is a conveyor that transfers the panels from the aft end of the TBM to the panel erector carriage. The conveyor also acts as a storage area. The last component is the erector carriage. The erector carriage runs on rails that allow the erector carriage to travel over the work area of the probe drills to the area for installing the panel. In order to traverse the probe drill area the probe drills, which are mounted on a ring, are rotated below the tunnel centerline so that they do not interfere with the panel installation operation. Two removable rails are then installed to complete the necessary track for the mesh erector carriage to travel upon.

The first panel that is loaded on the carriage is positioned so that it is in the center. The next panel is loaded to the one side so that it overlaps the center panel. The side panel is located using a set of spring-loaded pins that engage the wire mesh and support the wire mesh in the desired location.

The third and last panel is loaded on the opposite side. The panel erector carriage then travels forward to the desired location. The lifting arm of the carriage is then raised hydraulically against the crown of the tunnel. The panel is then anchored to the crown after drilling with the roof drills, and using either the specified roof bolts (2.5m long) or short anchor bolts to hold the mesh in place prior to installing the crown arches or the ring beams. The panel erector carriage is stored behind



the probe drill when not in use, and the removable rails are stored beneath the panel transportation conveyor.

#### 4.8.2 Probe Drill Positioner System (NEW)

In the L1 area is mounted a probe drill positioner on an arched gear with gear positioning hydraulic drive, that can cover 360° of the tunnel.

#### 4.8.3 Fabricated Ring Panel Erector (NEW)

For installation of the fabricated ring beam panel a rotary arm type erector will be supplied. The erector will bring the pre-fabricated sections from the invert arm to a position on the tunnel wall. The sections will then be bolted together. Included in the supply is the following:

360° erector

Arm placement with 6 degrees of movement to align section Work platforms for access to the sections for bolting

Radio controller for operation

Axial movement (common with TBM stroke)

#### 4.8.4 Invert Auxiliary Thrust System

To assist with placement of the invert thrust segments and to aid in advance of the TBM in bad ground where the grippers are not able to provided full grip reaction, Robbins will provide (2) two invert thrust cylinders. The cylinders will be located in the vertical front support and will provide 500 tonnes of thrust. The stroke of the cylinder will be 1500mm.

N.2 additional shoes will be supplied as extension of auxiliary invert thrust cylinder.

### **4.9 Material Handling**

Material such as cutters, rock bolts, wire mesh, steel beams, etc is brought into the tunnel on flat cars to the back-up area. From this location the hoists and transport system used for the segments is used to move the material forward to the appropriate work area.

#### 4.9.1 Segment handling (NEW) On the Back.up

1 each 6 ton hoist and monorail at the segment unloading area. This hoist travels laterally to unload the segments from the supply car and place them in the segment storage area on either side of the first back-up deck.

2 each 6 ton hoists and monorails to transport the segments from the storage area on the side to the segment shuttle car on the L2 work platform

On the TBM:

1 each 6 ton hoist and monorail under the TBM conveyor extension to unload the shuttle car and lower the segment to the invert.

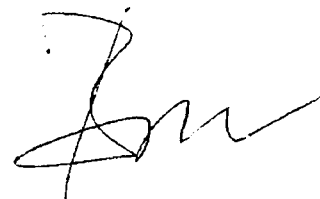
1 each 6 ton hoist and monorail mounted under the TBM to transport the segment forward to the area behind cutterhead support.

#### 4.9.2 Lifting Equipment for Lining Material (NEW)

Jib crane, capacity (2 t) located on top of main beam for handling of wire mesh, rock bolts and other support material.

#### 4.9.3 Work Decks and Platforms (NEW)

All work decks, platforms, walkways, handrails, and ladders to be installed to European Standard EN815.



#### **4.10 TBM Conveyor (REFURBISHED WITH NEW BELT)**

##### **4.10.1 General**

- Mucking capacity suitable for continuous operation at 6 m/hr
- Hydraulic operation – variable speed
- Belt Speed 0- 2.8 m/s
- All systems to be guarded per European Standards

##### **4.10.2 Assembly**

- Structure designed for high capacity muck removal
- Toughing idlers replaceable from outside main beam structure

#### **4.11 TBM Control (REFURBISHED AND UPDATED)**

##### **4.11.1 Operator's Cabin (REFURBISHED AND UPDATED)**

A soundproofed, ventilated and air-conditioned operator's cabin shall be provided. The inner surfaces shall be easily washable.

Particular attention has been given to the ergonomics of the control station. The operator is able to see the displays as well as reach all controls from a fixed position.

The operator's console shall contain an integral desk with writing surface and storage.

Sufficient space to be provided to install a surveying system access for surveyor during TBM operation is to be provided.

##### **4.11.2 Control System and Indicating Devices (REFURBISHED AND UPDATED)**

A Programmable Logic Controller (PLC) will be supplied to augment the original hard-wired control system of the TBM. The PLC will provide data logging abilities, key high level interlocking, and supervision of the VFD drive system

A keyed lockout for the control system is provided

##### **4.11.3 General Requirements for Sensors (TBM and Backup)**

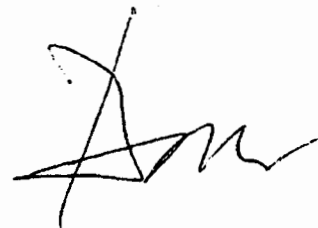
Analog sensors shall be rated 4-20 mA or 0-10 Volts only. All limit switches and position sensors shall employ inductive rather than electro-mechanical control.

##### **4.11.4 TV Monitoring (TBM and Backup) (NEW)**

A four (4) camera video monitoring system to watch the relevant areas is to be incorporated into the design. The display monitor system must be able to show all or just one camera at anyone time.

The cameras will overview the following areas:

- Muck discharge from TBM
- Rock Drill area
- Working area under bridge
- Conveyor installation area



#### 4.11.5 TBM Survey System (NEW)

- Space to be provided in operators cabin for survey system
- Two (2) laser brackets to be provided on TBM
- Survey window will be provided full length of backup and TBM.

### **BACK-UP**

#### General

The back up system will be composed by a series of rolling decks with closed bottom, plus a conveyor discharging to a continuous conveyor system.

The decks are used to incorporate all the TBM, back-up equipment as described in the present contract and back-up ancillary equipment supplied by the VENAUS.

The back up is designed to pass a 1.4 m wide segment with adequate clearance.

Other main features:

- Suitable for curves at 500 m radius
- Designed to provide easy access to all units for maintenance and repairs
- All cross-sections to be designed to allow pulling back through the tunnel at project completion without major disassembly.
- Safe passage along the whole length of the deck section.
- L2\* Rolling Working Platform

#### 4.12 **L2\* Working Section**

##### General Layout

- Rolling platform with integrated invert conveyor and work platform for ground support..
- Platforms to be double track to accommodate the ground support systems and the transportation forward and storage of the segments .
- Platforms include wheel assemblies riding on top of invert segment
- Chute with baffles and shrouds for muck from TBM conveyor to invert conveyor
- Sliding tow system
- Invert conveyor
- Grid covers for conveyor
- Space for mounting Shotcrete system
- Space and positioner for mounting Radial Drill drill system
- Space for mounting Core Drill system

##### 4.12.1 Rolling Deck Section

- All gantries are closed deck and running on 36 kg/m rails of 900 mm gauge
- Wheel loads less than 10t / wheel
- Safe passage along the whole length of the gantry section
- Platforms and structure , to house TBM, back-up and ground support equipment .

##### 4.12.2 Rail and Rail Support System

- Rail weight approx. 36 kg/m
- Gauge 900 mm
- Rail support system to be pre-cast invert



#### 4.12.3 Material Hoist

- Number (5) five unit
- Capacity 6 t capacity each
- Traveling speed approximately 20m/min
- Safe and simple material transfer from platform and to main beam crane at all times

#### 4.13 **Back Conveyor System**

##### 4.13.1 Invert Conveyor Intergrated into L2\* Working Platforms

- Belt width 750mm
- Drive designed to start belt under all load conditions
- Drive pulley with replaceable lagging
- Impact pan
- Guarded as per European Standards

##### 4.13.2 Assembly and Handling of Conveyor Material

- Space for structure assembly approx. 6m (adequate room)
- Space for idler assembly approx. 6m (adequate room)
- Storage area for idlers and frames for 24 hr of production
- Adequate transfer conveyor system to ensure a careful transfer of the material from the Back-up conveyor into the continuous conveyor Tail end station

#### 4.14 **Shotcrete Storage Area**

Storage area for n.2 shotcrete containers, coming by the rolling unit, to be available on the back-up along with the pump to transfer the shotcrete material to the shotcrete unit. Equipment not included.

#### 4.15 **Ventilation and De-dusting (REFURBISHED)**

##### 4.15.1 Ventilation Cassettes and Handling

- N.2 Cassettes for ventilation duct diameter 2000 mm
- Cassette Capacity 100 m
- Transport by rail to platform directly under cassette position
- Crane to bring and hold cassette in position, unloading in horizontal position and located at end of backup

##### 4.15.2 Dust Scrubber (REFURBISHED)

To suit local requirements and the overall ventilation system

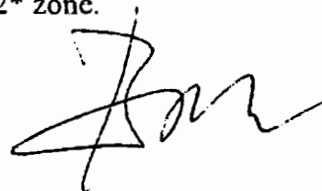
Type dry type  
Capacity 600 m<sup>3</sup>/min  
Air outlet end of backup

##### 4.15.3 Fans & silencers (REFURBISHED & UPGRADED)

Dust scrubber fans 2 x55 KW + silencers  
Fresh air fans 2 x55 KW + silencers

##### 4.15.4 Ventilation ducting (NEW)

Fresh air vent line is supplied to the rail installation area, from where two smaller vent lines continue under the work section platforms to the forward end of the L2\* zone.





Rigid ducting from TBM to the scrubber is supplied.  
Scrubber output duct will be supplied to overlap the fresh air out let by 15 m approximately.

#### 4.16 Compressed Air

##### 4.16.1 Compressors (REFURBISHED)

Type 2 x air-cooled units  
Capacity 2 x 11 m<sup>3</sup>/min @ 7.5 bar

##### 4.16.2 Receiver and Piping

Receiver 1 x 4 m<sup>3</sup>  
Pipes and hoses design pressure 10 bar

#### 4.17 General Layout of Primary Cooling System (REFURBISHED)

Open loop system with:

- Pump
- Various heat exchangers (oil, motors etc.)
- Heat exchanger to tunnel system
- Water tank
- Tank capacity approximately 4 m<sup>3</sup>
- Corrosion inhibitor type
- Dewatering and sedimentation tank, (5 m<sup>3</sup> capacity).

#### 4.18 Industrial Water

##### 4.18.1 Hose Reel (REFURBISHED)

Capacity 50 m for hose internal diameter 75 mm, design pressure 16 bar (Hoses not included)

##### 4.18.2 Distribution on Backup and TBM

- Design pressure 16 bar
- Filter system
- Min. 50mm main line on backup
- Min. 25mm distribution lines to all consumers

#### 4.19 Gas / Environment monitoring (NEW)

##### 4.19.1 Radon detection

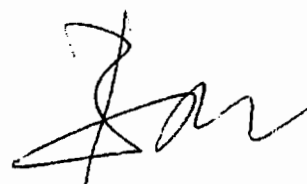
Three sensors: One on back of cutterhead support, one in vicinity of control cabin, one in ventilation exhaust discharge.

##### 4.19.2 Metan detection.

Three sensors: One on back of cutterhead support, one in vicinity of control cabin, one in ventilation exhaust discharge.

##### 4.19.3 Temperature measurement.

Three sensors: One on back of cutterhead support, one in vicinity of control cabin, one in ventilation exhaust discharge.



#### 4.20 Tunnel Dewater Tank\_(NEW)

- 5 cu m tank mounted on backup
- access doors for cleaning

#### 4.21 Personnel Facilities

##### 4.21.1 Workshop (NEW)

Proper workshop for mechanical / electrical with appropriate storage facilities, not included is the tools or fixtures for the workshop.

##### 4.21.2 Safety Container (NEW)

- capacity: 12 people
- dimensions: 5000 x 1600 x 2000
- weight: 2500 kg
- cabinet mechanical resistance : 500 N/m<sup>2</sup>
- living space:  $\geq 0,5$  m<sup>2</sup>/person
- fire resistance: 2 hours
- acoustic level attenuation: min. 30 dB(A)
- pressurization system: by compressed air @7.5 bar max pressure
- inner pressure range: 0,6 mbar operative - 0,2 mbar standby
- compressed air flow for inner atm regeneration: 120Nm<sup>3</sup>/h - 10Nm<sup>3</sup>/person
- emergency breathing system: by nr.9 high pressure cylinders 50 liters capacity /ea
- survival time without pressurization: 12 hours (with emergency breathing system)
- lighting system: 4 lights with 3 hours battery back-up for 12 hrs autonomy.

##### 4.21.3 Communication System (NEW)

A communication system between the TBM, workstation, and the following areas will be provided:

- TBM operators station
- L1\* work zone
- Inching drive station
- L2\* work zone
- Track laying area
- Muck loading station
- Rear most area of backup
- Safety container.

#### 4.22 L2\* Working Zone Equipment

##### 4.22.1 Radial Drill System

- Space e positioner only.

##### 4.22.2 Shotcrete System

- Space only

##### 4.22.3 Core Drill System

- Space only



#### 4.22.4 Man Lift Bucket Assembly

To assist with the crown ground support of the forward drill a hydraulically operated man lift bucket assembly is proposed.

#### 4.23 **Fire Suppression System**

An automatic fire suppression system is proposed. This system consists of approximately six (6) LTA-101-30 systems placed to provide protection at the hydraulic packs, lubrication pack, and at electrical equipment as required. In addition, approximately twelve (12) 7.7 kg. Cartridge type, manually operated fire extinguishers are provided located throughout the TBM and backup system.

#### 4.24 **Radon Monitoring**

The radon monitoring system offered is a 3-sensor system and provides for continuous radon monitoring. The first sensor is located immediately behind the cutterhead support, the second sensor is located in the vicinity of the operator and the third senses the dust scrubber exhaust.

The monitor allows settings for alarm/events at detection of gas at two different levels. At the detection of the presence of gas at the lower level, visual and audible alarms are sounded. On the detection of the presence of gas at the higher level, automatic shutdown of non-essential services occurs. The only remaining powered systems are the battery backup lights (1 hour) and the methane detector on separate circuit.

#### 4.25 **Data Recording System (REFURBISHED AND UPGRADED)**

An automated electronic Data Recording System is offered as an option using the PLC on the TBM. It reads and displays the operating levels of the machine's various hydraulic and electric systems and logs them in the hard disc on the PC. The following data is an example of what can be recorded:

- Power
- Torque
- Thrust of propelling jacks
- Number of running motors for cutterhead & motor amps
- Machine clock time for starting & ending or boring
- Propelling stroke length
- Cutterhead rpm
- Gripper force
- Tow force

The "Remote Version" consists of a desktop PC located on the surface. It is connected to the PLC of the TBM via a cable or radio modem (supplied by others). The surface PC records the same parameters as the laptop PC.

The data logger can log in excess of 50 variables plus data and time. The data logger displays all variables in real time on a screen. Bar graph and digital values are displayed for each variable.

Components of data logger ("Remote version")



- 1 Laptop PC
- 1 TBM kit, including PLC communication modules, and cabling
- 1 Data logging software
- 1 Desktop PC
- 1 Communication software line. Drivers as needed

Additional information can be provided if requested.

#### **4.26 Communication System (NEW)**

Communication system between the TBM workstations and the backup workstations. System includes eight (8) handsets located at operators station, L1\* work zone, inching drive station, L2\* work zone, segment laying / track laying station, safety container, muck loading station and rear most area of backup.

#### **4.27 Acceptance of Drawings and Systems**

All major system and overview drawings and systems to be checked and confirmed by Contractor.

#### **4.28 Data Exchange**

##### **4.28.1 Manuals for all Equipment Including Original Suppliers**

Three complete sets of manuals will be provided per machine.

Manuals will be in English language.

##### **4.28.2 Spare Parts Lists**

Spare parts lists with Robbins part number, price and drawing reference to be provided as EXCEL sheets and updated via mail, ftp- server or CD.

#### **4.29 Electric generator. (REFURBISHED)**

A refurbished electric generator 100 kVA will be supplied.

#### **4.30 Occupational Health and Safety**

The tunneling plant to include the TBM and backup system is to comply with the CEN European Standards EN 815 "Safety of unshielded Tunnel Boring Machines and rod less Shaft Boring Machines for rock". All relevant sections of the CEN Standards shall apply.

#### **ATTACHEMENTS**

- Drawing P3514
- Drawing P3532
- Delivery schedule



## **5. PRICE OF SUPPLY**

The price is in Euro, EX-WORKS FACTORY, per INCOTERMS 2000. Price exclude sales tax or fees and charges to be paid in Italy , which are to be borne by the Customer.

### **5.1 Robbins 6.3m H.P. Hard Rock Tunnel Boring Machine and Back-up system.**

The Robbins Company ("The Seller") will supply to VENAUS Società Consortile a r.l. ("The Buyer") the refurbished H.P. Hard Rock TBM -299 modified to 6.3m diameter and the back-up system, as per specifications and description of section 4 "Scope of Supply", including:

Supervision for field assembly / training (6 man-months)..... Included  
Shop test and documentation ( as per attached list) ..... Included  
Painting ..... Included

FIXED PRICE for Robbins 6.3m TBM and BACK-UP..... **Euro 6.200.000,00**

### **5.2 Invoicing**

The Seller requires that the payment of the TBM and back-up will be done as follows:

**The Robbins Company** of Solon (Ohio)-USA will invoice ex-works Solon (Ohio) the refurbished and modified **H.P. HARD ROCK TBM 1812-299-3** at.....**Euro 4.100.000,00**

**Robbins Europa S.r.l.** of Cesate (Mi) – Italy will invoice ex-works (seller's designed shop) Italy the **BACK-UP** at ..... **Euro 2.100.000,00**

### **5.3 Payment.**

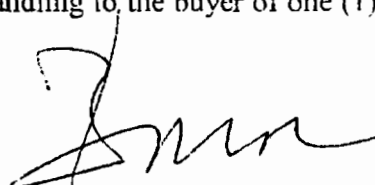
**5.3.1 The amount of Euro 4.100.000,00 covering the H.P. Hard Rock TBM -299, will be paid to The Robbins Co. of Solon (Ohio) – USA as follows:**

**Euro 410.000,00** as down payment after 20 days starting from the signature of the present contract but not later than the end of may, against handing over the buyer of one (1) original invoice and bank guarantee or stand-by letter of credit for the same amount.

**Euro 820.000,00** at reaching milestone n.1 (readiness of the basic structural TBM assembled in Robbins shop (cutterhead support, main beam, rear legs, and gripper carrier); completion of the TBM general drawings; performance bond and handling to the buyer of one (1) original invoice..

**Euro 820.000,00** at reaching milestone n.2: readiness of the new ring gear, refurbished and certified main bearing, hydraulic power pack, and handling to the buyer of one (1) original invoice.

**Euro 820.000,00** at reaching milestone n.3 (readiness of new inner cutterhead, four (4) refurbished outer segments, electrical cabinet, structure of roof drill and probe drill positioners, panel erector, and handling to the buyer of one (1) original invoice.



**Euro 820.000,00** at readiness into the factory, completion of the factory acceptance test, , and handling to the buyer of one (1) original invoice.

**Euro 410.000,00** against handling over to the buyer of one (1) original invoice, completion of the boring of first 500 m of tunnel and signature of the penetration performance certification but not later than 180 days from the readiness date ex works Solon (Ohio) – USA.

The Robbins Co. will submit the documentation proving that the milestone has been achieved signed for confirmation by a Buyer's Representative.

### **5.3.2 Advance Payment Guarantee.**

The Robbins Co. of Solon (Ohio)-USA shall provide a bank guarantee or stand-by letter of credit, drawn upon a first class bank, approved by the Buyer, against the advance payment of Euro 410.000,00.

The bank guarantee shall be returned to The Robbins Co. at the date of readiness for shipment of the TBM ex-works Solon (Ohio) – USA.

### **5.3.3 The amount of Euro 2.100.000,00 covering the Back-Up system, will be paid to The Robbins Europa S.r.l. of Cesate (Mi) – Italy, as follows:**

**Euro 210.000,00** as down payment after 20 days starting from the signature of the present contract bt not later than the end of may, against handling over the buyer of one (1) original invoice and bank guarantee or stand-by letter of credit for the same amount.

**Euro 420.000,00** at reaching milestone n.1 : completion of back-up layout general drawings; delivery of the Seller's performance bond , and handling to the buyer of one (1) original invoice.

**Euro 420.000,00** at reaching milestone n.2 : completion of back-up structures, and handling to the buyer of one (1) original invoice.

**Euro 420.000,00** at reaching milestone n.3 availability of back-up main following equipment: transformers, ventilation fans, compressors, electric cable reel, man bucket, segment transport car; and handling to the buyer of one (1) original invoice.

**Euro 420.000,00** at reaching milestone n.4 : readiness at factory of back-up. Completion of the factory acceptance test of the "L2 working zone" and handling to the buyer of one (1) original invoice.

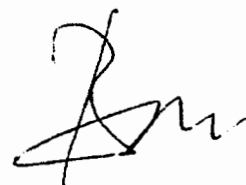
**Euro 210.000,00** against handling over to the buyer of one (1) original invoice, completion of the boring of first 500 m of tunnel and signature of the penetration performance certification but not later than 180 days from the readiness date ex works Italy.

Robbins Europa S.r.l. will submit the documentation proving that the milestone has been achieved signed for confirmation by a Buyer's Representative.

### **5.3.4 Advance Payment Guarantee.**

Robbins Europa S.r.l. shall provide a bank guarantee or stand-by letter of credit, drawn upon a first class bank, approved by the Buyer, against the advance payment of Euro 210.000,00.

The bank guarantee shall be returned to Robbins Europa S.r.l. at the date of readiness for shipment of the BACK-UP ex-works Italy.



#### 5.4 Delivery time:

The TBM will be ready for delivery not later than October 28<sup>th</sup>,2005.

The Back Up System will be ready for delivery not later than November 4<sup>th</sup>,2005.

#### 5.5 Delivery terms.

Robbins will supply f the machine/equipment packed for the transport as break bulk or in flat/open top containers supplied from the customer.

The Seller will load the machine/equipment on the trucks

Estimated TBM and back up shipping weights and dimensions to be supplied to the Buyer within 90 days from the signature of this Contract

### 6 BUY BACK OPTION

**6.1 At the completion of the first 7,000 m bored, but not later than 38 months from the contract date,**

Request for the application of buy back option to be notified in writing at reaching of 6.000 m tunnel bored.

The Robbins Co. of Solon (Ohio) – USA and the Robbins Europa S.r.l. of Cesate (Mi) – Italy will buy back the equipment supplied at 15% (fifteen percent) providing that the equipment is complete, in normal working conditions, not damaged or modified, serviced with original spare parts supplied from Robbins, maintained and disassembled accordingly to the Robbins service manuals and under a Robbins field Supervisor.

TBM delivered at Robbins – Solon (Ohio) – USA.

Back-up delivered at Robbins Europa – Cesate (Mi) – Italy.

**6.2 At the completion of the first 10,000 m bored, but not later than 45 months from the contract date,**

Request for the application of buy back option to be notified in writing at reaching of 9.000 m tunnel bored.

The Robbins Co. of Solon (Ohio) – USA and the Robbins Europa S.r.l. of Cesate (Mi) – Italy will buy back the equipment supplied at 12% (twelve percent) at the same conditions above reported at item 6.1.

#### PRELIMINARY IN-FACTORY ACCEPTANCE

The Buyer reserves the right to send inspectors to the Seller's factories, without earlier notification , to check for readiness conditions of the machine/equipment under this Contract.

The Buyer representative personnel shall be allowed to gain access to the Seller's factories or those of its sub-suppliers and be given the required information.



The commencement of the preliminary assembly operations and/or tests shall be notified to the Buyer in due time, to allow the Buyer's technicians and inspectors to schedule their visits.

The procedure to be used for the tests shall also be notified in advance in binding terms to the Buyer.

The factory test will include the following main functions:

For TBM:

- Inner cutterhead
- L1 working zone.

For back-up:

- L2 working zone.

The Seller shall set up the test list ( including test requirement and test procedure) to be approved in writing by the Buyer within 30 days from the signature of this Contract.

This document will define the factory acceptance test. The satisfactory completion of the factory acceptance test shall result in the issuance of the factory acceptance certificate, stating simply that the factory acceptance test has been completed, which shall be signed by both parties.

## 7. SITE ASSEMBLY

### 7.1 Buyer obligations.

The Buyer is responsible for providing all labor, lifting devices, transportation fixtures, electric power, water, compressed air, etc. to unload, transport and field erect the machines/equipment and all lubricating compounds, hydraulic oils and labor, operating and maintenance personnel required to place the machine/equipment into operating condition.

### 7.2 The Seller's service personnel.

The Seller will provide experienced field technicians for supervising site assembly and test of the TBM on the construction site and to advise the personnel, designated by the Buyer, in operating and servicing the TBM. The Seller will provide to the Buyer these technicians including travel to and from the site, free of charge, for a total of six (6) man-months. The hours worked by these technicians will be the same as those worked by Buyer personnel. Accommodation, meals, and car availability at job site will be provided by the Buyer at no cost to the Seller.

## 8. SITE ASSEMBLY ACCEPTANCE

The "white testing" of the TBM on site shall be effected at the end of the site assembly. The "white testing" shall consist of testing under load, where possible, of those TBM and back-up systems, which have not been tested or have been tested under no-load conditions in the factory. The Seller shall submit the test procedures to the buyer prior to the on site assembly. On satisfactory completion of all tests and after satisfactorily excavating the first 3 STROKES, a site acceptance certificate will be accordingly issued and signed by both parties.





## 9. PENALTIES FOR DELAY DELIVERY

The above mentioned delivery schedule was agreed with the Seller and accepted by both parties. If it will not be honored by the Seller for reasons imputable to or at the risk of the Seller or his sub-suppliers, excluding solely causes of force majeure, after an initial period of grace of two (2) weeks, a penalty of **1% of the total contract price for each full week of delay** shall be applied to the Seller up to a **maximum amount of 5% of the total contract price**.

If the buyer incurs no damages due to the delayed delivery, no penalty will be applied to the Seller.

## 10. LIMITATION OF THE SELLER'S LIABILITY

Robbins' liability shall in no case, except in case of gross negligence or willful misconduct on the part of the Seller, exceed a total of 10% (percent) of the price of the machines/equipment of part thereof, which gives rise to the total claim.

With the foregoing exceptions neither party shall in any event be liable to the other for indirect, special or consequential damages whatever way they arise..

The Seller shall be responsible for all losses, liabilities, claims, costs and expenses that may result from damage to any property, including environmental damages, or physical injury to any person that may arise out or in connection with the Seller's performance of the present Contract due to negligent faults, acts or omissions of the Seller or his personnel up to the site acceptance certificate.

## 11. WARRANTY

The Seller warrants that any equipment will be free from defects in either design, material or workmanship.

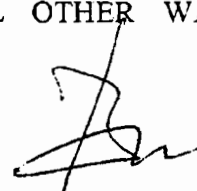
The Seller will modify, repair or replace, at its own expenses, any part of the goods proven defective either in design, material or workmanship. The parts replaced under warranty will be provided ex-works USA, Europe or Italy. This warranty is effective on the following conditions:

- That the goods have been operated and serviced according to the Seller instructions.
- That the defects became apparent within 12 months after the ex-works delivery or 1000 m of tunnel have been excavated, whichever occurs first.
- The main bearing is covered by the Robbins' warranty for the total length of 10 (ten) km of the tunnel.
- The cutterhead structure is covered by the Robbins' warranty for the total length of the 10 (ten) km of the tunnel.

The Seller is entitled to inspect any part claimed defective and to arrange technological and other examinations. The Buyer agrees to provide manpower and equipment necessary to replace defective parts, at his own expense. Effects of corrosions, erosions, and normal wear and tear are specifically excluded from this warranty. The replaced products became the property of the Seller.

Warranty does not apply to defects in material provided by the buyer or design stipulated by the Buyer.

THE WARRANTIES, AGREEMENTS AND REPRESENTATIONS SET FORTH IN THIS CONTRACT ARE EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES.



AGREEMENTS AND REPRESENTATIONS CONCERNING QUALITY OR PERFORMANCE, WRITTEN, ORAL OR IMPLIED, AND ALL OTHER WARRANTIES INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR PURPOSE ARE HEREBY DISCLAIMED.

**12. FORCE MAJEURE**

Force Majeure shall apply in this contract. "Force Majeure" shall mean any circumstances beyond the reasonable control of the party concerned and shall include, but not be limited to, any of the following matters: confiscation, destruction or requisition by order of any government or any public authority, war, revolution, invasion, insurrection, riot, civil commotion, mob violence, sabotage, blockage, embargo, boycott, military or usurped condition, epidemic, quarantine, accident, relevant entity strike or lockout or other industrial action by workers or employees, earthquake, flood, fire, or other natural physical disaster.

Should either party be prevented from executing the Contract due to a case of force majeure, the time for implementing the Contract shall be extended by a period equivalent to the effect of the occurrences.

The prevented party shall inform the other party as soon as possible by fax or mail within seven (7) days of the occurrence of the force majeure for the examining by and confirmation of the other party.

**13. PENETRATION PERFORMANCE WARRANTY**

Robbins guarantees that the TBM can perform a complete advance cycle, consisting of boring a length of 1,80 m with the following rates of penetration (the RoP) according to different geological conditions, as follow:

Rock Type	Class	Advance Rate M/hrs
Calcitic Schist	III + II	Up to 5 m / hr
Gneiss	II	Up to 4 m / hr
Gneiss	III	Up to 5 m / hr
Mica - schist	II	Up to 5 m / hr
Mica - schist	III	Up to 5 m / hr

The performance test, will be carried out at the job site on machine within the first 500 m.

If the Seller doesn't pass the first test, the Seller will be allowed 60 days to make improvement to the system and repeat the test at discretion of the Buyer, the results of the second test shall be binding.

After the completion of the penetration test with positive result, a penetration performance certification shall be accordingly issued and signed by both parties.

The penalty is limited is limited to Euro 75.000,00 and is payable at reduced performance pro rata of Euro 5.000,00 per 0,2 m per hour.

**14. PERFORMANCE GUARANTEE**

The Seller shall deliver to the Buyer a performance guarantee, in the form of bond or bank guarantee or stand by letter of credit issued by a bank acceptable to the Buyer, as guarantee that

the manufacturing of the machine/equipment will be carried out to its completion conforming to the technical characteristics defined in the present contract.

The performance guarantee shall amount to 5% of Supply Price Euro 310.000,00 expiring upon the date of issuance of the penetration performance certificate of the TBM and the first 500 m of boring but not later than 180 days from the readiness date ex works of the equipment, if the performance certificate is delayed for reasons not due to fault of the Seller.

It is understood that in case of delay or non fulfillment of the supply, the Buyer shall proceed with the enforcement of this performance guarantee and reserve the right to claim under this guarantee for eventual damages, that might arise from such delay or non fulfillment, as set out in the present contract.

## 15. SPARE PARTS

The necessary spare parts that should be kept on hand fall into two categories: minor spare parts (sometimes referred to as maintenance spare parts) and major spare parts (sometimes referred to as insurance spare parts). The Seller shall submit a recommended spare parts inventory list (including wear parts) and a list of recommended fixture and tools to the Buyer not later than end of July 2005 to allow the Buyer to review the list and allowing sufficient time for the parts to be on site when TBM erection begins.

The list shall include:

- a) list of recommended first hand spare parts
- b) list of recommended spare parts and wear parts for a 2,000 hours service
- c) list of eventual rotation group (major components)
- d) list of specific fixtures and tools

The above lists shall indicate the description and the reference number, the recommended quantity, the expected time for delivery and the unit price.

Upon completion of the works, the spare parts and wear materials unused will be returned to the Seller's Factory and the Seller will credit to the Buyer the 50% of the initial invoiced value of the returned parts.

The Seller's acceptance of such returned parts is conditioned on the parts being in a good state of preservation.

The Seller shall accept unused or excess spare parts on return to a maximum total value of Euro 100,000 (i.e. Euro 200,000 list price).

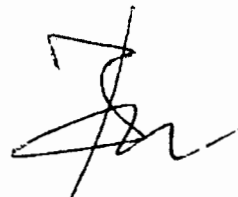
## 16. MAJOR SPARE CONSIGNMENT

The Seller will consign the following major spare parts for the duration of Venaus project:

Ex works Solon (Ohio) – USA ft.

- No 1 (one) refurbished main bearing (Warranty as per item 11)
- No. 1 bull gear Euro 54.400,00

At the Project Site, with transport at customer care and charge :



- |                                    |                |
|------------------------------------|----------------|
| • No. 1(one) main drive motor      | Euro 41.200,00 |
| • No. 1 (one) main thrust cylinder | Euro 36.800,00 |
| • No. 1 (one ) torque cylinder     | Euro 12.360,00 |
| • No. 1 (one) gear reducer         | Euro 48.400,00 |
| • No. 1 (one ) wedge cylinder      | Euro 8.480,00  |

*A 15% advance payment of the total value of the above major spare parts will be paid by the Buyer as stocking charge fee due on delivery.*

Such advance will be credited to the Buyer against purchase of any of these major spare parts.

## **17. PROPRIETARY INFORMATION AND CONFIDENTIALITY**

The Seller has proprietary interest in all data, drawings, designs, specifications, information or documents of any kind supplied to the Buyer or coming to his knowledge by way of performance or the Contract. The Buyer warrants the Seller that itself, its employees, suppliers or any other third party under his employment shall not directly or indirectly copy, reproduce, publish, use or disclose the said information to cause direct competition with the Seller except as may be necessary for the performance of the Contract and then only on a confidential basis. Prior to any disclosure as disclosure as aforesaid to any third party or to any employees the Buyer shall obtain from such third part or employees an irrevocable commitment to keep information strictly confidential and shall notify this commitment to the Seller.

The Commitments set for the hereinabove shall not apply to any information which:

- was or becomes part of the public domain otherwise than through any act or commission on the part of the receiving party
- was already in the possession of the receiving party at the time of receipt without any restrictions on disclosure imposed by the disclosing party.

On a general basis, in the event of the Buyer or the Seller is aware that the Contract can infringe any patent or that a third party may take legal action against the Seller or the Buyer, both parties shall provide to each other information and assistance that can be useful for any settlement negotiation or suit to fight the claim or to protect the title.

## **18. PATENT INDEMNITY**

The Seller shall at its own expense defend any suits or proceedings brought against the Buyer based on an allegation that the products furnished hereunder constitute an infringement of any claim of any patent , other than a claim covering a process performed by said products or a product produced by said product, provided that such products are manufactured by the Seller, are not supplied according to the Buyer detailed design, are used as sold by the Seller, the Buyer shall have made all payments then due hereunder and the Seller is notified promptly in writing and given authority, information and assistance for the defense of said suit or proceeding and the Seller shall pay all damages and costs awarded in any suit or proceedings to defended, provided that this indemnity shall not extend to any infringement based upon the combination of said products or any portion thereof with other products or things not furnished hereunder unless the Seller is a contributory infringe. The Seller shall not be responsible for any settlement of such suit or proceeding made without its written consent. If in any suit or proceeding defendant hereunder any product is held to constitute infringement and its use is enjoined, the Seller shall, at its option and its own expense, either replace said product with non-infringing products or modify them so that they become non-infringing or remove them and refund the purchase price and the transportation

cost thereof. THE FOREGOING STATES THE ENTIRE LIABILITY OF ACT WITH RESPECT TO PATENT INFRINGEMENT.

To the extent that said products or any portion thereof are supplied according to the Buyer's detailed design or instruction or modified by the Buyer, or combined by the Buyer with equipment or things not furnished hereunder, except to the extent that the Seller is a contributory infringer or are used by the Buyer to perform a process or product a product and by reason of said design, instructions modification, combination, performance or production a suit or proceeding is brought against ACE, the Buyer agrees to indemnify the Seller in the manner and to the extent the Seller indemnifies the Buyer in the PATENT INDEMNITY section insofar as the terms hereof are appropriate.

## 19. STORAGE

In the event of storage of the TBM or part of the TBM by the Seller for any reason other than fault of the Seller, the Buyer shall bear all costs and risks associated with this storage.

## 20. TERMINATION OR CANCELLATION

Any order or contract may be cancelled by the Buyer only upon payment of reasonable charges (including all direct costs and a reasonable allowance for overhead and profit) based upon costs and expenses incurred and commitments made by the Seller.

Upon notification of cancellation by the Buyer the Seller will act with the reasonable speed to stop work and prevent unnecessary additional costs.

All goods produced will become the property of the Buyer upon receipt of payment as due.

## 21. ARBITRATION

All disputes arising between both the parties in connection with the Contract shall be settled through friendly consultations between both parties. In case no agreement can be reached through consultations, they shall be submitted to arbitration for settlement.

The arbitration shall take place in Geneva – Switzerland and the arbitration shall be performed by the International Chamber of Commerce in accordance with the relevant rules of arbitration (Rules) of said Institute. The Committee of Arbitration shall be formed by (3) three arbitrators appointed by both the parties, in accordance with the Rules.

The arbitration award shall be final and binding on both the parties. Both the parties shall act accordingly.

In the course of arbitration, the Contract shall be executed continuously by both the parties, except those matters under arbitration.

The English language shall be used as the language for arbitration.

The internal substantive law of Switzerland (Code of Obligations), with the exclusion of the rules of conflict of laws, shall be applicable to the Contract.



**22. LANGUAGE**

The official language of the present Contract is English and, unless otherwise agreed between the parties, all the correspondence shall be in English

Acceptance by Robbins

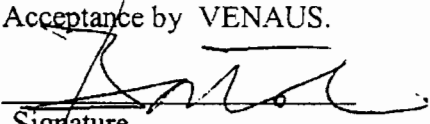
\_\_\_\_\_  
Signature

\_\_\_\_\_  
Name

\_\_\_\_\_  
Title

\_\_\_\_\_  
Date

Acceptance by VENAUS.

  
\_\_\_\_\_  
Signature

POMPEO BERTOLINI  
Name

PROCURATORE  
Title

10 MAGGIO 2005  
Date