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Llogara Tunnel Design Consortium **iC consulenten □ Elea iC □ IBE □ Seed Consulting □ Infrakonsult**	Document Number: LLO_IBE_DD_ EL_TSS_1000_RP_EN_W_02

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1. GENERAL

The intend of this document is to present the tunnel surveillance and control systems that are foreseen to protect road users and to ensure safe and uninterrupted traffic in the tunnel. The following systems are elaborated:

- Tunnel control system
- Redundant Ethernet tunnel data network
- Optical transmission network
- Video surveillance system
- Automatic incident detection system
- Fire alarm system
- Traffic equipment
- Radio system
- Sound system
- Emergency call system

A control center for the management and control of traffic and of all devices in the tunnel is planned in the portal building North. In addition, an auxilliary control center is foreseen in the portal building South that will operate in the event of a failure of the main center or in case of maintenance works.

The requirements for materials and installed equipment are given in the following sections. The construction requirements, technical characteristics, installation method, tests and measurements for the installed equipment are given. The equipment supplied and installed must be carried out in compliance with the requirements given in this document.

Where no specific equipment or function requirements are specified, the requirements of the Austrian guidelines RVS 09.02.22 should be used.

2. CONTROL SYSTEM

The control system for the Llogara tunnel enables remote monitoring and control from the main control center in the portal building North, from the reserve control center in the portal building South and the automatic operation of individual safety devices in the tunnel.

The control system of all safety devices in the tunnel represents a complete functional unit consisting of local stations as input and output points for signal acquisition, command issuance and execution of automatic control sequences, TCP / IP Ethernet data network and workstations for control and management in control centers.

The data transmission network is divided into two levels: the local network (layer2) at the level of the tunnel and the backbone network (layer3), which connects the local network and equipment in control centers.

The control system will be built from 43 local stations. Local stations are located inside the tunnel in emergency call niches, in electrical niches and in electrical spaces in portal buildings. The entire system will be interconnected via an autonomous tunnel optical Ethernet network.

All other subsystems are connected to the control system system via discrete signals, RS485 and Ethernet communication.

In the event of a failure of the main center (primary servers) in the main control center, it must be possible to manage the entire control system from the backup workstation. All integration and connection functions of all embedded subsystems must also be retained.

The control system must concentrate all device states in the so-called master concentrator (MC), which in the system further takes care of writing signals into the database and distributing the signal states to SCADA applications.

2.1 SPECIAL REQUIREMENTS FOR SUPPLIED EQUIPMENT

All equipment connected to the network should support the possibility of monitoring and reporting errors via the SNMP protocol. The supplier must first deliver the MIB files for the equipment he wants to install.

All computer systems that have Windows installed must be able to install an antivirus program and be able to install security system patches. During the warranty period, the contractor must ensure that all these safety corrections are installed.

If during the trial operation, until the handover of the facility to the client, it is established that in order to ensure functional and safety requirements and compliance with applicable regulations and recommendations, amendments or changes to the software for management and control are needed, all these changes are already taken into account in the offer price for the production of software and thus no longer represent additional work.

The bid price also includes all necessary hardware extensions to meet these requirements.

System parameterization, setting of individual time constants and parameters, limit, alarm and switching values must be enabled programmatically, at any time in an easy way via the control system and without additional costs.

For all devices, after completion and delivery to the customer, it is necessary to ensure scalability for at least 25% of additional signals on each individual device. Passive elements (cabinets, cable routes, dividers,…) must allow the installation of equipment for 25% of additional signals, while active elements (controllers, software…) must allow upgrading of modules for connection and processing of these additional signals without replacing any already installed element.

At the same time as the hardware, the contractor must hand over to the client all the necessary registration procedures, entry codes, passwords or keys for all delivered systems, which will allow the client access with full rights, so that it will be possible to maintain, supplement and change the supplied application software also by the client.

The supplier must submit detailed software documentation on servers, workstations and controllers, which must include at least:

- Detailed instructions for installing, configuring, and using the software on servers, workstations, and controllers
- Installation files for all installed server, workstation, and controller software
- Software source code

All requirements for computer equipment and components represent the minimum requirements that apply, taking into account the current state of technology. The delivered hardware must meet the latest technological standards at the time of delivery at no additional cost.

The offer will take into account in uniform prices all additional requirements for hardware and software, which would arise from the used system and application software for automatic control and monitoring.

All delivered devices must correspond to continuous operation for 24 hours / 7 days.

The uniform prices for the individual services listed in the inventories must cover all the costs necessary for the complete delivery and its flawless operation, regardless of whether they are explicitly stated below or not, or incompletely described.

Prior to the execution of works, the contractor must make a detailed analysis of the systems, which must be fully coordinated with the other supplied systems. The results of the detailed analysis and the descriptions of the detailed hardware and software requirements must be documented in a "functional requirements notebook". This notebook will be submitted to the client for confirmation.

2.2 FUNCTIONS OF THE CONTROL SYSTEM

The following systems and devices will be connected to the control system via local stations in the tunnels or via the TCP / IP data network:

- MV and LV power supply devices

- Lighting systems
- Tunnel ventilation
- Ventilation of cross passages
- Ventilation of technical rooms
- Video surveillance system
- Automatic incident detection system (AID)
- Radio communication and sound system
- Emergency call
- Traffic equipment
- Measurements of CO, visibility and longitudinal air velocity in the tunnel
- Point and line fire alarm system
- Other signalling

Connections and integration of the control and monitoring system with the video surveillance system, automatic incident detection system, radio, sound system, emergency call, fire alarm, Ethernet network control and other systems will take place via TCP / IP level.

The system allows manual and automatic control. In automatic operation, all control sequences in the tunnel take place automatically according to the programs for individual functions while the operator in the control center can intervene at any time with manual commands in the process.

All tunnel management system devices must be synchronized with the time synchronization device and operate on a single time base.

The software is an integral part of the computer control and management system and is divided into:

- local station software (level 1),
- control system software (level 2).

The management and control of the Llogar tunnel must be functionally feasible for all systems simultaneously from both control centers. From both locations it must be possible to control and manage at the same time and in case of failure of the main center also only from the reserve center without the necessary prior physical interventions to establish redundant control and management.

The system and application software of the control workstation performs and enables the following functions:

- reception and analysis of processed information from all systems in the tunnel,
- additional processing of information,
- display of data, information and alarms via graphical SCADA interface,
- dialogue with the operator,
- logging events on the printer,
- archiving.

The operator communicates with the control system via the screen, mouse and keyboard. The screen displays images and alphanumeric texts that represent: states, state changes, alarms, measurements, and other necessary presentations. All screenshots are accessed via the basic image, which shows the tunnel as

a whole. Between the images of systems and parts of systems that are technologically connected, it is necessary to provide for the possibility of direct transition without the use of tree drop-down menus. Screen images must be made in vector format for all individual systems and parts of systems in tunnels.

At least the following screens must be prepared:

- Basic image
- Alarms and warnings
- Traffic equipment (traffic lights, variable signs, inductive loops)
- Fire detection
- Video surveillance
- Automatic incident detection
- Fire and hydrant water
- CO / visibility and longitudinal air velocity measurements
- Ventilation
- Radio
- Sound system
- Emergency call
- Lighting
- MV power supply
- LV power supply

Individual screen images should be represented by individual "windows" that open within the basic screen image. Within individual screen images, it is necessary to get more detailed information about individual elements by opening "windows". All alarms, signals and measurements and commands should be displayed on or via screenshots.

The software connection to the video surveillance system must be made in such a way that all the installed video equipment is shown on the screen image of the tunnel. The operator must be able to obtain a live video data stream by simple selection or request, which must be visualized in the video field of each workstation.

A list of alarms and notifications must be displayed for all integrated signals. The list of alarms and notifications must be organized in such a way that it can be easily inspected. It should be possible to:

- scrolling forward,
- scrolling back
- instant first page display.

2.3 LOCAL STATIONS

The basic element of the control system is the local station. A total of 43 local stations are included in the Llogara tunnel.

The local station is a modular controller with power supply, the appropriate number of digital and analog inputs and outputs, modules for connecting traffic equipment (traffic lights, turn signals, variable traffic

signs, inductive loops), communication connections with other devices, CPU and Ethernet interface to connect to the process Ethernet network of tunnels.

The local station is intended for data acquisition on the state of devices and systems in the part of the tunnel covered by each station, performing local and automatic control sequences, partial data processing (counting functions, control loops, etc.), data transfer to other local stations and control center, receiving orders from other local stations or from the control center and the execution of commands.

The function of the local station software is as follows:

- data acquisition from an individual system in the part of the tunnel to which the station belongs,
- partial data processing,
- communication with other local stations and control equipment
- autonomous execution of local control sequences in the event of communication interruption

The connection to the Ethernet network of the tunnel includes not only the transfer of process data, but also all the necessary system tasks, such as programming, uploading and transmitting data and programs, parameterization and diagnostics. These functions must run in parallel with process communications.

Local stations must operate flawlessly and in coordination with the control system (process visualization and control system).

Description of local stations

Local stations consist of computer, communication, energy control and power supply modules:

All modules are designed for panel mounting in standard 19-inch frames. The minimum equipment requirements are:

Work environment:

- operating temperature: from -25°C to +60°C
- relative humidity: 5 to 95%
- altitude: up to 2000m (80 to 106kPa)
- vibration: 2g
- strokes: 15g
- el. static discharge: 8kV (150pF / 150Ohm)
- radiated EM field: 10V / m
- el. magn. compatibility: 1kV / 200Ohm choked sine 2kV / 50Ohm fast transition

Local station requirements.

- The main processing unit of the local station must have at least a 32-bit microprocessor with at least 200 MIPS processing power. At least 64 MB of working memory and at least 64 MB of program memory are required. Software applications run independently of each other in a multitasking operating system environment.
- The real-time clock must be battery-backed, with an autonomy of at least 72 hours

- Rated supply voltage: AC230V (-13% + 10%)
- Operating temperature range: -25 ° C to + 60 ° C
- Compact industrial design with easy-to-pull modules
- DIN rail mounting
- Housing protection: IEC 60529 class IP44 (or better), EN 50102 class IK07 (or better)
- Stress protection: Class 1, tested according to IEC 61140,
- The electronics are without moving parts.

The local station must have an Ethernet port for higher-level communication, which allows diagnostics via the Ethernet network, and pre-programming from the control center.

The local station is mounted in a set (together with terminals, protective elements and cable ducts) on a supporting frame and thus installed in an electrical cabinet.

The basic capacity of the local station must enable at least 4 serial communication channels for communication with sensors and equipment in the tunnel and at least 2 Ethernet communication ports for communication with other subsystems.

In case of communication failure or in the event of a local station failure, the exits should be placed in such a state that activates the safety systems (switching on the safety lighting, etc.).

It must be possible to expand all local stations (controllers) at any time with additional modules without replacing the basic rear bus.

The installed equipment must meet the requirements of the following standards:

- Standard EN 50556 (Road Traffic Signal Systems), which is a harmonized European standard for all systems to which devices classified as signaling and safety devices are connected. In the case of tunnels, these are traffic lights and turn signals.
- Standard EN 50293 (Road traffic signal systems - Electromagnetic compatibility) is a harmonized European standard for electromagnetic compatibility for all systems operating along road infrastructure. This includes signaling and safety devices, (variable and fixed) traffic signals, controllers, housings, roadside poles, communication connections, traffic detectors, power supplies, etc.

2.4 DATA ARCHIVING

Data archiving includes the editing and storage of all operational data on the condition of tunnels for the purposes of:

- on-demand request
- subsequent analytical data processing.

Archiving takes place continuously and periodically at fixed time intervals. Only correct data is archived. Incorrect as well as missing data must be specially marked.

The following are archived:

- automatic tunnel control commands,
- manual tunnel commands,
- all events
- alarms,
- status change notifications,
- measurements and other data required for on-demand protocols.

In addition to the above information, the files must also contain information on:

- date and time
- the type of data and the place to which it relates.

The organization of the files must be such as to allow events to be generated on demand. The software interface should make it easy to find:

- all events and alarms for local stations,
- all control station data,
- general parameters of the tunnel.

3. ETHERNET NETWORK

The local Ethernet network of the control system and the Ethernet network of the video surveillance system should be built as two individual units. As a whole, both networks are connected via a backbone network. To provide greater protection and control over network traffic, the control system is connected to the backbone network via firewalls.

The video data stream from the cameras will be transmitted over the network in multicast mode, so all backbone and video network devices must support the multicast routing protocol.

All network devices should be integrated into a central monitoring system for monitoring system networks, which will be integrated into the monitoring control system.

3.1 BACKBONE ETHERNET NETWORK

The backbone Ethernet network consists of L3 network switches, two of which are located in the system room in the portal building North and two in the system room in the portal building South. The backbone switches form a ring structure. The connection between the switches should be 10Gbit / s. Communication between individual segments and control center devices should be carried out at the L3 level using routing protocols.

The Ethernet network of the tunnel control system is connected to the backbone network via firewalls, which enable easier and more transparent network management, greater protection and control over network traffic, support for OSPF and PIM multicast routing protocols, etc. Connections will be made at two locations in both portal buildings.

Due to the rational use of network equipment, the backbone network is also used for the needs of the video surveillance system. The local video network is directly connected to the backbone network, which together with the backbone network switches form local rings. Other devices of the video surveillance system (video detection cards, recorders and servers) are also directly connected to the tunnel backbone switches.

The equipment of the main and backup control center (workstation, video wall display equipment, printer, etc.) is also connected to the backbone switches.

3.1.1 Backbone network data switch

Backbone switch requirements (such as x460-g2-48t-10Ge4):

- 48 x 10/100 / 1000BASE-T interfaces
- 8 x 1000BASE-X SFP interfaces, 4x can be shared with 10/100 / 1000BASE-T interfaces
- Possibility to install 4 x 10 Gbase-X SFP +
- 1x 10/100/1000 BASE-T control connector
- 4x corresponding SFP module 10G
- 8x corresponding SFP module 10G
- Support L2 / L3
- Support STP (IEEE 802.1D), RSTP (IEEE 802.1w), MSTP (IEEE 802.1s)

- Support IGMP snopping v1 / v2 / v3
- Support PIM (Protocol Independent Multicast) DM and SM
- VLAN support (IEEE 802.1q)
- Support Link aggregation (IEEE 802.3ad) static and LACP
- LLDP protocol support (IEEE 802.1ab)
- Support Routing IPv4 and IPv6
- OSPF routing protocol support
- VRRP protocol support
- Support ERPS (Ethernet Ring Protection Switching) G.8032
- QoS support
- Management and control protocols: SNMP v1 / v2 / v3, SSH, WEB (Https)
- Possibility to upgrade the switch via TFTP and the possibility of software updates
- Possibility of traffic restriction (ACL) incoming and outgoing traffic
- Port mirroring
- Possibility of compliant connection (4 switches)
- Operating temperature range 0 C ° 40 C °
- Built-in power supply 230V
- Built-in redundant power supply 230V
- Installation in communication cabinet 19 ''

3.2 LOCAL ETHERNET NETWORK OF VIDEO SURVEILLANCE SYSTEM

The local Ethernet network of the video surveillance system enables connection between cameras in the tunnel area with local video equipment (digital video detectors, recorders, servers, etc.) and connection to the backbone Ethernet network, which enables connection to devices in the control center. Given that the Ethernet video network is extremely important, as when it is interrupted, the operator in the control center loses its visual connection to the tunnel, the system must be built according to the principles of ensuring high reliability.

The local Ethernet video network should be built as a complete unit. The local network switches, together with the backbone switches, should form the ring structure of the network. The Red protect: ITU-T.8032 or similar protocol should take care of the operation of redundant paths. The connection between local switches should be 1Gbit / s. At each location where the camera or group of cameras is located, one L2 (Layer 2) PoE ++ Ethernet switch is installed, which should provide up to 90W of power on each port. All cameras should be connected and powered directly from the PoE ++ switch. In the event of camera faults or non-response, it should be possible to perform a hard reset by switching off the power supply of the cameras. Each switch must be powered by two power supplies.

3.2.1 Video surveillance network data switch

PoE ++ switch requirements (such as SISPM1040-582-LRT):

- Switch control: SNMP v1 / v2 / v3, SSH, CLI, WEB
- Functionalities: Port security, MAC authentication, Storm control.
- Operating temperature range: -40C to + 70C

- Connections: at least 2 100 / 1000Base-X SFP optical ports and at least 4 100/1000 Base-T ports
- 2x SFP module; 1000 Mbps LC SM; Max. radalja: 10 km
- PoE total power: at least 360W
- PoE on Base-T connectors: 90W simultaneously on at least 4 ports
- PoE standard: 802.3af (PoE), 802.3at (PoE +), 802.3bt (PoE ++)
- VLAN (IEEE 802.1q)
- Multicast: IGMP Snooping V1 / V2 / V3, MVR, MLD Snooping V1 / V2
- Ring protect: ITU-T.8032
- Support for large packages (Jumbo Frame): 9k bytes
- Switch bandwidth 16 Gbps
- Support 802.1D (STP), 802.1w (RSTP), 802.1s (MSTP)
- Port Mirroring
- 2x Power supply 48 ~ 55 VDC, 10A, 480 Watts
- DIN rail mounting
- 2x 10km Gigabit SFP module, -40C to + 70C, 1000Base-LX Single Mode (LC "twin" connection: Tx, Rx)

3.2.2 Firewall for connection with the tunnel control system

The firewall is used to connect the Ethernet network of the control system and the backbone network.

Firewall requirements (such as Sophos XG115 with EnterpriseGuard license):

- Ports: 4 x 10/100/1000 Base-T
- Throughput:
    - FW: 3600 Mbps
    - VPN 450 Mbps
    - NGFW 1Gbps
- Routing:
    - Static routing
    - RIP
    - OSPF
    - Multicast PIM
- IEEE 802.1q VLAN support
- QoS support
- Possibility of connection in high availability topology (Active / passive, Active / Active)
- Support for predefined reports (Traffic, Blocked applications, VPN, users, ...) in HTML, PDF format
- Link aggregation IEEE 802.3ad
- IEEE 802.1D STP support
- Stateful and stateless firewall
- Zone-based firewall
- Restricting IP traffic by geo location
- IP monitoring with the possibility of switching (interface failover)
- IP sec VPN support for site-to-site connectivity
- Support for remote users via IPSEC and / or SSL (User -to-Site)
- Two-factor authentication support for administrators and VPN remote users

- Support for integration with AD (Active directory), RADIUS, LDAP
- IPS (Intrusion Prevention) Support
- Support transparent proxy
- Support URL filter
- Malware scanning support
- Restrict unwanted applications
- Management and control: SSH, SNMP v1 / v2 / v3
- Support DNS, DHCP, NTP
- Temperature range 0 C ° to 40 C °
- Possibility to use a redundant power supply
- Redundant power supply 230V
- Installation in a communication cabinet 19 ''
- Appropriate license to provide the above functionalities for a period of 3 years with the possibility of renewal

3.2.3 Firewall for Internet connection

The firewall is installed in the control center in the portal building North for the needs of a secure connection to the Internet and remote access for the needs of rapid troubleshooting.

Firewall requirements (such as Sophos XG115 with EnterpriseGuard license):

- Connections: 4 x 10/100/1000 Base-T
- Throughput:
    - FW: 3600 Mbps
    - VPN 450 Mbps
    - NGFW 1Gbps
- Routing:
    - Static routing
    - RIP
    - OSPF
    - Multicast PIM
- IEEE 802.1q VLAN support
- QoS support
- Possibility of connection in high availability topology (Active / passive, Active / Active)
- Support for predefined reports (Traffic, Blocked applications, VPN, users, ...) in HTML, PDF format
- Link aggregation IEEE 802.3ad
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- Zone-based firewall
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- Temperature range 0 C ° to 40 C °
- Possibility to use a redundant power supply
- Redundant power supply 230V
- Installation in a communication cabinet 19 ''
- Appropriate license to provide the above functionalities for a period of 3 years with the possibility of renewal

4. ETHERNET NETWORK OF THE CONTROL SYSTEM

The control system is built distributed and consists of several local stations that are interconnected via an Ethernet network. The Ethernet network must be reliable and efficient. Therefore, the network will be separated into a local tunnel network and a backbonel network. Where the networks merge, network segmentation at layer 3 of the ISO / OSI model will be provided. Where the networks merge, segmentation on layer 3 of the ISO / OSI model (layer3) will be provided. The system designed in this way will ensure complete segmentation and isolation of data traffic within the tunnel.

The Ethernet network of the control system is intended for the transmission of data of the control system as well also for the transmission of audio and control signals for the radio system, sound system, emergency call, fire alarm, except for video.

4.1 BACKBONE ETHERNET NETWORK OF THE CONTROL SYSTEM

4.1.1 Network topology

The backbone Ethernet network of the control system consists of industrial network switches (such as: Moxa IKS-G6824A-8GSFP-4GTXSFP-HV-HV) L3, which are installed in 19 "server cabinets, which will be located in the system rooms in both portal buildings.

All network switches will form a ring topology. In case of failure of one optical connection or. active network equipment, the system must be established after a redundant connection in less than 50ms. The use of VRRP protocol is envisaged to perform redundancy within the tunnel. The VRRP protocol will, in the event of a failure of an individual network switch, enable the correct routing of data traffic and thus ensure the smooth operation of the entire control and monitoring system. Every outage or fault must be signaled appropriately at the control center.

Built-in optical connections are of the single mode type. All network equipment must use single mode SFP modules for single-fiber communication in WDM technology for connection. Active network equipment must have a device ground connection.

The entire backbone Ethernet network should be monitored via the SNMP protocol. As a subsystem, it is integrated into the control system of the tunnel.

The connection between the control system backbone network and the tunnel backbone network will be made through additional firewalls.

VLAN

The following VLANs must be configured for individual systems:
A: control system
B: radio system
C: emergency call and sound system
D: fire alarm system
E: service access

Each subsystem is assigned its own VLAN with corresponding bandwidth.

Monitoring the operation of network equipment

For reliable operation of the network equipment, the equipment must be constantly monitored. A fault signal should be transmitted in less than two seconds (2s) to the control center. The application that takes care of the operation of the network equipment must be integrated into the control system SCADA. Alarms and warnings must also be displayed in a common alarm line.

For each switch, the following information must be displayed on the SCADA:

- Operation of the primary and
- Secondary power supply,
- State of ring communication
- Communication with network switch,
- Status of operation of individual ports and
- Traffic at these ports.

For each switch It is necessary to graphically display on the SCADA the following:

- Location of the switch,
- IP address of the network switch,
- Network switch model,
- Firmware version and
- Uptime.

In normal operation, all signals give the status of operation OK, but in the event of any failure, the failure must be signaled accordingly.

For the transmission of information the SNMP protocol is used.

Ring communication

The entire network topology is designed in a ring architecture, which means that in the event of a failure of an individual element, the failure does not affect the operation of other equipment. This increases the reliability of the system and ensures redundancy in the event of passive optical transmission equipment failures.

The time required to establish a redundant connection must be less than 20 milliseconds, which allows the rest of the equipment not to detect that anything has happened on the transmission path.

Each failure must be alarmed in the control system, and displayed accordingly on the SCADA. The graphic display allows the maintenance personal to rectify the fault as quickly as possible.

Primary and secondary power supply of the switch

The switch must be powered by a primary and redundant 230VAC power supply, which must be powered from different phases. The failure of an individual power supply must be signaled as an alarm in the control

system.

Each port of the switch should be monitored and represented on the SCADA. The display must contain the port number, the data transfer rate on that port. In the event that any of the ports stops working, this must be properly alarmed in the system.

4.1.2 Control system backbone data switch

Technical requirements to be met by Layer3 type industrial switch hardware (such as: Moxa IKS-G6824A-8GSFP-4GTXSFP-HV-HV)

- number of ports 8x SFP 20x RJ45
- at least 4 slots for the installation of appropriate SFP optical ports,
- possibility to install at least 4 giga SFP ports,
- at least 12 RJ45 10 / 100BaseT (x) ports
- compatibility with existing equipment (VRRP, Turbo Ring V2 and Turbo Chain)
- management via http
- SNMP support v1,2,2c, 3,
- redundant-ring operation, reconfiguration in less than 1 s,
- IGMP and GMRP support for multicast traffic filtering,
- VLAN support for individual ports (at least 8), IEEE 802.1Q for backbone,
- QoS, TOS, bandwidth reservation, at least 4 priority types,
- IPv6 support (for the future),
- port trunking,
- port mirroring (allows analyzer connection),
- possibility of relay input and output,
- reporting alarms via digital signals and e-mail,
- redundant power supply (two independent 230VAC power supplies),
- compact industrial design - with mounting in a 19 inch frame,
- MTBF (declared): at least 300,000 hours.

4.1.3 Firewall of the control system

The installation of firewalls is envisaged for connecting the control system to the backbone network, connecting to third systems, time synchronization and filtering of network traffic.

Technical requirements for control system firewall hardware:

- industrial computer without moving parts
- processor: Onboard Intel® ATOM N270 1.6GHz
- circuit set: Intel 945GSE + ICH7M
- memory type: DDR2 2G 400/533 MHz, non-ECC
- hard drive: 512GB SSD
- hard disk controller: Serial ATA x 1, CompactFlash x 1
- network card: 6 x GbE ports Intel controller 4x 82574L LAN, 2x Intel 82541PI
- I / O & port: 1x Console RJ45, 2x USB 2.0 USB

- operating temperature: -20ºC ~ + 70ºC

4.2 LOCAL ETHERNET NETWORK OF THE CONTROL SYSTEM

The control system is built distributed and consists of several local stations that are interconnected via an Ethernet network. The Ethernet network must be reliable and efficient. Therefore, the network will be separated into a local tunnel network and a backbonel network. Where the networks merge, network segmentation at layer 3 of the ISO / OSI model will be ensured.

All switches are connected in a ring topology. In case of failure of one optical connection or. active device, the system must start operating using a redundant connection in less than 50ms.

4.2.1 Network topology

The local Ethernet network of the control system terminates on backbone switches. For the local Ethernet network of the control system industrial switches L2 are envisaged.

All network switches will form a ring topology. In case of failure of one optical connection or. active network equipment, the system must be established over a redundant connection in less than 50ms. An appropriate protocol (such as: Moxa turbo ring) is envisaged to perform redundancy inside the tunnel. Every outage or fault must be signaled appropriately on the SCADA.

All network equipment should use single mode SFP modules for single-fiber communication in WDM technology. Active network equipment must have a device earthing connection.

4.2.2 Control system local network switch

The tunnel part of the network is built with managed industrial network switches (layer2).

L2 switch (such as. MOXA EDS 508A.):

- 6 RJ45 10 / 100BaseT (x) ports
- at least 2 single mode optical ports,
- RJ45 console port,
- compact design - DIN rail mounting,
- management via HTTPS or SSH
- SNMP support v1, v2c, v3,
- support for Telnet management protocol
- Syslog,
- TFTP to load the configuration,
- DHCP Option 82,
- DHCP Server / Client,
- IPv6
- NTP, IEEE 1588 PTP V2 clock synchronization,
- MIB-II, RMON MIB Group 1, 2, 3, 9,
- IEEE 802.3x flow control, back pressure flow control,
- Port Lock function to lock the port to a specific MAC address,

- 8K MAC addresses,
- STP (spanning-tree protocol) support,
- redundant-ring operation, reconfiguration in less than 20ms,
- IGMP and GMRP support for multicast traffic filtering,
- Bradcast Storm protection,
- VLAN support (at least 8) for individual ports, IEEE 802.1Q for backbone,
- QoS, TOS, bandwidth reservation, at least 4 priority types,
- port trunking,
- port mirroring (allows analyzer connection),
- reporting alarms via digital signals and e-mail,
- redundant power supply (industry standard is 24V),
- Packet buffer at least 1Mbit,
- history of events that must be sent to the syslog server,
- MTBF (declared): at least 300,000 hours.
- Operating temperature range: -20 .. + 70 ° C and humidity up to 95%.

5. SERVER SYSTEM OF THE CONTROL SYSTEM

A modern server system is envisaged, which must consist of a server cluster of three independent servers. The servers must be delivered in a 19" version with a low built-in 1U height and installed in a 19" server cabinet in the system rooms of the portal buildings North and South, completely ready for operation, installed, configured and tested.

All tunnel safety systems must operate on a single time base, which must be synchronized with the time base of all other devices in the control center (emergency call, radio system, video, etc.). For this purpose, it is necessary to include in the server all the necessary equipment to meet these requirements.

5.1 DATA PERIPHERAL EQUIPMENT MASTER CONCENTRATOR

A peripheral data master concentrator (MC) is a device that communicates in two directions with the central part of the control system on one hand, and with the peripheral equipment on the other hand. As an interface, the concentrator collects, processes and stores data for a short time and transmits them to the central part of the system. In the opposite direction, it receives commands from the SCADA application and forwards them to peripherals.

In addition to the functions described above, MC combines or. takes care of communication connections between different systems (video, radio system, sound system, emergency call or all installed subsystems). This connection is crucial for system tunnel management and allows to automatically transfer information between the control system and other systems.

In addition to the requirements described above, the MC is also a link between the SCADA and the lower level of local stations and equipment installed in the tunnel.

5.2 VIRTUAL SERVER ENVIRONMENT

The virtualization of the server environment is performed on the basis of the so-called highly accessible active computer cluster "High Availability Cluster" hereinafter (HA Cluster).

The solution envisages physically three servers on both sides of the tunnel, which are connected to each other in a computer cluster.

The primary servers form the main core of the HA Cluster. The designed solution must ensure synchronization of processes and data between the two primary servers in real time. An open source software platform (such as Proxmox) is provided for this purpose. The system must provide transitions of individual virtual servers from one primary server (node) to another in real time (eg: for hardware maintenance time on one of the nodes). Transitions must be made in the range of a few milliseconds. This will ensure that the end user (operator in the control center) will not detect that the entire operating system with all processes has moved to another server.

The third server is important because it must play a key role in voting on the availability status of servers (nodes) in the HA cluster. The third server must also take on the role of archiving server of the primary server nodes in the system.

The system must also enable the so-called passive cluster mode, in which it is necessary to manually start the migration of virtual servers. In time, processes must run just as fast, only without automation.

The synchronization network connection must be made via Ethernet bonding with three gigabit network cards directly between the primary servers without an Ethernet switch. The connection is expected to reach min. speed 300MB / s. The synchronization data network connection must be made separately from the process network.

Technical requirements for server hardware (MC)

Intel 19 "Server 1U Height Installation - Basic (equivalent to “HP Proliant DL360 Gen10”)

- Processor: 1x Intel Xeon Silver 4110, 2.10GHz / 8-core / 20MB
- Memory: HPE 32GB (2 x HPE 16GB 2Rx8 PC4-2666V-R Smart Kit)
- Hard drive: 2 x HPE 240GB SATA RI SFF SC DS SSD, 2 x HPE 1.92TB SATA RI SFF SC DS SSD
- Disk controller: HPE Smart Array P408i-a / 2GB SR Gen10 Ctrlr (RAID 0/1/1 + 0/5/5 + 0/6/6 + 0)
- possibility to install a total of 8 disks with additional extensions
- Network connections: HPE 1Gb Ethernet 4-Port 331i Adapter + HP Ethernet 1Gb 4-port 366FLR Adapter
- Built-in support for error notification via e-mail, SNMP trap
- Built-in support for remote console management independent of the installed OS via HP iLO IP network Advanced incl 1yr TS U E-LTU
- Built-in support for mapping the local CD and floppy drive of the control station to the server over an IP network
- Built-in support for remote server start-up and shutdown independently of the OS over an IP network
- Hot plug redundant fans
- 2 x Hot-Plug redundant power supply 2x 500W HPE FlexSlot
- 1U high rack housing with accessories for installation in a rack cabinet
- 5 year warranty (5-5-5) (all parts-replacement-at the customer)

6. VIDEO SURVEILLANCE SYSTEM

The video surveillance system is intended for constant visual observation of traffic events in the area of the tunnel, in the cross passages and in the portal areas.

The number of cameras must be sufficient to ensure visible coverage of both lanes along the entire length of the main tunnel tube, portal areas, cross passages, emergency call niche and emergency call stations. The number of cameras must also be appropriate to the requirements of key manufacturers of automatic incident detection system.

The installation of cameras must provide visual coverage of all controlled areas. In the areas in front of the portals, the cameras are mounted on suitably rigid hot-dip galvanized poles. In the tunnel tubes themselves, the cameras are mounted above the walkway on the left side of the main tube.

The installed software of the video surveillance system must also enable automatic control of PTZ cameras when receiving an alarm from the surveillance control system (eg. emergency call niche or cross passage door opening, fire alarm activation,…), the camera must rotate automatically, that the field of view will be facing in the direction of the location in question.

All cameras are digital (so-called IP cameras). The cameras to be mounted inside the tunnel must be installed in robust V4A stainless steel housings. Also all fasteners (screws, washers, nuts, inserts) must be made of material V4A (W.Nr. 1.4571). All cameras must support the possibility of remote parameterisation and remote hard reset by switching off the power supply via PoE switches.

Digital cameras that support the IP protocol are provided for capturing images. In addition to the fixed cameras in the tunnel, which will be used for detection, the tunnel portals will also be monitored with fixed cameras.

Rotating IP cameras with a remote-controlled "zoom" lens (speed dome camera, PTZ camera) will be installed in all tunnel tubes to monitor the occupancy of lay-by niches, the interior of the cross passages as well the entrances of the cross passages.

The image will be transferred from the cameras to the nearest communication node (in emergency call niches, emergency call station cabinets or connection cabinets) via SFTP cables (hereinafter UTP). These cables are partially located in the open space of the tunnel, so the insulation of the cables must be without halogen (LSNH - Low Smoke - No Halogen). The fire resistance of the mentioned cables is not required because the powered element (camera) is not fire resistant either. UTP cables will be terminated at all nodes with appropriate RJ45 sockets.

Industrial Ethernet switches will be installed at the nodes, which will be used to transmit video streams, and to power cameras (PoE ++). These switches will also be used to remotely reset the cameras as needed.

The local video Ethernet switches are connected to Backbone switches in portal buildings. The optical transmission network, including the associated patch panels, is included in the Optics section.

Video streams in H.265 format, intended for Automatic incident detection, will be connected to video traffic

detectors via RJ45 patch cables.

A system for continuous real-time camera recording will also be installed on both sides of the tunnel. History videos must be stored in the full video quality and speed provided by the camera, and must be stored in a RAID array for a period of at least 7 days.

Control and management will take place through common (integrated) workstations (for control system, video, automatic incident detection, radio, sound system, emergency call, fire alarm,…) in the control control center.

The display of individual cameras and alarm recording will take place automatically on the basis of algorithms built into the application, which will include the available switching criteria from the control system and automatic incident detection (fire, emergency call, niche entry, stopped vehicle, reverse driving, etc.).).

The video surveillance system consists of the following elements:

- Fixed color cameras in the tunnel
- Fixed thermal cameras in the tunnel
- PTZ color cameras in the tunnel
- PTZ color cameras in front of the tunnel
- Fixed color cameras in front of the tunnel
- Recorder
- Application software of video surveillance system on the common workstation

6.1 FIXED COLOR CAMERA IN THE TUNNEL

Fixed color cameras will be mounted along the entire length of the tunnel at a distance of about 80 m from each other.

Activation of video display from individual cameras and alarm recording should be performed automatically on the basis of certain switching criteria (fire, emergency call, opening of doors to niches, etc.) or manually at the command of the operator. It must also be possible to sequentially display cameras along the entire length of the tunnel.

The cameras in question must meet at least the following minimum technical requirements:

- Sensor: progressive scan CMOS, size 1/3 "or larger
- Light sensitivity: Color 0.13 lux; B / W 0.03 lux or better
- Support for the ONVIF standard
- Video compression: H.264, H265 and Motion JPEG
- Cameras must provide at least three simultaneous independent video streams at full image speed and full resolution
- Resolution min. 1920x1080
- Day / night function with automatic automatic switching of the IR filter
- Image speed: 25 fps (at Full HD)
- Two-way audio input / output

- compression G.711 / G.726 / AAC / LPCM
- 100 Mb Ethernet network compatibility and support for IPv4, IPv6 USGv6, HTTP, HTTPSa, HTTP / 2, SSL / TLSa, QoS Layer 3 DiffServ, FTP, CIFS / SMB, SMTP, Bonjour, UPnP ™, SNMP v1 / v2c / protocols (MIB-II), ONVIF, DNS, DynDNS, NTP, RTSP, RTP, SRTP, SFTP, TCP, UDP, IGMP, RTCP, ICMP, DHCPv4 / v6, ARP, SOCKS, SSH, LLDP, MQTT, SyslogVarnost HTTPS, IP filter, IEEE 802.1x
- Operating temperature range -10 to + 55 ° C
- The camera must allow "multicast streaming" (RTSP, RTP, UDP-multicast)
- System integration: open integration API
- It should be possible to install software and plug-ins with additional functionalities from at least 15 different manufacturers on the camera
- The camera must provide adequate security protection against cyber attack, support for signed firmware (camera operation only with the manufacturer's signed firmware) and secure boot (a secure boot system that ensures that the camera starts only with the allowed firmware)
- The camera manufacturer must provide authorized camera service outside the warranty period

Type like or equivalent Axis P1375.

6.2 FIXED COLOR CAMERA IN THE TUNNEL HOUSING

The camera housings in question must meet at least the following minimum technical requirements:

- material INOX V4A (W.Nr. 1.4571)
- IP65 housing protection
- housing tilt options 30 ° vertically, 360 ° horizontally
- possibility to replace the camera without moving the position
- housing seal and glass seal durable up to 170 ° C
- protective glass with anti-reflective coating
- movable camera stand for all types of cameras
- camera base mounted on shock absorbers
- the housing contains an anti-fog heater
- the housing includes a bracket for ceiling mounting made of the same stainless steel material

6.3 FIXED THERMAL CAMERA IN THE TUNNEL

At the location of the first and last fixed color camera in the tunnel, one additional thermal camera is installed, with a built-in AID function. With the help of a thermal camera, the number of false alarms in the AID system is reduced due to the appearance of shadows, wheels in the event of a wet road and other external weather and light influences.

The cameras in question must meet at least the following minimum technical requirements:

- Stainless steel housing V4A
- IP protection: IP66, IP67
- 640x512 resolution
- Wavelength 7.5 - 13.5 µm

- Integrated heater with lens anti-icing function
- Video stream MPEG-4 and H.264
- Multicast way to stream video streams
- PoE + and 12-38 VDC power supply
- Integrated video detection function

Type e.g. or equivalent Thermibot2,

6.4 PTZ COLOR CAMERA IN THE TUNNEL

PTZ IP cameras with remote control will cover the entrance to the cross passage.

- Stainless steel housing V4A with the following level of protection: IP66, NEMA 4X and IK10
- Resolution min. 1920x1080
- Optical zoom at least 32x
- Sensor: progressive scan CMOS, size 1 / 2.8 "or larger
- Day / night function with automatic automatic switching of the IR filter
- Light sensitivity: Color 0.15 lux (at 50 IRE F1.6); B / W 0.003 lux (at 50 IRE F1.6) or better
- Lens with a horizontal viewing angle of at least 2 ° - 65 ° or better
- Changed focal lengths and focus via remote access
- Image speed: 25 fps (at Full HD)
- Aperture speed: auto-iris aperture, electronic aperture setting to minimum
- ranging between 1/33000 s and 1 / 3s or better
- Camera settings: WDR 120dB, compression, color, brightness, sharpness, contrast, white balance, shutter setting, private zones, image defogging
- Rotation speed - pan: at least 450 ° / s
- Rotation speed - tilt: at least 450 ° / s
- Support for the ONVIF standard
- Protocol support: HTTP, HTTPS, SSL / TLS, FTP, UDP, TCP, RTSP, SRTP, RTP, IGMP
- Video compression: H.264 and Motion JPEG
- Cameras must provide at least three simultaneous independent video streams at full image speed and full resolution
- The camera must allow advanced settings to reduce data flow by an average of at least 50% by optimizing data flow without losing quality
- PoE power supply (High PoE)
- Power consumption: max 65 W
- Operating temperature range -20 to + 50 ° C
- The camera must allow "multicast streaming" (RTSP, RTP, UDP-multicast)
- System integration: open integration API
- It should be possible to install software and plug-ins with additional functionalities from at least 15 different manufacturers on the camera
- The camera manufacturer must provide LTS (Long-Term Supported) firmware that contains only fixes for critical errors, security vulnerabilities, and performance troubleshooting.

- The camera must provide adequate security protection against cyber attack, support for signed firmware (camera operation only with the manufacturer's signed firmware) and secure boot (a secure boot system that ensures that the camera starts only with the allowed firmware)
- The camera manufacturer must provide authorized service outside the warranty period

Type e.g. or equivalent Axis Q6075-E in stainless steel housing:

6.5 PTZ COLOR CAMERA IN CROSS PASSAGE

PTZ IP cameras with remote control will cover the inside of the cross passages.

- Aluminum housing with the following level of protection: IP66, IP67, NEMA 4X and IK10
- Resolution min. 1920x1080
- Optical zoom at least 32x
- It must support local recording to SD card.
- Sensor: progressive scan CMOS, size 1 / 2.8 "or larger
- Day / night function with automatic automatic switching of the IR filter
- Light sensitivity: Color 0.15 lux (at 50 IRE F1.6); B / W 0.003 lux (at 50 IRE F1.6) or better
- Lens with a horizontal viewing angle of at least 2 ° - 65 ° or better
- Changed focal lengths and focus via remote access
- Image speed: 25 fps (at Full HD)
- Aperture speed: auto-iris aperture, electronic aperture setting to minimum
- ranging between 1/33000 s and 1 / 3s or better
- Camera settings: WDR 120dB, compression, color, brightness, sharpness, contrast, white balance, shutter setting, private zones, image defogging
- Rotation speed - pan: at least 450 ° / s
- Rotation speed - tilt: at least 450 ° / s
- Support for the ONVIF standard
- Protocol support: HTTP, HTTPS, SSL / TLS, FTP, UDP, TCP, RTSP, SRTP, RTP, IGMP
- Video compression: H.264 and Motion JPEG
- Cameras must provide at least three simultaneous independent video streams at full image speed and full resolution
- The camera must allow advanced settings to reduce data flow by an average of at least 50% by optimizing data flow without losing quality
- PoE power supply (High PoE)
- Power consumption: max 65 W
- Operating temperature range -20 to + 50 ° C
- The camera must allow "multicast streaming" (RTSP, RTP, UDP-multicast)
- System integration: open integration API
- It should be possible to install software and plug-ins with additional functionalities from at least 15 different manufacturers on the camera
- The camera manufacturer must provide LTS (Long-Term Supported) firmware that contains only fixes for critical errors, security vulnerabilities, and performance troubleshooting.

- The camera must provide adequate security protection against cyber attack, support for signed firmware (camera operation only with the manufacturer's signed firmware) and secure boot (a secure boot system that ensures that the camera starts only with the allowed firmware)
- The camera manufacturer must provide authorized camera service outside the warranty period

Type e.g. or equivalent Axis Q6075-E

6.6 FIXED COLOR CAMERA AT THE PORTAL

In addition to tunnel fixed cameras, color fixed cameras will also be mounted on both tunnel portals, namely one video surveillance camera on each side.

- Aluminum housing with the following level of protection: IP66, IP67, NEMA 4X and IK10
- Built-in IR illumination with automatic adjustment
- Built-in electronic stabilization of EIS
- resolution: 3072x1728
- aperture: auto-iris, setting in the range between 1 / 100000s
- operating temperature range: -40 to + 60 ° C
- with automatic day / night IR filter switching
- light sensitivity: Color: 0.24 lux (at 50 IRE F1.5); B / W: 0.04 lux (at 50 IRE F1.5) or better
- settings: WDR, compression, color, brightness, sharpness, contrast, whiteness, private zones, defogging
- support for the ONVIF standard
- compression: H.264 and Motion JPEG
- Cameras must provide at least three simultaneous independent video streams at full image speed and full resolution
- settings to reduce data flow by an average of 50% by optimizing data flow without losing quality
- PoE power supply (High PoE midspan 1 – port: 100–240 V AC, max 1.35 A)
- max power: 25.5 W
- possibility of multicast streaming (RTSP, RTP, UDP-multicast)
- connectivity support: open integration API
- -possibility to install software and plug-ins with additional functionalities from at least 10 different manufacturers
- Manufacturer Support: LTS (Long-Term Supported) firmware that includes fixes for critical bugs, security vulnerabilities, and performance troubleshooting.
- cyber attack security, signed firmware support (camera operation only with manufacturer-signed firmware, and secure boot only with allowed firmware)
- The camera manufacturer must provide authorized camera service outside the warranty period
- compliance with standards:
- EMC EN 55032 Class A, EN 61000-3-2, EN 61000-3-3, EN 61000-6-1, EN 61000-6-2, EN 55024, FCC Part 15 Subpart B Class A, ICES-003 Class A , VCCI Class A, RCM AS / NZS CISPR 32 Class A, KCC KN32 Class A, KN35
- Safety IEC / EN / UL 60950-1, IEC / EN / UL 60950-22

- Environment EN 50121-4, IEC 62236-4, IEC 60068-2-1, IEC 60068-2-2, IEC 60068-2-6, IEC 60068-2-14, IEC 60068-2-27, NEMA 250 Type 4X IEC / EN 60529 IP66, IP67, IP6K9K, NEMA 250 Type 6P, MIL-STD 810G 509.5
- Network NIST SP500-267
- Support for HTTP, HTTPS, SSL / TLS, FTP, UDP, TCP, RTSP, SRTP, RTP, IGMP protocols

Type e.g. or equivalent Axis Q1647-LE

6.7 PTZ COLOR CAMERA AT THE PORTAL

Rotating IP cameras with remote control and built-in IR illumination will cover the area in front of both portals of the tunnel tubes. The camera should be powered and connected to the local video network via equipment mounted in the connection terminal box on the pole. In order to be able to visually monitor what is happening even at night, these cameras must be equipped with IR illumination of greater range.

- resolution: 1920x1080
- optical zoom: 30x
- speed: 50 fps (at Full HD)
- aperture: auto-iris, setting between 1 / 30000s and 1 / 6s
- metal housing with a degree of protection equivalent to IP67 or NEMA 4X
- operating temperature range: -30 to + 50 ° C
- built-in IR lighting with automatic adjustment to lighting conditions and a range of at least 400m
- built-in wiper to remove water droplets or snow
- sensor: progressive scan CMOS, size 1 / 1.9 "or larger
- with automatic day / night IR filter switching
- light sensitivity: Color: 0.1 lux (at 50 IRE F1.6); B / W: 0.01 lux (at 50 IRE F1.6) better
- viewing angle horizontally: from 4 ° to 58 °
- remotely changing focus
- settings: WDR, compression, color, brightness, sharpness, contrast, whiteness, private zones, defogging
- pan rotation speed: 150 ° / s
- tilt rotation speed: 150 ° / s
- support for the ONVIF standard
- compression: H.264 and Motion JPEG
- Cameras must provide at least three simultaneous independent video streams at full image speed and full resolution
- settings to reduce data flow by an average of 50% by optimizing data flow without losing quality
- PoE power supply (High PoE midspan 1 – port: 100–240 V AC, max 1.35 A)
- max power: 75 W
- possible service extraction from the base (plug-play)
- possibility of multicast streaming (RTSP, RTP, UDP-multicast)
- connectivity support: open integration API
- possibility to install software and plug-ins with additional functionalities from at least 10 different manufacturers

- Manufacturer Support: LTS (Long-Term Supported) firmware that includes fixes for critical bugs, security vulnerabilities, and performance troubleshooting.
- cyber attack security, signed firmware support (camera operation only with manufacturer-signed firmware, and secure boot only with allowed firmware)
- The camera manufacturer must provide authorized camera service outside the warranty period
- compliance with standards:
- EMC EN 55032 Class A, EN 61000-3-2, EN 61000-3-3, EN 61000-6-1, EN 61000-6-2, EN 55024, FCC Part 15 Subpart B Class A, ICES-003 Class A , VCCI Class A, RCM AS / NZS CISPR 32 Class A, KCC KN32 Class A, KN35
- Safety IEC / EN / UL 60950-1, IEC / EN / UL 60950-22
- Environment EN 50121-4, IEC 62236-4, IEC 60068-2-1, IEC 60068-2-2, IEC 60068-2-6, IEC 60068-2-14, IEC 60068-2-27, NEMA 250 Type 4X IEC / EN 60529 IP66, IP67, IP6K9K, NEMA 250 Type 6P, MIL-STD 810G 509.5
- Network NIST SP500-267
- Support for HTTP, HTTPS, SSL / TLS, FTP, UDP, TCP, RTSP, SRTP, RTP, IGMP protocols

Type e.g. or equivalent Axis Q6215-LE.

6.8 DIGITAL VIDEO RECORDER

For the needs of a more detailed analysis of alarm events retrospectively, appropriate recording devices are also a necessary and obligatory part. The operation of the recorders must be based on digital technology, and the recording of the history must be provided in full quality (FullHD resolution, 25 frames / s) for a period of 7 days. As part of the basic functionality, it must be possible to filter eligible users with the right to access saved recordings. The detection, recording and traceability of user activities in terms of viewing or exporting archived recordings must also be supported.

The video recorder must provide at least the following functionality:

- It must ensure the appropriate quality and speed of capturing video images, but it must not limit or in any way reduce the transfer of individual images to the control center..
- Live video images must still be available in the control center in the event of a failure of the recording equipment (video streams must be controlled on separate devices from the recorder).
- Viewing video history should be enabled via a graphical User Interface (GUI) for tunnel operated workstations in control centers. Also, the workstation should report a failure or. disk failure, RAID array errors, and errors
- recording video history.
- Watch Dog function which allows you to reset and restart the system in case of shutdown or malfunction.
- Protect images from manipulation and control the authenticity of images.
- Video archive access control and user management.
- License for full access to the recorder.
- It must support the possibility of simultaneous access by at least 10 clients.
- Export images and any length of video archive at any time for multiple cameras simultaneously.

- Possible export to normal removable media (AVI / MP4 format). The exported recording must also contain information on the date and time of creation.
- Recorders should allow you to export videos in a format that can be played with the most common video players such as VLC Media Player or Windows Media Player.

The video recorder must also control the right of access to videos:

- If the archive of videos is of the file type (video streams from cameras are written to disks in the form of files), the following requirements must be met:
- network access to all recordings in the archive must be enabled - known username and password,
- known video length (eg 1, 5, 10 minute videos),
- the name of the recording file (eg "\ yyyyMMddHHmmss-KameraID.avi") where the name should contain the real start time of the recording,
- videos must be encoded with a video codec that is supported in the most common video players, such as VLC Media Player or Windows Media Player.
- the following file formats can be used: asf, avi, wmv,
- Prior to the installation of the video recorders, the contractor must provide the client with detailed documentation with detailed instructions for accessing and reviewing the video history on the recorder.

If the video archive is not of the file type or does not meet the above requirements (eg video archive on recorders where the recordings are stored in its own database and cannot be played with the most common video players), the contractor must, before installing video recorders , hand over an ActiveX component or software module to the client free of charge, which enables the review of video history and can be included in the .Net environment. Documentation for the implementation of the ActiveX component or software module in third-party systems must also be attached.

The hardware platform for the video recorder must meet at least the following minimum technical requirements:

- Server housing with pull-out guides for installation in the RVN cabinet
- Intel® Xeon® Processor E5-2620 v3 2.40 GHz
- 16GB DDR4 working memory
- System drive 3x SSD 500GB, hot-swappable, RAID1 + hot-spare drive
- Archive disk array 16TB, hot-swappable, RAID10 + hot-spare drive
- 4x 1GbE RJ-45 network interface (1000 Base-T)
- Power supply 2x Hot-Plug redundant power supply
- Remote control and management of iDRAC8, iLO or a comparable other solution
- MS Windows 10 Pro 64bit or MS Windows Server 2019 Standard or later
- Virtualization of Microsoft Hyper-V Server 2019
- The platform must be a product of a world - renowned manufacturer (such as HP, Dell or IBM

6.9 OTHER VIDEO EQUIPMENT

6.9.1 Signal cables

UTP-type signal cables terminated with RJ45 connectors are used to connect cameras to Ethernet switches. The length of each line must be shorter than 90 m, depending on the location of each camera. The cables should be category 6 in the version, protected with shield (S) and foil (F). According to the fire requirements in the tunnel pipe, UTP cables must have a sheath of low smoke (LS) without halogen (ZH) material.

UTP network cable specifications:

- FTP type
- Connector type 2x RJ45
- Category 6
- Halogen-free wrapper (LSZH)

6.9.2 UTP patch cables

UTP patch cables are used to connect devices to Ethernet switches. The appropriate length is provided depending on the layout of the equipment.

Patch cable specifications:

- UTP type
- Connector type 2x RJ45
- Category 6
- Color green

6.9.3 Surge protection

To protect cameras, network and other video equipment from overvoltage disturbances as a result of atmospheric discharges or disturbances originating from the power supply network or UPS power supply, it is necessary to install surge protection in appropriate places.

Surge protection requirements:

- suitable for Cat 5e (up to 100 MHz) and Cat 6e (up to 250 MHz)
- data transfer rate up to 1Gbps
- protection level 10kV, 5kA into the ground at 8/20 µs
- protection response time <1 ns
- RJ45 connector, metal clad, all 4 pairs protected
- suitable for PoE + IEEE 802.3at
- operating temperature range: -30℃ to + 60℃

6.9.4 Tunnel optical cabling

The configuration of connections from nodes where L2 switches are installed to equipment in portal

buildings will take place in two separate tunnel optical cables. The optical transmission network, including the associated splitters, is included in the Optics section.

6.9.5 Local optical cables

FO wiring is provided for external cameras planned in the area of both portals. The optical wiring of the video surveillance system will be used to transfer images and data from external cameras to nodes.

Optical cable specifications for cameras:

- 12 SM 9/125 micron optical fibers
- Halogen-free wrapper (LSZH)
- Standard G.652
- Attenuation at a wavelength of 1310nm up to 0.38dB / km
- Attenuation at a wavelength of 1550nm up to 0.25dB / km
- Dispersion at 1310nm 3.5 and at 1550nm 18
- Temperature range -30 ° C to + 70 ° C

6.9.6 Optical patch panels

An optical patch panel with 12 LC connectors should be provided in the connection cabinets of all external cameras. In the associated nodes, the fibers of the external cameras will also terminate on an optical patch panel with 12 LC connectors.

6.9.7 Optical patch cables

Optical patch cable specifications:

- Type SM 9/125 micron
- Standard G.652
- Halogen-free
- The connector is determined by the optical splitter and the device

6.9.8 Camera connection cabinet

Connection cabinets are foreseen for the installation of video Ethernet switches and power supplies for portal cameras. Cabinets will be mounted on camera poles.

The cabinet must contain the following elements:

- DIN rails
- fuses
- surge protection elements
- service socket
- optical patch panel (can be also just pigtail and attach to a DIN rail)
- heater with thermostat

6.9.9 Camera poles

For outdoor cameras on the tunnel portals, hot-dip galvanized poles are foreseen, with a minimum height of 8 m, on which a connection cabinet box can be installed. An appropriately dimensioned foundation must also be provided. The pole must be attached to the foundation via suitable flanges. At the point of attachment of the camera, the column must provide an oscillation of less than 0.5 ° at maximum gusts of wind at the location.

7. AUTOMATIC INCIDENT DETECTION SYSTEM (AID)

The automatic incident detection system is designed to detect incident traffic situations. The system is based on the analysis of images from video surveillance cameras.

The AID system consists of the following elements:

- Video detectors
- AID server
- AID application software on a common workstation

7.1 VIDEO DETECTORS

Video detection processors are provided in both portal buildings. The processor, with the help of digital analysis of an individual image and embedded system software, enables the detection of various traffic events and traffic data for each lane separately. The video detection processors will be connected to a local video Ethernet network, from where they will receive digital encoded video signals from the cameras.

The video detection processor must be able to display alarm type information on live video, and the detected object must be location-marked. In this way, the operator will be able to quickly understand the type and location of the detected event via a live video image on the alarm part of the wall display and react accordingly.

Video detectors are provided for processing IP HD signals. The design of the detectors should be modular for installation in a 19 "rack housing, which also contains a pull-out power supply. One separate single-channel detector with a built-in RJ45 socket for connection to an Ethernet switch should be installed for each detection camera.

Traffic incident detection requirements:

- stopped vehicle detection
- (The time from stopping to successful detection of the vehicle must not be longer than 12 s, the reliability of detection must be at least 98%, and the number of false alarms in 24 hours must not exceed 0.19 alarms / camera)
- detection of driving in the wrong direction (overtaking, driving in the opposite lane)
- (The time from reverse driving to successful detection of the vehicle must not be longer than 10 s, the reliability of detection must be at least 95%, and the number of false alarms in 24 hours must not exceed 0.05 alarms / camera)
- detection of slow driving vehicles (too low speed)
- (The time from slow driving to successful detection of the vehicle must not be longer than 10 s, the reliability of detection must be at least 90%, and the number of false alarms in 24 hours must not exceed 0.15 alarms / camera)
- pedestrian detection

- (The time to successful detection of a pedestrian must not exceed 10s, the reliability of detection must be at least 80%, and the number of false alarms in 24 hours must not exceed 0.25 alarms / camera)
- smoke detection
- (The time to successful smoke detection is estimated from 30s to 90s - depending on the case, the detection reliability must be at least 99%, and the number of false alarms in 24 hours must not exceed 0.05 alarms / camera)

Traffic and other data detection requirements:

- average volume of vehicles, divided into passenger cars and lorries
- average speed
- total traffic flow (number of vehicles)
- classification of vehicles into at least three classes
- video signal failure
- poor video signal quality (eg due to dirty glass on the camera body)

7.2 AID SERVER

An AID server is a powerful server-type computer with duplicate computer components and a high level of operational reliability. It should run software adapted for operation in virtual environments, which enables communication with cameras, workstations and other devices in the system, and takes care of the production, storage and service of alarm recordings and images. Alarm messages from the control system are sent to the server via a TCP / IP alarm connection. The following alarms from the control system should be recorded in the alarm database:

- emergency call
- activation of SOS push button
- fire alarm
- opened door
- opened cross passage door

Minimum requirements for video detection server software:

- Communication interface for communication and management of video cameras.
- Communication interface for communication with workstations and other clients.
- Alarm communication and event service with a control system.
- Services for creating temporary video and image archives.
- Service for making alarm videos and pictures.
- An image and a 30s alarm recording must be made for each reported alarm (with 10s before the alarm recording).
- Database of all alarm events.
- Archive for videos and pictures of alarm events for a period of one year with the oldest events being automatically transcribed.
- Video image archive 1 image / second for 24 hours for a quick overview of the history of extraordinary events.

- All software must be adapted to run in virtual environments and the latest Windows server operating systems.
- The review of alarms and alarm recordings and their export should be enabled via the river-graphic SCADA interface for tunnel management at workstations in control centers. Also, the workstation should report a failure or. base and failure to produce alarm recordings.

The hardware platform for the AID server must meet at least the following minimum technical requirements:

- Server housing with extended guides for installation in 19Ъ closet
- Intel® Xeon® Processor E5-2620 v3 2.40 GHz
- 16GB DDR4 working memory
- System drive 3x SSD 500GB, hot-swappable, RAID1 + hot-spare drive
- Archive disk array 16TB, hot-swappable, RAID10 + hot-spare drive
- 4x 1GbE RJ-45 network interface (1000 Base-T)
- Power supply 2x Hot-Plug redundant power supply
- Remote control and management of iDRAC8, iLO or a comparable other solution
- MS Windows 10 Pro 64bit or MS Windows Server 2019 Standard or later
- Virtualization of Microsoft Hyper-V Server 2019
- The platform must be a product of a world-renowned manufacturer (such as HP, Dell or IBM)

8. MAIN CONTROL CENTER EQUIPMENT - NORTH

At the main control center, two equivalent work places are provided for remote monitoring and control of all tunnel systems. Each work place will be equipped with a workstation with three 4K monitors on which a graphical SCADA interface is installed, which must enable the management of all safety systems installed in the tunnel.

For secure login to the system, workstations should be equipped with a combined fingerprint reader and ID media.

For a better overview of what is happening in the tunnel, a wall display consisting of three 55 '' LCD displays will be installed. The upper half should be used for video display (alarms, sequence, live video), and the lower half along its entire length for schematic SCADA display of tunnel status.

A multifunction device should be installed in the control center for report printing and other administrative purposes.

8.1 SCADA INTERFACE

With a graphical SCADA interface, the operator is enabled to transparently manage all safety systems installed in the tunnel via one workstation with three monitors. This allows the operator easy and transparent access to all the essential functionalities of the systems he manages in his daily work.

The graphical SCADA interface must be designed so that the upper half of the monitors will be used to display video, and the lower half to display the control-command interface and alarm bar of all embedded systems. For easier and faster management of the video system (selection of the appropriate camera in the event of an alarm event), it must be possible to select the camera directly from the SCADA schematic representation of the tunnels. It must also be possible to view the history and alarm events, operate the wall-mounted display and access all other system functions, including administration.

Workstation software must be running on Windows 10 or later.

- General requirements for graphical SCADA interface:
- Unified tunnel management functions.
- It enables arbitrary assignment of facilities to an individual workplace, which enables arbitrary organization and division of labor.
- In the event of a failure of one workstation, management can be transferred to another.
- It enables control and management of tunnels and built-in signal safety equipment.
- Managed enabled through dynamic screen images and automatic pop-ups. Management via drop-down or tree menus are not allowed.
- Alarms from all systems are collected and processed in a uniform way, without duplication and the need to acknowledge the same alarm in several separate systems.
- It allows you to manage and confirm alarms from one place.
- Allows general confirmation of alarms: the alarm "confirmed" on one workstation is automatically confirmed on all other workstations.

- Allows you to control the display and arrangement of content on the wall display.
- Enabled any and easy expansion or. upgrade with new equipment and new features.
- The rendering of the screen images must be in vector format, which enables any magnification without losing the quality of the graphic display.
- The entire user interface must be in the Slovenian language.
- It is optimally adapted to the needs of operators.

Software requirements for the video part:

- Display a different number and arrangement of windows with live video and sequences, and save a large number of such settings.
- Uploading cameras to video fields (uploading cameras should be enabled from the map with cameras, the list of cameras in the taskbar or the NCS schematic of tunnels with "Drag Drop" strokes).
- Quick overview of alarm images or history of individual alarm events.
- Interface for quick history image review 1 image / second for the last 24 hours for all cameras.
- Setting the reporting of individual alarms for each zone separately.
- Display of camera status and reporting in case of failure.
- Reporting a failure or. server failures and automatic switching to a running server in the event of a failure of one of the servers.
- Support onvif, rtsp, multicast, rtp, http, rtmp protocols.
- Support for hardware decoding of video signals using DXVA-DirectX Video Acceleration and Intel® Quick Sync technology.
- Operated by rotating cameras via a computer keyboard.
- View and export alarm history and alarm recordings for different periods and synchronous view for multiple cameras simultaneously.
- Make arbitrarily long recordings from history and live video.
- Control over the export of recordings, protection against unauthorized access to recordings through the central registration system.
- Wall video player control interface.
- It must be possible to connect to other tunnel systems - alarm communication, alarm status display.
- Display of indication and reporting of connection failure with the control system.
- Reporting a failure or. disk, disk array, and redundant power failures on servers and recorders.

8.2 ALARM INTERFACE

Tunnel systems will be controlled via workstations from two locations. In order to avoid duplication of alarms and warnings, central acknowledgment must be enabled: The alarm "acknowledged" on one workstation is automatically acknowledged on all other workstations.

It is necessary to create a user interface for alarming and acknowledging alarms, which will enable the collection of alarms from all systems, the reporting of audible alerts with an alarm display and the central acknowledgment of active alarms. In this way, alarms will be collected and processed in a uniform way, which eliminates all duplication and the need to validate alarms in multiple subsystems.

The following alarm data must be reported to the operator for each alarm event:

- the time of the alarm event
- a general description of the alarm event
- alarm state - active / inactive (active / inactive state changes depending on the alarm state in the system from which it was reported)
- confirmation status: confirmed / unconfirmed (alarm confirmation can be done manually by one of the supervisors, alarm confirmed on one workstation means automatic confirmation of alarms on other workstations as well)

Each active alarm triggers an audible alert (the audible alert is only reported by the alarm and acknowledgment interface, on other interfaces (SCADA) the audible alert is basically turned off, but it must be possible to turn the audible alert on / off).

As long as an unconfirmed alarm is present on the interface, a recurring audible warning sounds. An audible warning only triggers an active alarm.

The status confirmed alarm is sent back to the device or system from which the alarm was received, and this device sends the confirmed alarm to other software interfaces for acknowledging alarms. Acknowledged alarm for the device also means automatic confirmation of states on the SCADA and in the system.

The interface must allow the creation of groups of signals with the possibility of setting various audible alerts. As a suggestion we give the group fire alarms, equipment outages, weather conditions…

The final list will be customized to the needs of operators for easier and more efficient management of the entire system.

If there is a video camera in the alarm area, the camera image is displayed in addition to the alarm. Reporting alarm states with an alarm status display and an audible warning and a graphical display of these on the graphical interface.

8.3 ALARM REPORTS INTERFACE

The interface must include the possibility to present all events in a tree drop-down menu that report the status of all equipment. The basic selection must allow the display of alarms, alerts, events, statuses and measurements.

Functions to be provided by the interface for review, production and export of traffic and alarm reports:

- tree drop-down display of devices with associated signals
- easy selection of the desired signal, right-click device
- selective keyword search
- separate display for alarms and alerts
- separate display of events
- overview of archived events in the system (reports)
- selection of time period for data capture and display (optional calendar)
- graphical display of measured values in the system (plotting graphs)
- supported export of events to Microsoft Excel format for further processing

8.4 OPERATOR LOG-IN

The operator must be able to centrally log-in to all applications on an individual workstation, which means that for this purpose it is necessary to create a software interface that will also enable this.

Functions to be enabled by the operator log-in interface:

- drop-down display of system users
- transparent login password entry - pop-up window
- automatic login using an RF ID card or use of fingerprint
- access levels (users, administrators)
- entering a new user and modifying an existing user
- passwords and leveling for each user
- printout of the currently logged in user
- automatic logout after an adjustable time interval in hours / minutes
- single database / users with automatic mapping to all workstations

For the purpose of automatic login using an RF ID card or. the use of a fingerprint provides a combined biometric fingerprint reader and ID media. The reader is installed on an individual workstation with a USB3.0 connection.

The operator will have at each workstation access to the following:

- control system
- video surveillance system

The operator will log in to his work environment with a central login, and credentials must be automatically transferred to all systems.

The user's rights to access to the control systems are limited to:

- control only,
- issuing commands,
- acknowledging alarms.

For the Video Surveillance System, the requirements must follow the General Data Protection Regulation - GDPR, which prescribes:

- traceability of watching a "live" image from video surveillance cameras (who has ever watched a live image),
- traceability of video surveillance footage,
- traceability of exporting recordings from video surveillance cameras to external media (eg USB key).

8.5 SYSTEM COMMUNICATION DEVICES MONITORING

The entire tunnel system will consist of a large number of system communication elements (network switches, firewalls, local stations, server equipment ...), which will form a whole with interconnections.

Depending on the size of the system, a central monitoring system will be provided to check the operation of all devices in the network. With such control, it will be much easier to detect and signal and eliminate possible equipment outages.

The graphical interface for displaying the built-in equipment is integrated into the tunnel control system SCADA as a stand-alone screen image. A schematic representation of the entire system must be provided. Graphic elements must be located in accordance with the layout of the equipment in the tunnel. This provides the operator with a basic overview of the operation of the system.

The data must be stored in the database - archive. This enables the analysis of network operation and the diagnosis of faults for maintenance purposes.

All devices need to be included in the SNMP performance data collection. The content of the diagnostics depends on the type of device. Devices must be able to support protocols: SNMPv2 or SNMPv3. In the event that the device is the final element of the network, it must at least enable a response to the demand (ping).

Hardware for the installation of SNMP manager software and applications for monitoring the availability of the device (ping) are provided.

Software requirements to be enabled by SNMP manager:

Periodic query of devices (SNMP agent), which must respond at least with the following information:

- Device location
- IP address
- device model
- firmware version
- uptime since last device start-up
- operation of all power supplies
- activity of each port
- traffic at individual ports

Receiving SNMP Trapo-in network devices, whereby the SNMP agent sends information to the SNMP manager (SNMP Trap) when an event occurs. The minimum set of events that an SNMP agent must send is as follows:

- Restart the device
- Link Up
- Link Down
- device authentication
- configuration change
- traffic at the port exceeds the limit.

SNMP Manager Hardware Requirements:

- Industrial computer without moving parts
- Operating system: Linux

- Processor: Onboard Intel® ATOM N270 1.6GHz
- Set of circuits: Intel 945GSE + ICH7M
- Memory type: DDR2 2G 400/533 MHz, non-ECC
- Hard drive: 128GB SSD
- Hard disk controller: Serial ATA x 1, CompactFlash x 1
- Network card: 6 x GbE ports Intel controller 4x 82574L LAN, 2x Intel 82541PI
- I / O & port: 1x Console RJ45, 2x USB 2.0 USB
- Operating temperature: -20ºC ~ + 70ºC

8.6 WORKSTATION HARDWARE

The tunnel control system workstation must be a responsive and powerful computer system so that the user interface will operate continuously and smoothly, even under heavy loads. All workstations must be equipped with a 32 '' IPS LCD monitor with 4K resolution. A speaker is also installed on the monitor of each workstation.

Minimum workstation hardware requirements:

- 9th Generation Intel® Core Processor i7-9700K Processor (12M Cache, up to 4.90 GHz), Intel® HD Graphics 630 or better
- 32GB DDR4 working memory
- System disk M.2 SSD with a capacity of at least 500GB
- Storage space for important data of at least 4TB
- 2x powerful graphics card like e.g. nVidia GeForce RTX 2080
- 2x 1GbE RJ-45 (1000 Base-T)
- Operating system Windows 10 Professional, 64 Bit, Albanian language
- World-renowned computer (such as HP or IBM)

Technical requirements 32 '' IPS LCD Monitor (such as: "HP Z32 Monitor"):

- IPS 32 '' screen
- Resolution: 3840 x 2160 @ 60Hz; UHD (16: 9)
- Luminance: 350 nits (cd / m2)
- Viewing angle: 178 ° horizontal / 178 ° vertical
- Response time: 14 ms
- Connections: 1x DP 1.2, 1x Mini DP 1.2, 1x HDMI 2.0, 1x USB-C
- Bottom-mounted speaker, USB power, stereo audio input (such as the HP LCD Speaker Bar)

Keyboard and mouse

Low-power wireless mouse and keyboard kit for long battery life, comfortable palm rest, ergonomic mouse with Hyper scroll wheel and additional forward / reverse buttons. Wireless operation at 2.4GHz via a single USB receiver up to a distance of 10 meters (such as the "Logitech MK710").

Keyboard technical requirements:

- wireless connection up to 10 meters at a frequency of 2.4GHz via USB,
- low power consumption for long battery life (from 2-3 years),
- keys with a rounded edge,
- comfortable palm rest,
- multimedia keys,
- Albanian characters.

Mouse technical requirements:

- wireless connection up to 10 meters at a frequency of 2.4GHz via USB,
- low power consumption for long battery life (from 2-3 years),
- 1000dpi laser sensitivity sensor,
- forward / reverse keys,
- 4-way Hyper scroll wheel,
- ergonomic shape.

8.7 VIDEO WALL DISPLAY

The hardwre platform for the wall display must meet at least the following minimum technical requirements:

- size 55 ''
- 4K resolution 3840x2160px
- professional LCD monitor suitable for 24/7 operation (not LCD TV)
- at least 1x computer video input (HDMI or DisplayPort)
- viewing angle 178 degrees (vertical and horizontal)
- panel light 700 cd / m2
- the maximum edge of the housing is 15 mm

Video cable connection requirements:

- Hybrid optical HDMI cable 30m long
- Resolution support up to 4K at 50 / 60Hz
- Data transfer speeds up to 18 Gbps
- Metal housing
- Double shielded cable

Wall bracket requirements:

- Screen size: 55 ''
- Load capacity: up to 35 kg
- WEIGHT: 200 x 200 to 400 x 400
- Vertical tilt: -12 ° ~ + 5 °
- Horizontal tilt: -90 ° ~ + 90 °
- Distance from the wall: 60mm - 500mm

8.8 VIDEO WALL GRAPHIC CONTROLLER

The hardware platform for the video wall graphics controller must meet at least the following minimum technical requirements:

- 9th Generation Intel® Core ™ i7-9700T vPro Processor (12M Cache, up to 4.30 GHz), Intel® HD Graphics 630
- 8GB DDR4 working memory
- System disk M.2 SSD 256GB
- Network interface 1x 1GbE RJ-45 (1000 Base-T)
- AMD Radeon kartica RX 560 4GB GDDR5 graphics card
- Ports at least 2x USB 3.0, at least 2x DisplayPort (can also be 2x DVI or 2x HDMI or a combination of the listed ports)
- Microsoft Windows 10 Pro 64bit operating system

9. EQUIPMENT OF THE RESERVE CONTROL CENTER - SOUTH

One workstation with three 4K monitors is installed in the reserve control center in the portal building South. A graphical SCADA interface should be installed on the workstation, which should enable the management of all safety systems of the tunnel.

To securely log in to the system, the workstation is equipped with a combined fingerprint reader and ID media.

For a better overview of the situation in the tunnel, a 55 '' LCD wall display is mounted on the wall, which should be used to display video (alarms, sequence, live video).

9.1 WORKSTATION

A workstation and software of the same specifications as in the main control center shall be used.

9.2 VIDEO WALL DISPLAY

The video wall display in the backup control center should consist of one 55 '' professional 24/7 LCD monitor with 4K resolution. It should be used to display video (alarms, sequence, live video). To display the content, the display should be equipped with a VideoWall graphics controller with dedicated software, which must enable the reception of digital video signal from the Ethernet network, its processing and any display on the wall display.

Requirements for 55 '' professional 24/7 LCD monitor:

- size 55 ''
- 4K resolution 3840x2160px
- professional LCD monitor with 24/7 operation (not LCD TV)
- at least 1x computer video input (DVI or HDMI)
- viewing angle 178 degrees (vertical and horizontal)
- panel light 700 cd / m2
- the maximum edge of the housing is 15 mm

9.3 VIDEOWALL GRAPHIC CONTROLLER

Video wall graphics controller is implemented as a stand-alone device with a network interface and monitor output (DVI / HDMI).

Minimum hardware requirements for Videowall graphics controllers:

Smaller computer system (such as the HP EliteDesk 800 G5 Desktop Mini PC): with RACK mount option:

- 9th Generation Intel® Core ™ i7-9700T vPro Processor (12M Cache, up to 4.30 GHz), Intel® HD Graphics 630
- 8GB DDR4 working memory

- System disk M.2 SSD 256GB
- Network interface 1x 1GbE RJ-45 (1000 Base-T)
- AMD Radeon kartica RX 560 4GB GDDR5 graphics card
- Ports at least 2x USB 3.0, at least 2x DisplayPort (can also be 2x DVI or 2x HDMI or a combination of the listed ports)
- Microsoft Windows 10 Pro 64bit operating system

9.4 GRAPHIC CONTROLLER SOFTWARE

The software must be able to display live video, sequences of individual cameras and display alarms, ie live video from cameras covering the area where an individual event was detected, as well as a printout of the reported alarm in text form. Alarms from the monitoring control system must be displayed. In the case where the area is covered by a rotating camera, the camera must also be automatically rotated to the preset PTZ position, which covers the location of the reported alarm.

VIDEO DECODING SOFTWARE REQUIREMENTS

- possibility to display up to 16 live videos in full quality
- video fields should be programmable and configurable to display sequences, alarms, or any live video from detection cameras
- the operation of the sequence and the display of the alarm video should be independent of the operation of the workstation (in case of failure of the workstation, the sequence and display of the alarm video must still work)
- Automatic display of live video from the camera on which the alarm was reported on the alarm part of the wall display with an alarm display and indication of the detected event
- it must enable communication with third systems for the needs of alarm communication - reception of alarm messages according to the TCP / IP protocol (support for TAMP and TAMPxml protocol)
- switching between sequential videos must be continuous ("no blinking")
- support onvif, rtsp, multicast, rtp, http, rtmp protocols
- support for hardware decoding of video signals using DXVA-DirectX Video Acceleration and Intel® Quick Sync technology
- video display control on the wall player should be enabled via the user interface on workstations. The following functionalities must be enabled:
- arbitrary upload of cameras to video fields (upload of cameras from a map, camera list or NKS SCADA graphical interface with "Drag Drop" pulls)
- it must be possible to call up preset video field layouts with any combination of live images and sequences and to save a large number of such settings
- Alarm confirmation (video off on the alarm monitor) this function is also performed automatically when the alarm is confirmed
- setting the sequence of any cameras and setting the switching time between sequence cameras
- on / off the sequence on each video field
- command for full screen display of one camera (in case of direct connection of video decoding server to one wall display, full screen display is limited to the size of the display)
- remote restart - "restart" of decoding software
- remote restart - "restart" of the graphics controller

10. OTHER DEVICES

10.1 KVM SYSTEM

Each server cabinet is provided with the installation of a 19 "switching KVM console, which will allow connection in the cabinet of embedded servers. It must provide connection for at least 8 servers together with the server connection package.

Such as:

- HP LCD 8500 1U Console INTL Kit
- HP 0x2x8 KVM Svr Cnsl G2 SW
- HP IP Console 8 pack Interface Adapter

10.2 BIOMETRIC FINGERPRINT READER AND MEDIA ID

Workstations are equipped with a desktop biometric fingerprint reader and ID media. The connection to an individual workstation is made via a standard USB3.0 port.

Combined reader requirements eg: (CM03FP):

- dimensions: 80 x 80 x 25 mm,
- assembly: table,
- power supply and connection: USB3.0,
- operating frequency: 125 kHz and 13.56 MHz,
- integrated fingerprint reader,
- reading distance: fingerprint contact, cards or pendants 10 - 15 cm,
- verification: card, fingerprint or both,
- biometric sample stored in a central database
- FRR <5x10 - 3, FAR.

10.3 NTP TIME SERVER AND SYNCHRONIZATION TO A COMMON TIME BASE

To provide accurate time to the system devices of all systems, an NTP time server with a built-in GPS receiver and a highly stable and accurate oscillator is installed at the location of the main control center, which ensures uninterrupted operation even in case of interference or temporary reception failure.

NTP server requirements:

- Housing: 19 '' for mounting in a RACK cabinet
- synchronization of NTP and SNTP compatible clients
- two independent RJ-45 network ports, 10/100 Mbit Ethernet
- external antenna connected via standard coaxial cable RG58 up to 300 m long
- web interface for making settings and monitoring status, console interface
- full support for SNMP v1, v2, v3

- NTP protocol:
- NTP v2 (RFC 1119), NTP v3 (RFC 1305), NTP v4 (RFC 5905)
- SNTP v3 (RFC 1769), SNTP v4 (RFC 4330)
- MD5 / SHA-1 Authentication and Autokey Key Management
- PRP Protocol: Parallel Redundancy Protocol PRP (IEC 62439-3)
- TIME: Time Protocol (RFC 868)
- DAYTIME Protocol: Daytime Protocol (RFC 867)

10.4 MULTIFUNCTIONAL DEVICE

In the main control center a color, laser multifunction device (printing, scanning, faxing, copying and digital sending) with print support up to A3 size will be installed. For the purpose of printing reports the multifunction device is connected to the network and can be controlled from all workstations in the control center.

In addition to the original toners, an additional set of toners (color and black and white) must be included with the multifunction device, and the drawer must be filled with A3 and A4 80g sheets.

Technical requirements for a multifunction device (such as: "HP LaserJet M775z MFP"):

- Functions: print, scan, copy, fax, digital send
- Format and technology: A3, laser
- Print resolution: at least 600 x 600 dpi
- Print speed: at least 30st / min in color, at least 30st / min in black / white
- Connection: at least 1x Hi-Speed USB 2.0 and at least 1x Gigabit Ethernet 10/100 / 1000Base-T
- Color scanning: yes
- Scan resolution: at least 600dpi
- Duplex printing: yes
- ADF (automatic document feeder) function: yes
- Digital sending functions: Scan to e-mail; Save to Network Folder; Save to USB drive; Send to FTP; Send to LAN Fax; Send to Internet Fax
- Drawers: 1x 100-sheet side, 1x 250-sheet, 100-sheet with ADF function
- Additional drawers and base: 500-sheet internal sorter / stapler, 3 x 500-sheet drawer with base

11. OPTICAL TRANSMISSION SYSTEM

11.1 OPTICAL TRANSMISSION SYSTEM IN THE TUNNEL

An optical transmission system is provided at the tunnel level. Two SM optical cables (OC1 and OC2) are provided in the main tunnel tube and one optical cable (OC3) in the service tube. The OC1 cable with 24 SM fibers connects all emergency call niches and electrical niches and terminates at optical patch panels in both portal buildings. The OC2 cable with 24 SM fibers connects all emergency call cabinets and electrical niches and terminates at optical patch panels in both portal buildings. The OC3 cable runs continuously through the service tube and connects the South portal building to the North portal building. Optical cables are terminated at optical patch panels at individual locations.

In addition to optical cables OC1, OC2 and OC3, also local optical cables with 12 SM fibers will be used on the following routes:

- From the video camera connection cabinet in front of the portals to the system room in the portal buildings
- Between cross passages and electrical niches
- Between the elevated water reservoir and the portal building South

Local video cables and associated patch panels are included in the Video section.

11.1.1 Tunnel optical cables

The cables will be laid in the cable duct in the main tunnel tube, and in the service pipe it will be pulled into the protective pipe and laid on the cable shelf. In the area of the portals, the cables will be drawn into the cable duct.

For the implemented transmission system with optical cable, the TOSMd 03 SMAN cable is selected, optical fibers in accordance with ITU-T G.652-D:

Features and requirements:

- 24 fibers
- modal field diameter at 1310 / 1550nm 9.0 ± 0.4 / 10.1 ± 0.5µm
- coating protection diameter 125 ± 0.7µm
- modal field concentricity deviation ≤ 5µm
- ellipticity of the coating ≤ 1%
- profile of reflected refractive index: step
- equivalent group repulsion refractive index at 1310 / 1550nm, 1.46751 / 1.4681
- fiber attenuation coefficient at 1310 / 1550nm ≤0.34 / 0.2dB / km
- dispersion coefficient at 1310 / 1550nm ≤3.0 / 17ps / (nm.km)
- primary protection thickness 245 ± 5µm
- tensile test 8kN for 1, elongation 1%
- PDM≤0.2ps / km

Mechanical properties of optical cable:

- non-metallic central element
- mechanical protection with aramid fibers
- extruded outer casing HDPE with a thickness of min.2,0mm
- minimum permissible bending radius when laying: 10x cable diameter
- minimum permissible radius of curvature of the laid cable: 20x cable diameter
- tensile strength: 1.5dN / kg / km
- compression resistance (reversible attenuation) 2000N / 10cm
- installation temperature range -5 to + 50 ° C
- resistance to UV light
- content of the inscription on the cable sheath: designation and type of cable, name of the manufacturer, year of manufacture, running meter (inscriptions in white color min height 3mm)

11.1.2 Optical patch panels – tunnel cable

Optical patch panel for 24 fibers. The fibers terminate at the LC connectors. APC connectors are used for RF connections of the radio system.

11.1.3 Local optical cables

Same characteristics as tunnel cable, but with 12 SM fibers.

11.1.4 Optical patch panels – local cable

An optical patch panel with 12 LC connectors should be provided at the places where the local cable fibers will end.

12. TRAFFIC EQUIPMENT

In the Llogara tunnel, traffic signals (fixed and variable contents) are installed for the needs of traffic management both in normal condition and in case of emergencies (accident, fire, excessive CO concentrations, maintenance work,…).

The requirements of the following standards must be taken into account for traffic equipment and traffic equipment controllers:

- EN 50556 (Road Traffic Signal Systems)
- EN 50556 (Road Traffic Signal Systems)
- EN 50293 (Electromagnetic compatibility - Road traffic signal systems
- EN 60068-2 (Environmental testing)
- CLC / TS 50509 (Use of LED signal heads in road traffic signal systems)

The following elements of traffic equipment are installed in and in front of the tunnel:

- Fixed traffic signs
- Illuminated traffic signs
- Variable traffic signs
- Variable message signs
- Traffic lights
- Inductive loops
- Road barriers

12.1 FIXED TRAFFIC SIGNS

The following fixed traffic signs are provided in the tunnel:

- Double sided fixed traffic sign, pictogram: SOS, dimensions of the pictogram 500x500mm, Reflective material Material Stainless Steel V4A, included mounting bracket V4A
- Double sided fixed traffic sign, without illumination, pictogram: Extimguisher, dimensions of the pictogram 500x500mm, Material Stainless Steel V4A, included mounting bracket V4A

Characteristics of reflective foil in accordance with EN 12899-1.

12.2 SIGNS WITH INTERIOR LIGHTING

The following illuminated signs shall be provided in the tunnel:

- Lay-by niche, with additional inscription 60 m.

The signs will be mounted on the wall of the tunnel. The installation must allow the installation to be adjusted according to the building tolerances. The material will be stainless steel marked V4A.

12.3 VARIABLE TRAFFIC SIGNS:

The following variable signs in LED technology are provided:

- 4-display LED variable sign "speed limit" (80, 60, 40 km / h) and the inscription STOP
- 1-display LED variable sign "no overtaking for all vehicles"
- 1-display LED variable sign "two-way traffic"
- 2-displayLED variable lane control sign "cross / arrow"

The dimensions of the signs in front of the tunnel are 900 mm, in the tunnel 600 mm

12.3.1 1 and 4 display variable traffic sign:

The sign consists of high-brightness LEDs in red and white

LED diodes are protected from mechanical and atmospheric influences by lenses.

The LED variable traffic sign allows the display of all planned traffic signs.

Character functions:

- Constant, flashing or alternating display of character / characters (selection via command)
- RS 485 optically separate communication and open program protocol
- Constant brightness or automatic brightness control. Constant brightness can be adjusted in 16 levels via RS 485 communication.
- Via RS 485 communication it is possible:
    - to include any traffic content with the possibility of constant display or flashing
    - accept the sign information which traffic content is displayed
    - receive an alarm that one or more LEDs are not working
    - receive a general disturbance alarm
    - adjust the brightness of the character

Housing:

- Housing dimensions: 1050mm x 1050mm (650mm x 650mm)
- Material: V4A

Technical information:

- AC power supply: 230V 50Hz
- Operating temperature range: -25 ° C to +55 ° C
- Permissible humidity: up to 100%
- LED brightness angle: 30 °
- Luminance: L3
- Contrast: R2
- Color coordinates: C2
- Distance between LEDs: 25 mm red (triangle, circle), 20 mm white (silhouette)

Characteristics of white and red lighting elements according to EN 12966:

12.3.2 Lane control variable traffic sign (cross / arrow)

Variable traffic signs (red cross / green arrow) are installed above the lanes, which enable the closure of an individual lane.

Technical information:

- rated voltage: ~ 230 V AC
- rated frequency: 50 Hz
- voltage range: 180 - 250 V
- frequency range: 50 - 60 Hz
- maximum starting current: <3 A (10 ms)
- net display size: 600 x 600 mm
- distance between the centers of the points of light: 25 mm
- number of LEDs at the point of light: 1
- brightness control: automatic, 24 levels
- visibility:> 250 m
- LED protection: mechanical with lens, antistatic self-cleaning material impact resistant and UV stable
- display option: cross in red,
- green arrow,

Classification according to EN 12966-1:

- Red LED's: 626nm, 30 °, 2500cd / m2, color C2, beam width B4, luminosity L2
- Green LED's: 505nm, 30 °, 3300cd / m2, color C2, beam width B4, luminosity L2

temperature:

- T2, T3 (EN12966-1), -40 to + 55ºC

environmental:

- D4 (EN12966-1), the device is resistant to the constant presence of conductive substances formed from conductive dust and rain or snow.

Housing dimensions:

- 650 mm x 650 mm x 170 mm

mechanical protection:

- P2 (EN12966-1), IP65

Material:

- V4A

Interface:

- RS-485

12.4 FULL GRAPHIC DISPLAY - LED MATRIX SIGN

An information board will be installed in front of both portals and at lay-by niche locations to inform drivers about the situation in the tunnel.

The display has dimensions of 200 x 100 cm (H x W) in the locations of parking niches and 100 x 300 cm (H x W) in the area of the portals cm. The display is divided into 2 fields. The first field allows the display of graphic elements (ie traffic signs and other graphic symbols), and the second field displays alphanumeric messages.

A total of at least 16 graphic symbols and 24 alphanumeric messages can be programmed.

Individual pre-programmed messages and graphic symbols are switched on from the tunnel control system via the TCP / IP.

The version of the information board is with LED diodes, two-tone red and white.

Size of round traffic sign at least 60 cm, side of triangle 90 cm.

Letter height at least 20 cm.

Size of individual points:	max 13 mm
Viewing angle:	30 - Horizontal
	20 - Vertical
Radiation band width:	B3 according to EN 12966
Chromatic coordinates of LED elements	in accordance with EN 12966
Temperature range:	-30°C +50°C

Protection: P3

Luminous flux regulation 16-stages, depending on the lighting conditions at the location of the panel

The board provides good readability even in sunny weather and snowy landscape. The luminance requirements for L2 are in accordance with EN 12966.

V4A panel housing with protection level IP65. The housing has removable access covers to allow easy replacement of elements. Stainless steel fastener V4.

The sign can be freely programmed / set directly from the control system or. positions of traffic supervisor or turn on pre-programmed content. The variable message character can display any letter, punctuation, and numbers 0 to 9. Static and flashing display mode and variable display mode for multilingual messages are enabled.

Pre-programmed contents are stored in the character controller.

Communication via TCP / IP.

12.5 TRAFFIC LIGHTS

Traffic lights will consist of three firmly interconnected units, namely in the vertical direction. The interior of each unit must be accessible from the front by means of a rotating front panel.

Traffic lights will be installed in front of the tunnel and in the area of lay-by niches.

The light transmitters will be 300 mm in diameter and designed in such a way as to prevent glare to road users. The reflection of sunlight through the reflector must be as small as possible (phantom effect)

Highly efficient light transmitters with LEDs, a reflector and a colored lens will be used. Precise orientation of the optics must be possible.

Suitable plastic material (black) with high impact strength, corrosion resistance, temperature resistance and without the necessary periodic maintenance will be used as the housing material. Temperature range from -30 ° C to + 70 ° C.

The construction of traffic lights must comply with the "protective insulation" protection measure.

The degree of protection must be IP 65. It is therefore necessary to use seals with adequate temperature and anti-aging resistance.

Fastening structures must be adapted to the place of attachment. The design must allow the installation to be adjusted according to the building tolerances. It must allow adjustment in both the vertical and horizontal directions. V4A stainless steel will be used exclusively as the material.

Dimmed operation of portal traffic lights

The brightness of the external (portal) traffic lights must adapt to the illumination in front of the tunnel.

The planned modern LED traffic lights must enable dimmed operation, which means that the traffic lights can also be controlled in dimmed mode. The local station that controls the said traffic lights must allow operation in dimmed mode. The process must be carried out completely automatically. The information for switching to dimmed mode is received by the local station from a photometer, which measures the illumination in front of the tunnel and takes care of the correct regulation of the lighting. The traffic lights switch to dimming mode when the tunnel lighting goes into night mode (N).

The module that controls the traffic lights must perform smooth operation control, burnout and foreign voltage detection.

By performing the dimming, the portal traffic equipment will be evenly lit, there will be no disturbing exits golden in bad rainy weather.

12.6 INDUCTIVE LOOPS

As part of the traffic equipment, inductive loops for counting and classifying traffic are also installed in the Llogar tunnel.

Inductive loops will be installed in the area of the portals and every 1000 m inside the tunnel.

Basic functions of inductive loops:

- Number of passenger cars
- Number of lorries
- Average lane speed
- Maximum speed in the lane

All data is measured and sent to the control system. The traffic data is arbitrarily processed in the control system and displayed at the desired time interval.

Inductive loops are additionally installed in the lay-by niches to detect niche occupancy.

12.7 ROAD BARRIERS

Road barriers are installed in front of the tunnel portals.

Road barriers are complemented by traffic lights at the same location Barriers are electromechanical, with an electric motor drive.

The attachment of the barrier arm must be such that the collision of the vehicle with the closed barrier does not damage the barrier mechanism and that the arm pops out of its seat.

For better visibility of closed barriers, single red turn signals (three on each arm) are placed on the moving arms. The turn signals are activated at the same time as the barriers start to move and are switched on throughout the closing of the gates.

The barriers must also be able to be closed (opened) manually in the event of a power failure or failure.

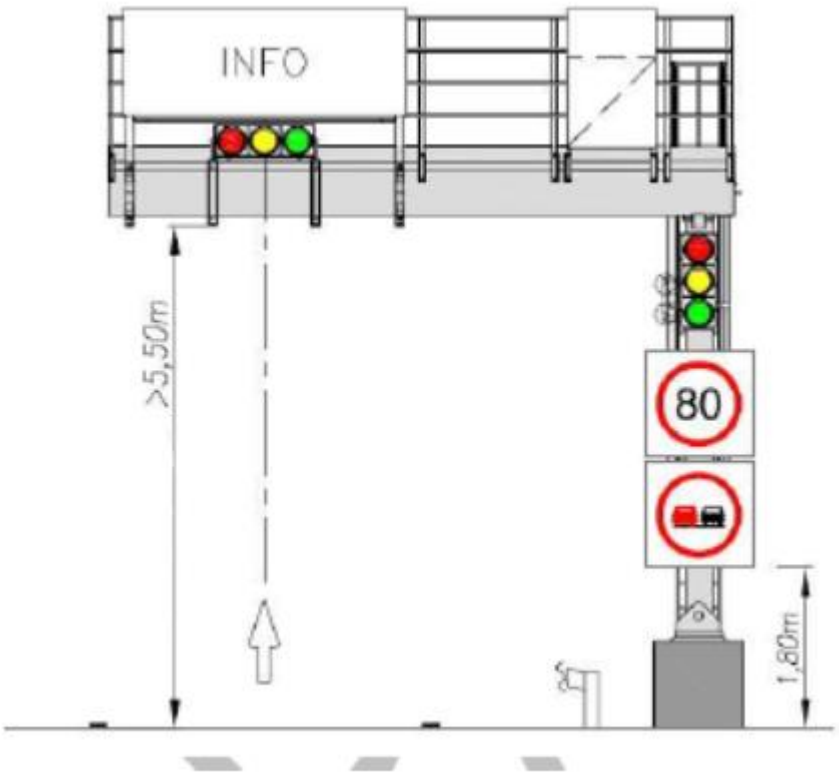
The barrier arm is colored with white and red reflective stripes. The length of the arms should be (approximately) 5.0 m.

Barrier housing protection IP54, galvanized sheet metal housing d = 2mm, powder coated with epoxy paint,

12.8 SUPPORTING STRUCTURE IN FRONT OF PORTALS

In front of the tunnel, a hot-dip galvanized construction is installed above the carriageway, which enables the installation of two variable traffic signs, two traffic lights and a variable information display. The load-bearing structure must meet the conditions of the installation site. The delivery also includes the

appropriate foundation for the structure and other necessary work for the installation.



13. FIRE ALARM SYSTEM

Automatic and manual fire alarm systems are planned in the Llogar tunnel and installed in:

- Main tunnel tubess,
- Facilities along the tunnel pipe (electrical niches and emergency call niches) and
- Portal buildings

The main tunnel tube is protected by a linear fire detection system.

Based on signals from the fire alarm system (line detection, manual call points in the tunnel, fire extinguisher raise), automatic control of fire ventilation and control of other safety systems (traffic signals, video, ...) are triggered via the tunnel control system. .

13.1 POINT DETECTION SYSTEM

The point fire alarm system consists of manual and automatic fire detectors.

Illuminated manual fire call point will be installed in the tunnel tube (on outside of the emergency call niches, emergency call station cabinets, in cross passages and in emergency call booths on portals). Manual call points must have dimensions of approx. 80 x 80 mm with round push button diameter approx. 40 mm and built-in LED. The red LED is permanently lit and flashes when the alarm is triggered. The marking of the hand-held detector must be made with a fluorescent sticker in the "HI" version with the inscription "FIRE" and the flame symbol. Protection IP65. Manual call points are connected to the addressable interface of the fire detection loop.

Two fire extinguishers are installed in the emergency call niches and in the emergency call station cabinets in the tunnel and in the emergency call booths on the tunnel portals. The raising of fire extinguishers is also detected as a manual fire alarm. For this purpose, magnetic switches are installed under the fire extinguishers, which are connected to an addressable interface.

Due to the size of the area where the controlled facilities are located, a fire alarm system is planned with several control panels, each of which controls its own area. The control panels are connected to the tunnel control system via TCP / IP. The connection to the tunnel control system is made on data switches.

All inputs and outputs from the control panel must be protected with overvoltage protection elements, so that false alarms due to overvoltage that can occur in the environment in which the equipment will be installed are completely eliminated.

The control panels are connected to the higher-level control and monitoring system via a tunnel Ethernet network.

All devices of the fire alarm system must operate on a single time base, which must be synchronized with the time base of all other safety devices in the tunnel and devices in the control center.

Automatic fire detectors are also provided in the double floor and suspended ceiling of individual rooms.

In the portal building South, fire dampers with remote automatic triggering in case of fire and signaling of the damper condition are planned in the wallof the MV room.. Addressable control interfaces are provided for this purpose. Fire dampers with status signaling are also provided in the transformer room in the area of lay-by niches in the tunnel.

The individual signal lines to which the manual and automatic detectors and the input-output control interfaces are connected are made with special red fire detection cables JE-H (St) H 2x2x0.8 mm with fire resistance E30 / FE180.

All elements of the fire alarm system have their own power supply with a battery with 48 hours of autonomy, which is powered from the UPS tunnel uninterruptible power supply system.

13.1.1 Fire alarm panel

The control panel is a compact unit with the configuration:

- Possibility to connect 2 addressable detector lines
- LCD display
- 4 control outputs for connecting signal horns, etc.
- Optical communication module for communication with other exchanges in the configuration of the ring via SM optical fibers in accordance with EN54.
- Power supply with batteries for 48 hours of backup operation
- All outputs will be galvanically separated (optocouplers, transistors, relays, ...)
- Housing for self-assembly
- Control of communication with neighboring exchanges.
- Module for Ethernet communication with the LAN of the control system
- The batteries must also be sufficient to power the illumination of the hand-held detectors and SOS buttons

The fire control panels are powered by the UPS tunnel uninterruptible power supply system.

Compliance with:

- 305/2011 / EU (CPR): EN 54-2 / EN 54-4
- 2014/30 / EU (EMC): EN 50130-4 / EN 61000-6-3
- 2014/35 / EU (LVD): EN 60950-1
- 2011/65 / EU (RoHS): EN 50581

A type like e.g. Siemens FC2020

13.1.2 Manual call point

Addressable manual call points with protective cover. IP64 protection.

Compliance with:

- 305/2011 / EU (CPR): EN 54-11 / EN 54-17

- 2014/30 / EU (EMC): EN 50130-4 / EN 61000-6-3
- 2011/65 / EU (RoHS): EN 50581

As e.g. Siemens FDM224

13.1.3 Optical smoke detector

Addressable optical smoke detectors with a suitable base and short-circuit isolator will be installed in portal buildings, electrical niches and emergency call niches. Point detectors will also be installed in the double floor and suspended ceiling of individual rooms.

Compliance with:

- 305/2011 / EU (CPR): EN 54-7 / EN 54-17
- 2014/30 / EU (EMC): EN 50130-4 / EN 61000-6-3
- 2011/65 / EU (RoHS): EN 50581

As e.g. Siemens FDO241

13.1.4 Parallel indicator light

A parallel light indicator is connected to all smoke detectors that will be installed in the double floor, which signals the activation of the detector.

Compliance with:

- 2014/30 / EU (EMC): EN 50130-4 / EN 61000-6-3

As e.g. Siemens DJ1192

13.1.5 4 - channel input/output interface

4-channel addressable input-output interfaces are designed to control fire dampers at the boundary of fire sectors. They are installed in a housing for damp / dusty rooms.

- 4 control outputs
- 4 controlled inputs
- Power supply via addressable loop
- LED status signaling, errors, test
- Integrated short circuit isolator
- Relay output: AC 250V / 4A, DC 30V / 4A
- IP65 protection

Compliance with:

- 305/2011 / EU (CPR): EN 54-18 / EN 54-17
- 2014/30 / EU (EMC): EN 50130-4 / EN 61000-6-3
- 2014/35 / EU (LVD): EN 60950-1

- 2011/65 / EU (RoHS): EN 50581

A type like e.g. Siemens FDCIO222 + FDCH221

13.1.6 1 - channel input/output interface

1-channel addressable input-output interfaces are intended for controlling the ventilation of technical rooms in case of fire and connecting the signals of manual fire detectors in the tunnel and magnetic switches that signal the rise of fire extinguishers.

1 channel interfaces are provided:

- 1 control outputs
- 1 controlled inputs
- Power supply via addressable loop
- LED status signaling, errors, test
- Integrated short circuit isolator
- Relay output: AC 22 / 2A, DC 30V / 2A

Compliance with:

- 305/2011 / EU (CPR): EN 54-18 / EN 54-17
- 2014/30 / EU (EMC): EN 50130-4 / EN 61000-6-3
- 2011/65 / EU (RoHS): EN 50581

A type like e.g. Siemens FDCIO221

13.1.7 Signal horn

Signal horn with visual alarm, power supply via addressable loop. Protection IP65, volume 99 dBA, volume adjustment in three stages, 16 alarm tones.

Compliance with:

- 305/2011 / EU (CPR): EN 54-3 / EN 54-17 / EN 54-23
- 2014/30 / EU (EMC): EN 50130-4 / EN 61000-6-3
- 2011/65 / EU (RoHS): EN 50581

A type like e.g. Siemens FDS226 + FDB227

13.1.8 Cables

The addressable fire alarm loop is made of cables with fire resistance E30 / FE180. Fire-resistant cables must be laid in accordance with DIN 4102/12.

13.2 LINEAR FIRE DETECTION

A line fire alarm system will be installed in the main tunnel tube. A system with a linear detection cable

mounted on the tunnel ceiling will be used.

A detection cable runs through the entire tunnel tube. The cable terminates on both sides at the controllers in the North and South portal buildings. Single-channel controllers are provided.

13.2.1 Controller

- Range 7000m
- min 5 programmable relay outputs
- min 4 programmable inputs,
- communication with the tunnel control system TCP / IP,
- system and application software
- additional cascade power supply 150W, complementary power supply to the main power supply with batteries for 48-hour backup power supply

The basics for a fire alarm are:

- Current absolute temperature at each point of the tunnel
- Temperature gradient at the controlled point of the tunnel
- Absolute temperature difference at the controlled point of the tunnel

Since the detection cable is connected to its controller channel at both ends, the length of the section of the tunnel in which the fire alarm system can fail in case of failure does not exceed 1000 m, which is required by applicable guidelines and regulations.

The controllers are connected to the upgraded tunnel control system via TCP / IP communication and a data switch in the portal building.

The controller is built into the 19” cabinet.

The controller has 3 relay outputs for connection to the point fire alarm system:

- fire in the tunnel pipe
- operation
- error

These signals are connected to the point fire alarm system via addressable interfaces.

13.2.2 Detection cable

- Cable type SC-MFLT4-FRNC
- Temperature range -30 ° C to +85 ° C (short-term 120 ° C / <5 min)
- Halogen-free cable sheath
- Insensitive to EMC interference and aggressive moisture in the tunnel

Tehnical specifications:

- Insensitive to EMC interference and aggressive moisture in the tunnel

- Hot smoke detection and differential detection of temperature change,
- Fire resistant and non-corrosive,
- Even sensitivity along the entire length of the cable,
- Redundancy using two optical fibers,
- Infrared absorption cable insulation (FRNC),
- Without electronic parts,
- Insensitive to electromagnetic interference,
- Robust design, resistant to environmental influences,
- Easy installation,
- No maintenance,
- VdS approval (G211076)

14. RADIO COMMUNICATION SYSTEM

The tunnel radio system is intended for providing radio communications in the tunnel for the fire brigade, rescue, police (2 channels), maintenance service and for informing drivers by means of messages inserted in public FM radio programs.

The radio communication system consists of:

- antenna system for connection to external systems (base stations, transmitters) at the location of the portal building North
- dislocated receiving station at the location of the portal building South for receiving signals that are not present at the location of the antenna system North
- receiving substation where signals from a dislocated receiving system are processed
- master station, where all signals are received and processed
- optical transmission system between main station, amplifier substations and receiving substation
- amplification substations
- tunnel antenna system – radiating cable
- Intercom system with radio microphone consoles connected to the system and with a system of pre-recorded messages

14.1 ANTENNA SYSTEM - NORTH

A dip hot galvanized pole is provided, mounted on the roof of the portal building, h = 7.00 m, with ladders.

The antennas are mounted using Fe / Zn antenna mounting brackets.

Antennas with the following characteristics are used for individual systems:

- Police 1: UHF directional antenna with Gain> 8dBi (LogPer or Yagi)
- Fire brigade: UHF directional antenna with Gain> 8dBi (LogPer or Yagi)
- Rescue: UHF directional antenna with Gain> 8dBi (LogPer or Yagi)
- Maintence: UHF directional antenna with Gain> 7dBi (Yagi) - coverage of area around northern portal
- FM: VHF directional antenna with Gain> 5dBi (Yagi or LogPer)

The antenna cables are attached to the antenna pole by a system of clamps. At the entrance to the building, surge protectors are installed outside the building. Eg. at the foot of the antenna pole. The antenna pole and surge protectors are connected to the earthing system of the building.

The antennas are connected with a 1/2 ”coaxial cable with the following characteristics:

- Cable with UV resistant, halogen free, low smoke, flame retardant jacket according to IEC 60754, IEC 60332-1, IEC 60332-3 cat. C, IEC 61034, NF C 32070 cat. C1, UL-1685-FT4 / IEEE 1202 and EN 50399 Cca-s1, d2, a1.Compliant to EN 50575.

14.2 ANATENNA SYSTEM - SOUTH

Due to the need to transmit radio signals of services that are not present on the north side of the tunnel, it is necessary to install a dislocated antenna system in the area of the southern portal of the tunnel and transmit radio signals to the main station (Master station) in the portal building North.

The antenna pole will be mounted on the building of the portal building South.

The antennas are mounted using Fe / Zn antenna brackets.

Antennas with the following characteristics are used for individual systems:

- Police 2: UHF directional antenna with Gain> 8dBi (LogPer or Yagi)
- Maintence: UHF directional antenna with Gain> 7dBi (Yagi) - coverage of area around southern portal
- FM: UKV directional antenna with Gain> 5dBi (Yagi or LogPer)

The antenna cables are attached to the antenna pole by a system of clamps. At the entrance to the building, surge protectors are installed outside the building. Eg. at the foot of the antenna pole. The antenna pole and surge protectors are connected to the earthing system of the building.

The antennas are connected with a 1/2 ”coaxial cable with the following characteristics:

- Cable with UV resistant, halogen free, low smoke, flame retardant jacket according to IEC 60754, IEC 60332-1, IEC 60332-3 cat. C, IEC 61034, NF C 32070 cat. C1, UL-1685-FT4 / IEEE 1202 and EN 50399 Cca-s1, d2, a1.Compliant to EN 50575.

14.3 RECEIVING STATION - SOUTH

Signals of Police 2 are proccessed with Channel Selective Digital repeater.

Down-Link (DL) signals are received, digitally filtered, amplified and sent as RF signals to Master radio station in Portal building North where they are combined with other signals.

Up-Link (UL) signals from North are received as RF signals, filtered and amplified in the direction of Police Repeater asigned for coverage of that area.

Transport of RF signals between Master station in portal building North and dislocated station in portal building South is done as an RFoG bi-direction optical link.

Channel Selective Digital repeater must have common port (UL and DL) toward antenna and separate ports for UL signals and DL signals to interface with RFoG optical Receiver and Transmitter.

Basic requirements for Channel Selective Digital repeater:

- Frequency range: 380-520MHz
- Gain DL: min 80dB
- DL Power: to corresponds to RFoG Optical Transmitter

- Gain UL: min 50dB (depending on RFoG link gain)
- UL Power: + 36dBm / 1 Channel

Channel Selective Digital repeater can be of modular type, assembled in a chassis or of a Stand Alone type.

Two (2) FM signals are planned to be received from south direction.

Signals are received, digitaly filtered, amplified and sent as RF signals to Master radio station where they are combined with other signals.

FM radio signals and UHF DL signal of Police 2 are combined with Multi Band combiner in order to use the same RFoG optical transmitter.

Digital repeater is used in order to keep the original signal received from external repaater fully transparent, without any demodulation. Therefor the system can operate on current analogue system as well in case of later upgrade to DMR or TETRA system.

The system is powered by duplicate power supplies. Industrial DIN power supplies or integrated dual power supplies.

All equipment will be installed in a 19 ”cabinet together with the equipment of the sound system (amplifiers for portals) and the equipment of the emergency call system (IoIP / VoIP converters for emergency call terminals in emergency call booths on portals).

The system is powered by duplicate power supplies. Industrial DIN power supplies or integrated dual power supplies. Power supply is performed in two phases to provide redundant power supply.

14.4 MASTER STATION - NORTH

At the main station, signals are received from the antenna system - North and the dislocated system - South via RFoG.

Radio 1, Police 2, Fire brigade and Rescue service radio signals are processed by Single Channel Digital Repeaters. The use of MultiChannel repeaters is not possible due to the frequency schedule and the 4.5 (4.6) MHz raster.

For the needs of the Maintenance radio system, which acts as a stand-alone cell covering the tunnel and the surroundings, an UHF repeater is used, which can operate in analog and DMR mode.

FM radio programs received on the North side (4x FM) are processed with a MultiChannel digital repeater and combined with FM signals from the South side. In this way, all RDS data of the original external FM signal is retained.

For the purpose of informing drivers about emergencies, the system is equipped with FM Modulators, which modulate the audio message to the FM radio frequencies of external radio programs.

The RF toggle switch provides a choice of which signal will be transmitted to the tunnel: an external radio FM signal or an FM signal with a modulated notification.

FM modulators must support the generation of RDS data, which is used to properly inform drivers.

Part of the Master Station is the Multicoupler, whose task is to combine and separate signals within the UHF band, and between UHF and FM bands.

Multicoupler provides connectivity between Digital Single Channel repeaters, Independent UHF repeater Maintence, FM signals from the switching field on one side and RFoG transmission system, local amplification substation to cover the first segment of the tunnel on the North side and interfaces for connectivity with microphone consoles in the main control center North .

The North portal building also houses the amplifier substation, which is identical to the amplifier substations inside the tunnel and is described below, with the difference that it does not require an RFoG connection.

All equipment will be installed in two 19 ”cabinets. Cabinet 1 is intended exclusively for the radio system. The second part of the equipment is located in cabinet 2, together with the equipment of the sound system (portal amplifiers) and the emergency call system (IoIP / VoIP converters for emergency call terminals in emergency call booths on portals).

The system is powered by duplicate power supplies. Industrial DIN power supplies or integrated dual power supplies. Power supply is performed in two phases to provide redundant power supply.

14.5 RFoG OPTICAL TRANSMISSION SYSTEM

The optical transmission system transmits already modulated and combined signals from the main station to the amplifying substations (DL signals) and signals from the tunnel in the direction of the main station (UL signals).

Equipment with WDM transmission mode (1310nm / 1550nm) is used, due to more rational use of optical fibers.

Basic parameters of RFoG Tx and Rx

Optical

Parameter	Specification				Notes
	Min.	Typ.	Max.	Unit	
Receiver					
Received wavelength range	1100	-	1650	nm	
Optical input power (1)	-8	-	+2	dBm	
Photodiode responsivity	0.80	0.90	-	A/W	
Optical return loss	40	-	-	dB	
Transmitter					
Wavelengths	-	1310	-	nm	
	-	1550	-	nm	
Optical output power for 1310nm transmitters	-	-	3	dBmO	
Optical output power for 1550nm transmitters	-	-	1	dBmO	
Optical isolation	30	-	-	dB	
Optical return loss	40	-	-	db	
Common					
Optical connectors & adaptors back reflexion (formal compliance)	-	-70	-	dB	

RF

Parameter	Specification				Notes
	Min.	Typ.	Max.	Unit	
Bandwidth	30	-	1000	MHz	
RF Impedance	-	50	-	Ohms	
Return loss (30 to 1000MHz)	12	17 - 1dB/oct	-	dB	
Receiver					
Receiver equivalent noise current	-	7	-	pA/√Hz	
Max. RF output level at 5% OMI (1)	-	-	-15	dBm	
RF output level attenuator range (0.5dB/step)	-	20	-	dB	
Output IP3 (1)	36	38	-	dBm	
Flatness (peak-peak)	-	1.5	2	dBpp	
Optical power analog reading (High impedance DC multiplexed on RF output connector)	-	2.5	-	V/mW	
RF output test point attenuation	18.5	20	21.5	dB	
RF backup input attenuation	2	3	4	dB	
Transmitter					
Input amplifier noise figure (2)	-	7	-	dB	
RF minimum input level for 5% OMI (2)	-35	-	-	dBm	
RF input attenuator range in remote mode (0.5dB/step)	-	15	-	dB	
Max. RF composite input level before clipping (2)	-	-20	-	dBm	
Laser driver IP3	38	40	-	dBm	
Flatness (peak-peak)	-	1.5	2	dBpp	
TX Chain RF port loss (2) (3)	-1	0	+1	dB	
OMI RF test point level at 5% OMI (2) (3) (4)	-	-35	-	dBm	

(1) Output level attenuator at 0dB and on the whole optical AGC range (from -8dBm to +2dBm of optical received power).
(2) With input attenuator set at 0dB.
(3) OMI RF Test point is the same port as TX Chain RF output.
(4) Equal to input level with input attenuator set at 0dB.

Basic parameters of RFoG Receiver:

All modules in the platform are controlled via a control module that serves to set parameters via the weg BUI interface and report alarms to the SCADA system via SNMP messages.

14.6 AMPLIFIER SUBSTATION

To provide a signal in the tunnel tube, 7 amplification substations are planned: one (1) in the portal building North and six (6) which are connected via RFoG link.

The task of the amplifying substations is to amplify the received DL signals from the Master station to a sufficient level to compensate for the losses of the radiating antenna system and to ensure the field strength in accordance with the RVS guidelines.

Conversely, the weak UL signals of mobile radio stations are amplified and transmitted to the Master station.

DL signals received via RFoG are first separated into FM and UHF bands and amplified separately with power amplifiers. The amplified signals are passively processed in the Multicoupler and transmitted to the tunnel antenna system.

UL signals received from the tunnel antenna system are first passively processed in the Multicouple and then amplified by a low-noise preamplifier. Thus, they are raised to a sufficient level to be able to stimulate the optical transmitter of the RFoG system and the signal is transmitted to the Master station.

The multicoupler consists of XBAND switches, narrow Band Bass Filters for separating DL and UL channels and a 1: 4 power divider to which segments of the radiant antenna system are connected.

The amplifier substation must provide sufficient signal and dynamics in the UL direction to provide coverage in normal operation mode and in redundant mode when the cable breaks and the redundant switching between the segments of the radiating cables occurs.

The calculation for both operating modes (C95% NORMAL and C50% REDUNDANT) shows that the amplifier substation must provide the following signal output levels from the amplifiers, with the predicted loss of the Multicoupler.

- UHF 5 channels = + 17dBm / channel
- FM 6 channels = + 15dBm / channel

The amplifying substation can be modular in 19 ”platform.

The locations of the reinforcement substations are ECN09, ECN19, ECN29, ECN39, ECN49 and the portal building South.

Amplifier substations are built into 19 ”cabinets, which are shared with a sound system (amplifiers for covering parking spaces and crossbars) and emergency call system equipment (IoIP / VoIP converters for emergency call terminals in ECN and ECS)

The system is powered by duplicate power supplies. Industrial DIN power supplies or integrated dual power supplies.

The supply is carried out in single phase, except for the equipment in the portal building Jug, where the supply is carried out in two phases due to the equipment of the dislocated receiving system.

14.7 TUNNEL ANTENNA SYSTEM

Even coverage of the tunnel tube is achieved by installing a radiating cable.

The basic purpose is to provide communication with car stations in vehicles and hand-held radio stations outside the vehicle.

The installation of the radiant cable is carried out along the ceiling of the tunnel tube. Deviation from metal shelves and parapet ducts, signs, fans and other obstacles must be observed in accordance with the manufacturer's recommendations.

The radiation system provides signals in the main tube and in the service / rescue tube.

In accordance with the RVS guidelines, the overhead antenna system is implemented in such a way as to ensure coverage from the signals even in the event of interruption of one segment of the radiant cable. For

this reason, the individual radiation segments are interconnected via an RF switching field.

In normal mode, each radiation segment is terminated on a load. In case of breakage or sufficient damage of one of the segments of the radiating cable, the switching field connects the radiating segments so that the signal to damage is provided through the undamaged segment, through the switching field and through the healthy part of the damaged segment.

For this purpose, the amplifier substation contains control modules for each segment separately, which measure the VSWR value. At the same time also inserting voltage into the radiating segments, through which they hold the switching field in the position when the radiating cables are terminated on the load. In the event of a detected fault, the control module interrupts the inserted voltage and the switching field between the segments disconnects the segments from the load and connects them.

For easier and faster indication, the switching field has a light fault indication.

Due to its properties, RMC (Radiating Mode Cable), size 7/8 ”and higher fire resistance is selected, which meets IEC-60754, IEC-60332-1, IEC-60332-3-24 IEC-61034 EN60332-1- 2 Eca, EN50575.

Due to the need to transmit the UHF frequency range, a 7/8 ”coaxial cable is used for the transport cable:

- UV resistant, halogen free, low smoke, flame retardant jacket according to IEC 60754, IEC 60332-1, IEC 60332-3 cat. C, IEC 61034, NF C 32070 cat. C1, UL-1685-FT4 / IEEE 1202 and EN 50399 Cca-s1, d2, a1.Compliant to EN 50575.

The technical characteristics of the radiating and transport cable can be seen in the table with the calculation of the signal strength.

During installation, the direction of the cable radiation must be observed in accordance with the manufacturer's instructions.

14.8 CALCULATIONS

Projekt: LLOGARA **PZI Rev.0**
Task: RA coverage RVS
Segment: longest
Mode: NORMAL - C95% date: February 2021

Initian conditions	Value	Value	Value	Unit
Frequancy	100	150	400	Mhz
Insertion loss	**12**	12	12	dB
Transport cable	**5228 HLFR**	5228 HLFR	5228 HLFR	-
Loss of transport cable	0,0112	0,0138	0,0246	dB/m
Loss of connectors and jumpers	2	2	2	dB
Radiating cable	**RMC 7/8**	RMC 7/8	RMC 7/8	-
Longitudinal loss of radiating cable	0,015	0,0173	0,0329	dB/m
Decoupling loss (IEC 61196-4; d=2m)	70	71	53	dB
Additional requ. for critical areas	0,00	0,00	0,00	dB
DL Pout - into radiating cable	**15**	**3**	**17**	dBm
Tx of Mobile station UL	-	30	30	dBm
RVS 09.02.61 DL requirement	-79,00	-92,00	-87,00	dBm
DL >>> Mobile station	Value	Value	Value	Unit
Transport cable lenght	**90**	90	90	m
Transport cable loss	1,01	1,24	2,21	dB
Radiating cable - lenght	**500**	500	500	m
Radiating cable Loss	7,50	8,65	16,45	dB
Sum Loss	92,51	94,89	85,66	dB
DL Pout	15	3	17	dBm
Signal at mobile station antenna	-77,51	-91,89	-68,66	dBm
RVS 09.02.61 DL requirement	-79,00	-92,00	-87,00	dBm
Margin	**1,49**	**0,11**	**18,34**	dB
Mobile station >>> UL LNA	Value	Value	Value	Unit
Transport cable lenght	-	90	90	m
Transport cable loss	-	1,24	2,21	dB
Radiating cable - lenght	-	500	500	m
Radiating cable Loss	-	8,65	16,45	dB
Sum Loss	-	94,89	85,66	dB
Tx of Mobile station UL	-	30	33	dBm
UL signal at LNA preamplifier	-	**-64,89**	**-52,66**	dBm
System requirements - TBD	-	-	-	dBm
Margin	**-**			dB

Projekt: LLOGARA **PZI Rev.0**
Task: RA coverage RVS
Segment: longest
Mode: BU C50%

date: February 2021

Initian conditions	Value	Value	Value	Unit
Frequancy	100	150	400	Mhz
Insertion loss	**12**	12	12	dB
Transport cable	**5228 HLFR**	5228 HLFR	5228 HLFR	-
Loss of transport cable	0,0112	0,0138	0,0246	dB/m
Loss of connectors and jumpers	3	3	3	dB
Radiating cable	**RMC 7/8**	RMC 7/8	RMC 7/8	-
Longitudinal loss of radiating cable	0,015	0,0173	0,0329	dB/m
Decoupling loss (IEC 61196-4; d=2m)	58	60	52	dB/C50%
Additional requ. for critical areas	0,00	0,00	0,00	dB
DL Pout - into radiating cable	**15**	**3**	**17**	dBm
Tx of Mobile station UL	-	30	30	dBm
RVS 09.02.61 DL requirement	-79,00	-92,00	-87,00	dBm
DL >>> Mobile station	Value	Value	Value	Unit
Transport cable lenght	**90**	90	90	m
Transport cable loss	1,01	1,24	2,21	dB
Radiating cable - lenght	**1000**	1000	1000	m
Radiating cable Loss	15,00	17,30	32,90	dB
Sum Loss	89,01	93,54	102,11	dB
DL Pout	15	3	17	dBm
Signal at mobile station antenna	-74,01	-90,54	-85,11	dBm
RVS 09.02.61 DL requirement	-79,00	-92,00	-87,00	dBm
Margin	**4,99**	**1,46**	**1,89**	dB
Mobile station >>> UL LNA	Value	Value	Value	Unit
Transport cable lenght	-	90	90	m
Transport cable loss	-	1,24	2,21	dB
Radiating cable - lenght	-	1000	1000	m
Radiating cable Loss	-	17,30	32,90	dB
Sum Loss	-	93,54	102,11	dB
Tx of Mobile station UL	-	30	33	dBm
UL signal at LNA preamplifier	-	**-63,54**	**-69,11**	dBm
System requirements - TBD	-	-	-	dBm
Margin	**-**			dB

14.9 MICROPHONE CONSOLES

The main control center of the Llogar tunnel is located in the portal building North. The workplace is equipped with microphone IP consoles to communicate with each of the radio channels, which is especially important in emergencies.

The workstation is also equipped with an IP console for inserting “live” messages via FM radio idles and a sound system (common console). The insertion and notification system is also equipped with a system for storing pre-recorded messages, recording additional messages and playing them via FM stations and / or a sound system.

For this purpose, an Intercom control panel is installed, which serves to connect the console of the workstation in the main center North, the consoles of the backup workstation South and the interfaces next to stationary radio stations and FM modulators and IP PA amplifiers.

14.10 INTERCOM SERVER

In the LlogarA tunnel, common server equipment for radio, sound and emergency call systems is planned.

For greater reliability, the system has two servers, the main on the north side and the back-up on the south side.

The job of the servers and software is to route traffic between all peripheral IP intercom equipment, store pre-recorded messages, play them, and record communication within the intercom network for possible subsequent event analysis.

For the purposes of integration with the Visualization system, it is equipped with a software module that enables integration via the ICX protocol, so that commands (selection, etc.) and display of equipment statuses are performed via a common SCADE tunnel.

The intercom servers will be built into 19 ”cabinets of the radio system.

Technical requirements for Interkom corset and software:

- Server housing with extended guides for installation in a 19 ”cabinet
- Preloaded Linux operating system Debian 9 (64 bit)
- Intercom software with a capacity of up to 448 IP / SIP users
- Back-up license
- Network connection and SNMP

Visualization and activation of pre-recorded messages takes place via a common workstation system for radio, emergency call and sound systems.

14.11 CONNECTION TO SCADA

All key elements of the radio system must be configurable via the Web GUI and with a number of standard Web interfaces.

The control over the operation of individual segments of the radio system takes place via SNMP connections and potential-free contacts with the SCADA system.

All equipment used with the exception of the power supplies themselves must support SNMP connectivity.

Elements connect to SCADA directly and not through additional servers and compilers.

14.12 FINAL TESTS

After the installation and commissioning of the system, the contractor must perform measurements of field strength by an independent institution and perform functional tests of operation with representatives of all services that will use the radio system in the tunnel.

15. SOUND SYSTEM

15.1 SYSTEM DESCRIPTION

The tunnel sound system is intended for notification in case of emergencies, when people are outside the vehicles and when there is no traffic or is stopped. Areas of communication are point-based and limited to key areas.

The tunnel is divided into information zones that are completely independent of each other.

- Zone 1: Portal area North
- Zone 2: Portal area South
- Zone 3: Lay-by niche at EN1
- Zone 4: Lay-by niche at EN2
- Zone 5: Lay-by niche at EN3
- Zone 6: Lay-by niche at EN4
- Zone 7: Lay-by niche at EN5
- Zone 9: Lay-by niche at ECN05
- Zone 10: Lay-by niche next to ECN15
- Zone 11: Lay-by niche next to ECN25
- Zone 12: Lay-by niche next to ECN35
- Zone 13: Lay-by niche next to ECN45
- Zone 14: Lay-by niche next to ECN55
- Zone 15: Cross passage GQ1
- Zone 16: Cross passage EQ1
- Zone 15: Cross passage GQ2
- Zone 16: Cross passage EQ2
- Zone 15: Cross passage GQ3
- Zone 16: Cross passage EQ3
- Zone 15: Cross passage GQ4
- Zone 16: Cross passage EQ4
- Zone 15: Cross passage GQ5
- Zone 16: Cross passage EQ5
- Zone 15: Cross passage GQ6

The system allows pre-recorded messages to be played independently in zones, with a minimum of two different messages in two different coverage zones. The system must programmatically disable the simultaneous playback of messages in zones that would interfere with each other and parallel playback would mean an insufficient level of intelligibility. In this case, the system must play before recorded messages alternately with a corresponding delay between messages.

In addition to pre-recorded messages, the system also allows "live" messaging for additional and specific emergency-related messages that are not well defined in pre-recorded messages.

In order to achieve higher audio signal quality and robust communication in the common IP network, the Interkom Audio transmission system is implemented using the IoIP protocol and is unified with the system of inserting messages into FM radio programs and communication with radio users in the tunnel.

Activation of individual zones and pre-recorded messages is done through a common system Visualization of FM systems for insertion, sound and SOS

For the purpose of "live" messaging, a common console is used for the radio system for inserting messages into FM radio programs and the sound system.

The connection between the Intercom server, consoles and amplifiers is made via a tunnel LAN network.

Transmission between amplifiers and speakers is a classic 100V ELA system due to low losses and interference resistance.

15.2 ELEMENTS OF SOUND SYSTEM:

- Intercom / audio server with software
- amplifying elements and IP input
- speakers on portals
- speakers in the tunnel tube
- speakers in the rescue tunnels

15.2.1 Intercom/audio server

In the Llogara tunnel, common server equipment for radio, sound and emergency call systems is planned.

For greater reliability, there are two servers in the system, the main one in PC North and the back-up PC South. . Project-wise, the two servers are included in the radio system. The purposejob of the server and software is to route traffic between all peripheral IP intercom equipment, store pre-recorded messages, play them, and record communication within the intercom network for possible subsequent event analysis.

For the needs of integration with the SCADA system, it is equipped with a software module that enables integration into the control system via the ICX protocol, so that commands (selection, etc.) and display of equipment statuses are performed via a common screen of the entire system.

All audio communication of the operator via the sound system must be recorded in WAV format and recorded in the database. Audio files must be played via the SCADA control system.

The graphic part of the SCADA interface must be implemented as a stand-alone screen image of the SCADA system, which connects to the process base of servers and through them to any IP amplifier. The system must allow the operator to activate the sound system (pre-recorded playback or "live" messages) within the common SCADA.

The graphical part of the SCADA interface must be implemented as a stand-alone screen image that connects to the process base of the servers and through them to any IP sound amplifier in the tunnel.

For the needs of the sound system, the Interkom server must be equipped with additional licenses

15.2.2 Amplifiers

The use of two different types of amplifiers is envisaged, which differ mainly in output power. To cover the portals, more power is needed, suitable for powering a selected number of external speakers.

A 120W power amplifier is sufficient to cover the portals.

The amplifiers are mounted inside 19 ”RVN cabinets of power plants and niches inside the tunnel.

Significantly lower power is required to cover the tunnel pipe and the restricted zone at the transitions between the tunnel pipe and the escape pipe. Therefore, a 50W amplifier is selected.

Due to the location of the installation and the purpose, the amplifiers must:

- be without forced cooling (fans)
- work in D class to keep equipment heating to a minimum
- have control over their operations
- control the output (line) before a short circuit or open loop
- communicate alarm via SNMP and local indication via LED
- have an IP input compatible with the intercom system used

15.2.3 Speakers in the tunnel tube

The tunnel tube represents an extremely acoustic space with reflections and increased noise. In accordance with the RVS guidelines, only the narrower area of the critical zone needs to be covered in a quality and understandable way. For this purpose, it is necessary to provide just the right power and sound level.

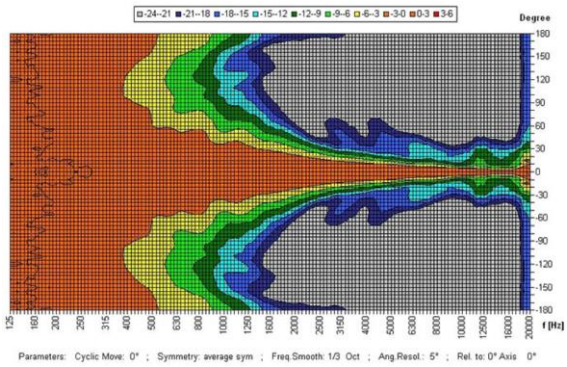
To cover an area with good audibility and not too high volume in the immediate vicinity of the speaker, 3 loudspeakers are needed arranged along the parking space and facing the direction of the driving vehicles.

Basic characteristics:

- Power: 30/20/10/5 (20) W (transformer junctions)
- Impedance: (100V) 333/500/1000/2000 ohm
- Frequency range: 592 - 6,900 Hz
- SPL 1W / 1m, peak 110.1 dB
- SPL, 1W / 4m, peak 98.1 dB
- SPL Pmax / 4m, peak 112.8 dB
- SPL, rated noise power / 4m 96.0 dB
- Sensitivity according to EN54-24, 1W / 4m 85 dB
- Sensitivity according to IEC 268-5, 1W / 1m 97.9 dB
- Dispersion -6dB at 500Hz: h / v 155 °
- Dispersion -6dB, at 1KHz: h / v 110 °
- Dispersion -6dB at 2KHz: h / v 65 °
- Dispersion -6dB, at 4KHz: h / v 35 °

Mounting on V4A "U" bracket. Orientation in the tunnel pipe: -4º vertical (downtilt) / 10 ... 15º horizontal

(towards the center of the carriageway)



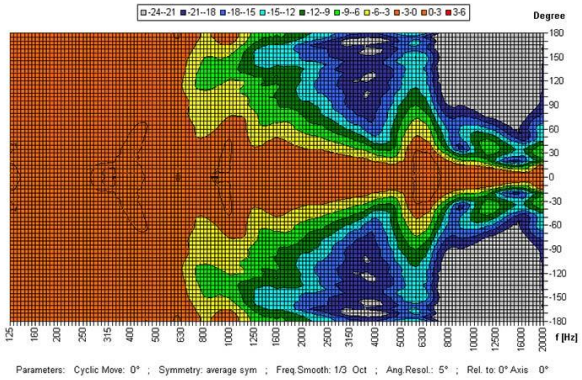
Loudspeakers

15.2.4 Speakers in cross passages

The sound system of the cross passage is intended to direct the evacuation. Due to their smaller dimensions and acoustic characteristics, sound projector speakers are used in the cross passages. Due to restrictions on the maximum allowable power of the SPL, the speakers are connected to the 10W branch of the integrated transformer.

Orientation of speakers in the cross passages: 0 ...- 4º vertical (downtilt) / 10 ... 15º horizontal (towards the middle of the cross passage)

- Power 20/10/5/2.5W (transformer junction)
- Impedance (100V) 500/1000/2000/4000 ohm
- Frequency Range 150 - 20,000 Hz
- Frequency Response 120 - 21,000 Hz
- SPL 1W / 1m, peak 99.5 dB
- SPL, 1W / 4m, peak 87.5 dB
- SPL Pmax / 4m, peak 100.5 dB
- SPL, rated noise power / 4m 89.0 dB
- Sensitivity EN54-24, 1W / 4m 75.0 dB
- Sensitivity EN54-24, 1W / 1m 87.0 dB
- Dispersion -6dB, 500Hz 360 °
- Dispersion -6dB, 1KHz 230 °
- Dispersion -6dB, 2KHz 110 °
- Dispersion -6dB, 4KHz 58 °



Speaker projector

15.2.5 Speakers on portals

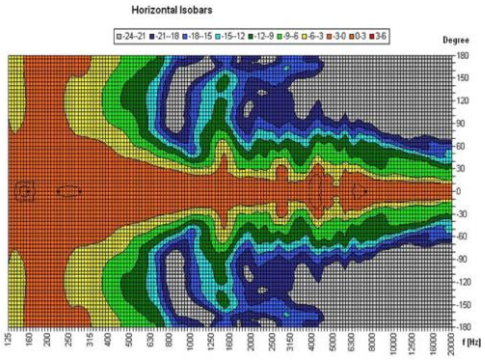
Speakers intended to cover the area outside the tunnel must be suitable for conditions where the propagation of sound is completely different from that in tunnels. Therefore, the frequency characteristics must be different. The need for orientation is also different.

To achieve a sufficient sound level and a wide frequency spectrum, which contributes to the intelligibility of speech, 2 track speakers (horns) are used on the portals.

Basic characteristics:

- Power: 30/15 / 7.5 / 3.75 W (branches on the transformer)
- Impedance: (100V) 333/667/1333/2667 ohm
- Frequency range: 237 - 21,100 Hz
- SPL 1W / 1m, peak 101.8 dB
- SPL, 1W / 4m, peak 89.8 dB
- SPL Pmax / 4m, peak 104.5 dB
- SPL, rated noise power / 4m 100.0 dB
- Sensitivity according to EN54-24, 1W / 4m 86.0 dB
- Sensitivity according to IEC 268-5 :, 1W / 1m 98.1 dB
- Dispersion -6dB at 500Hz: 190 ° (h) 205 ° (v)
- Dispersion -6dB at 1KHz: 70 ° (h) 90 ° (v)
- Dispersion -6dB at 2KHz 85 ° (h) 90 ° (v)
- Dispersion -6dB at 4KHz 80 ° (h) 110 ° (v)

Mounting on V4A support bracket. H orientation, 2 trumpets one above the other. On each side of the tunnel pipe portal. Orientation 0… -5º vertical (downtilt) / 0 ... 10º horizontal (towards the center of the carriageway)



Speaker horn 2 - portal

15.2.6 Sound system microphone consoles

The sound system uses the same microphone consoles (on workstations, auxiliary workstations and service consoles), which are also intended for inserting messages into FM radio programs and are described in the chapter "Radio system".

EE972 table console

EE971 service console

15.2.7 Connection to SCADA

The control system supervises the operation of the tunnel sound system and its individual elements. Capturing the status of the sound equipment is performed by the server S3, which transmits alarm states to the control system via the SNMP protocol.

16. EMERGENCY CALL SYSTEM

The emergency call system is designed to establish a voice connection from a specific location (voice terminal inside the tunnel) with the control center. The safety of users depends on the smooth operation of this system. The technical solution must ensure the smooth operation of the system regardless of different operating conditions. The system is intended for users who need help in the event of any accident or. failures inside the tunnel.

The emergency call system is intended for emergency communication between the driver and the supervisory center in the event of an emergency in a tunnel or near a portal.

SOS consoles are located in:

ECN - Emergency Call Niche: ECN01, ECN02, ECN03, ECN04, ECN05, ECN07, ECN09, ECNx10, ECN12, ECN14, ECN15, ECN17, ECN19, ECNx20, ECN22, ECN24, ECN25, ECN27, ECN29, ECNx30, ECN32, ECN34, ECN35, ECN ECNx40, ECN42, ECN44, ECN45, ECN47, ECN49, ECNx50, ECN52, ECN54, ECN55, ECN57, ECN59

ECS - Emergency Call Station: ECS02, ECS06, ECS08, ECS11, ECS13, ECS16, ECS18, ECS21, ECS23, ECS26, ECS28, ECS31, ECS33, ECS36, ECS38, ECS41, ECS43, ECS46, ECS51, ECS53, ECS56, ECS58, ECS-GQ1, ECS EQ1, ECS-GQ2, ECS-EQ2, ECS-GQ3, ECS-EQ3, ECS-GQ4, ECS-EQ4, ESC-GQ5, ECS-EQ5, ECS-GQ6

Emergency Call Booths on the portals: 4x

The emergency call system is built around the Interkom server with the appropriate software.

Transmission to consoles is IP via the tunnel LAN. There are IoIP or VoIP interfaces in the ECN. The connection between emergency call terminals and interfaces is 2wire digital to achieve better audio signal quality and resistance to external interference.

The emergency call system must meet the highest standards and must perform Self Monitoring of key elements:

- Line Monitoring checks the connections between the Intercom stations and the Server.
- The Intercom stations run continuous tests on the signal path between their loudspeaker and microphone
- Self-testing buttons for critical functions perform regular button activation simulation tests
- To protect Intercom stations against vandalism, sabotage detection switches will trigger an alarm at the Control Desk if the device is tampered with
- Server monitoring and redundancy ensure the required high availability

16.1 ELEMENTS OF THE EMERGENCY CALL SYSTEM:

- Intercom / audio server with software
- Software interface for connection to the Visualization system
- IoIP / VoIP interfaces
- Intercom industrial consoles

16.1.1 Interkom server with software and licenses

In the Llogara tunnel, common server equipment for radio, sound and emergency call systems is planned.

For greater reliability, there are two servers in the system, the main one in PC North and the back-up PC South. Project-wise, the two servers are included in the radio system.

The purpose of the servers and software is to route traffic between all peripheral IP intercom equipment, store pre-recorded messages, play them, and record communication within the intercom network for possible subsequent event analysis.

Software is running on the server for the needs of the emergency call system, which enables:

- SIP Server
- Master Concentrator (process base)
- SQL data server (database)
- Voice recorder

The server software must allow the system to be set up, managed, maintained and automatically tested. The server must perform data storage functions in the SQL database.

All calls must be recorded in WAV format and recorded in a database. Audio files must be played via the SCADA control system.

The graphic part of the SCADA interface must be implemented as a stand-alone screen image of the SCADA system, which connects to the process base of servers and through them to any VoIP interface. The system must allow the operator to receive calls within the common SCADA.

The management interface must connect to the database to allow calls to be displayed and played.

The integration of an emergency call into a common SCADO must cover the following functions

- graphical display of the emergency call signal from the voice set with the handset (making a call to a specific place
- conversation via a handset connected to the SCADA system with a user in the tunnel
- answering calls
- played archive calls

For the purposes of integration with the Visualization System (SCADA), the server is equipped with a software module that enables integration via the ICX protocol, so that commands (selection, etc.) and display of equipment statuses are performed via a common screen of the entire system.

For the needs of the emergency call system, the Interkom server must be equipped with additional licenses:

- IP end users (consoles, interfaces)
- recording communication on SOS consoles
- ICX interface for connection to the Visualization system

16.1.2 IoIP/VoIP interfaces

IoIP or VoIP interfaces are located in the portal building North and the portal building South, where they are installed in a common cabinet with radio system equipment. In the tunnel, they are installed in emergency call niches (ECN). At these locations, they are connected to the tunnel's Ethernet network via data data switches.

Interface features:

- Operating temperature range: –10 ° C to +50 ° C
- Relative humidity: up to 80%
- Connection:
    - IP uplink and IP downlink
    - Intercom 2-wire Digital
    - shielded RJ45 modular jacks with LEDs
    - for Intercom additional pluggable screw terminals
    - Power supply: 24 VAC ± 5% or 28 - 35 VDC
    - Protocol: IoIP protocol based on UDP / IP
    - Data rate: 2 x 10/100 MBit / s (full / half duplex)

For connectivity to the central system, the interface must support the following standard protocols:

- SIP protocol for VoIP PBX (RFC 3261)
- RTP and STUN protocols for VoIP audio transmission (RFC 3550)
- NTP, SNMP, syslog protocols (time synchronization, network management, event logging)
- IEC 60870-5-104 protocol, Modbus / TCP

The connection between the IoIP / VoIP interface and the emergency call terminals is made with a 2x0.8mm2 twisted pair cable, through which the digital connection and also the power supply of the consoles take place.

16.1.3 Emergency call terminal:

Features:

- handset
- compatible with Interkom software
- communication via IoIP or VoIP protocol
- with self-monitoring / self-testing function
- 2wire Digital communication
- audio transmission: 200 - 16,000 Hz
- Sound pressure: 90 dB / 1 W / 1 m / 1 kHz
- programmed according to functional requirements

17. EMERGENCY CALL CABINS AND CABINETS

17.1 EMERGENCY CALL CABINS

A type-tested, prefabricated cabin is installed in the construction-treated opening in the wall of the tunnel tube. The cabin provides space for the installation of a call set (handset, and associated electronics) of the emergency call system. The cabin also provides space for the installation of other devices of control and monitoring systems in the tunnel, which are installed in the distributor of safety devices, which is an integral part of the cabin.

The space between the front of the cab and the construction opening is closed with sheet metal cladding.

A total of 35 emergency call booths are planned in the tunnel.

The entire cab is made of stainless steel V4A (in accordance with material No. 4571 according to DIN 17440) reinforced with load-bearing profiles and frames and corrosion-protected. Also, all other fastening material, including screws, as well as other equipment such as e.g. hinges, magnetic switches and V4A stainless steel latches.

The entire structure must be highly resistant to mechanical stresses, e.g. due to throwing stones, overpressure or. vacuum due to passing vehicles and other environmental influences in accordance with the requirements of RVS 09.01.24.

The entire emergency call booth must be anti-corrosion protected with powder coating, application thickness min. 120 µm.

Color of doors, fire extinguishers and fronts: orange RAL 2004.

Other: gray RAL 7023

The cabin consists of:

- the front side in which there is a glazed door and a cabinet with fire extinguishers in which two fire extinguishers are installed. There is space under the cabinet door for the installation of a manual fire detector and an SOS button. A manual fire detector is supplied as part of the fire alarm project.
- double installation floor
- safety devices electrical cabinet
- frame and sheet metal wall and ceiling coverings
- recessed fluorescent lamp 2x13 W built into the cabin ceiling

Cab front protection with IP65 door.

<u>Warning sign in the cabin</u>

A warning sign in Albanian and English shall be placed inside the cab:

»There is no fire protection in this cabin. Follow the signs to the emergency exits «

The size of the board should be 400 x 450mm (width x height). The board should be RAL 1015 with letters and frame (15mm) in RAL 3020, with letter height 25mm or 15

Emergency call cabin doors:

Dimensions: 2000 x 1000 mm (height x width)

Single-leaf door made of painted stainless V4A sheet metal, min. 1.5 mm, sandwich construction min. Thickness 40 mm, safety glas (min. 65x160 cm). The glass is built into the door leaf with the help of a rubber profile. The door leaf is equipped with a self-closing mechanism and an over-open door limiter. The self-closing mechanism must ensure complete and tight closing of the door even at an opening of 10 cm. The gardens open outwards, to the left (in the direction of travel). It must be possible to open the door effortlessly even in case of overpressure or vacuum in the tunnel due to passing vehicles.

The door is equipped with a triple latch (in the middle and at the top and bottom of the door leaf), without the possibility of locking. The sealing of the entire door leaf is done with double seals.

The door hinges are reinforced due to the high mechanical stresses inside the road tunnels.

The door is monitored by a magnetic sensor that signals the door opening to the control system.

Partition with fire extinguishers

On the right side in the upper part of the front side of the cabin there is a built-in cabinet with fire extinguishers. The cabinet has a glazed door measuring approximately 800 x 600 mm (height x width) with safety glass. The glass is installed with the help of a rubber profile. Behind the door are two powder fire extinguishers (6 kg and 9 kg). The supply of fire extinguishers is included in the machine plan. The fire extinguisher is controlled by a lift sensor that is included in the fire alarm system. The opening on the cabinet door must be countersunk. The compartment door has a double latch (top and bottom) and has a double seal. The inside of the cabinet is illuminated with a 1x9W fluorescent lamp.

Also, a magnetic switch is installed on the cabinet door with fire extinguishers.

Safety devices electrical cabinet

The safety device cabinet consists of two parts and is intended for the installation of devices and parts of tunnel guidance and control systems. The left part has dimensions of approx. 800x2000x500 mm, and the right part 700x2000x500 (WxHxD), with the available width in the upper part due to the compartment for fire extinguishers being approx. 430 mm.

Depending on the location, video surveillance and video detection equipment, optical transmission equipment, a data switch, an optical patch panel and a local control system station are installed in the left part of the cabinet. In the lower part of the cabinet, there is a built-in power supply with a main switch, surge arresters, circuit breakers and sockets. (main switch, service socket, surge protection, 16x10A fuse and 6x16A fuses)

In the right part, other electronic equipment is installed. The call set of the emergency call system is built into the upper part of the door of the right part.

Cable entry from the bottom and from the top through the glands. All manifold doors have a cylinder lock and a triple latch (in the middle and above and below).

Double floor

The double floor in the cabin is made of stainless steel V4A, covered with a rubber tread. The double floor has a built-in flap to access the cable space below it.

Other sheet metal linings

All sheet metal linings necessary to close or seal the emergency call booth shall be installed. They consist of painted sheets as described above. The profiles that may be required to achieve the required strength shall be taken into account.

Painted sheet metal, like doors, is resistant to heavy mechanical stresses, such as throwing stones, and to all other environmental influences.

17.2 EMERGENCY CALL STATION CABINET

The emergency call station cabinet is recessed in the wall of the tunnel and is made of stainless steel V4A, no. 1.4571, dimensions approx. 1600x800x300 mm (wxhxd). Sheet thickness 1.5 mm. Degree of protection IP65. The color of the cabinet is light orange (RAL 2004).

The cabinet consists of two separate compartments for the installation of two fire extinguishers 9 and 6 kg and an emergency call terminal. A fluorescent lamp is installed in both compartments.

Between the two compartments there is a space for the installation of electrical equipment (video, optical splitter, power supplies,…). An SOS button and a manual fire detector are installed on the lid of the middle compartment.

The emergency call terminal will be installed in the prepared panel in the corresponding compartment of the cabinet.

To open, the doors of both compartments are equipped with a recessed handle.

The cable entry into the cabinet is through sealed glands.

17.3 EMERGENCY CALL BOOTH ON PORTALS

In the area of the portals, an emergency call booth is placed on each side of the carriageway, in which an emergency call terminal, two 6 and 9 kg fire extinguishers, a manual fire call point and an SOS button are installed. A ceiling lamp is installed in the booth to illuminate the booth. Material V4A.

17.4 EMERGENCY CALL PILLAR IN CROSS PASSAGES

In the cross passage an emergency call pillar will be installed. In the pillar (free standing cabinet) an emergency call terminal is installed and on the outside a manual fire call point and and SOS push button are installed. Material V4A.

18. OTHER

18.1 SOS PUSH BUTTONS

In front of the emergency call booths (emergency call niches), on the emergency call station cabinets, in the emergency call booths next to the portals in addition to the fire alarm call point SOS push buttons are installed. The keys are of the same dimensions and design as the fire call point push buttons.

The SOS push button has dimensions of approx. 80 x 80 mm with round knob diameter approx. 40 mm and built-in LED. The blue LED lights up permanently and flashes when the alarm is triggered. The designation of the SOS button is made with a fluorescent sticker in the "HI" version with the inscription "SOS". The degree of protection of the button is IP 65. The SOS push buttons are the same design as the manual fire call points, only in blue.

The power supply of the SOS push button illumination is carried out jointly with the power supply of the fire alarm push buttons at the same locations and is processed in the fire alarm plan.

The SOS push buttons are connected directly to the corresponding local station.

18.2 OTHER SIGNALS

Other signalings include the connection of other signals to the tunnel control system.

The following signals are expected to be connected:

- measurement of temperature and humidity in the battery and control room of the portal buildings
- opening the door to the emergency call niches in the tunnel
- opening the door of the emergency call station cabinets in the tunnel
- opening the drawer door with fire extinguishers on the front of the emergency call niches
- opening the emergency call booth door in front of the tunnel
- activating SOS push buttons
- fire water system signals.

For this purpose, magnetic switches are installed on all doors.

All signals are connected to the control system via the nearest local station.

18.3 ELECTRICAL CABINETS

The following electrical cabinets are provided for the installation of safety equipment:

18.3.1 Server cabinet

- frestanding metal construction
- width 800 mm
- depth 1000 mm

- height 42HE (2070 mm)
- cover with opening for installation of refrigeration unit
- cooling unit
- 19 "front and rear profiles
- vertical cable guide
- bottom shelf
- removable sides, perforated front
- removable rear door with perforation
- glass front door in a metal frame with perforation
- cable entry through the double floor
- with the following power supply equipment installed: main switch, surge arresters such as e.g. Protec C, service socket, 3x installation circuit breaker 16A, 16x installation circuit breaker 10A, 19 "sockets with sockets, wired set with terminals

18.3.2 Safety devices cabinet

- Freestanding cabinet 700x700x2000, with load-bearing frames for mounting communication and power supply equipment in 19 "grid,
- Mounting plate for mounting other equipment
- cable editors,
- main switch 25 A
- surge arresters such as e.g. Protec C
- 11W lamp with limit switch on the door
- heater with thermostat
- 1x service socket
- 3x circuit breaker 16A
- 16x circuit breaker 10A
- set wired with terminals

Annex A – Control matrix of traffic signalisation

Remark:

– "-": the event does not affect the operation of the traffic equipment item
– Normal condition of individual elements of traffic equipment:
- Traffic light: green
- 4 – display variable traffic sign: 80 km / h.
- 1 - display variable traffic sign: overtaking for all vehicles is prohibited
- 2 – display lane control– on the right driving lane: green arrow
- 2 – display lane control– on the overtaking lane: red cross

– LED markers: constantly lit.

CONTROL MATRIX OF TRAFFIC SIGNALISATION

Event in the tunnel	Traffic signs – portal area					Traffic signs – inside the tunnel			
	Traffic light	Lane control sign – on the right driving lane	Lane control sign – on the overtaking lane	Variable 4 – display traffic sign	Variable 1 – display traffic sign Overtaking prohibited	Variable 4 – display traffic sign	Variable 1 – display traffic sign Overtaking prohibited	Traffic light	LED markers
Fire alarm – linear detection	Red	X	X	STOP	Off	STOP – in front of the fire location	Off	Red – in front of the fire location	Blinking
Fire alarm – manual alarm or automatic point alarm in the tunnel	Red	X	X	STOP	Off	STOP – in front of the fire location	Off	Red – in front of the fire alarm location	Utrip
Extinguisher raise	Red	X	X	STOP	Off	STOP – in front of the fire location	Off	Red in front of the alarm location	Utrip
Manual fire alarm from the operator	Red	X	X	STOP	Off	STOP – in front of the fire location	Off	Red in front of the alarm location	Utrip
Niche door opening in the tunnel	Yellow blinking	↓	X	60 blinking	-	60 blinking	-	Yellow - blinking	-
Extinguisher cabinet door opening	Yellow blinking	-	↓	X	60 blinking	-	60 blinking	-	Yellow - blinking	-
Croos passage door opening	Yellow blinking	-	↓	X	60 blinking	-	60 blinking	-	Yellow - blinking	-
Emergency call activation	Yellow blinking	-	↓	X	60 blinking	-	60 blinking	-	Yellow - blinking	-
SOS push button activation	Yellow blinking	-	↓	X	60 blinking	-	60 blinking	-	Yellow - blinking	-
AID – pedestrian or stopped vehicle alarm	Yellow blinking	-	↓	X	60 blinking	-	60 blinking	-	Yellow - blinking	Utrip
CO measurement – alarm value	Red	X	X	STOP	Off	60 blinking	Off	Yellow - blinking	-
Visibility measurement – alarm value	Red	X	X	STOP	Off	60 blinking	Off	Yellow - blinking	-

Annex B – Basic specification of tunnel ventilation software

Content

1. GENERAL INFORMATION

1.1 SCOPE OF THE DOCUMENT

The scope of this document is the description of the methodological approach for ventilation control of the Llogara tunnel for normal and incident operation modes during bidirectional traffic use. This specification gives the minimum requirements (a basic specification) of the tunnel ventilation control system. Other tunnel systems – e.g., traffic control signals, etc. – are not considered in this document.

The following general principles are considered during normal operation:

- In any traffic situation, the health of tunnel users and operating personnel may not be influenced negatively during their stay.
- To allow safe driving, the necessary visual range must be maintained.
- Reduce the operating and maintenance cost to a minimum

In case of fire procedure:

- The escape routes must be kept free from smoke to allow self-rescue.
- The activities of emergency services must be supported by providing the best possible conditions over a sufficient time.
- The extent of damage and injuries (to people, vehicles, and the tunnel structure itself) must be kept to a minimum.

The following step to this functional specification should be the technical detail specification which has to be created by the contractor. The design, the layout and basic information of the tunnel are provided in report of detail design of ventilation system [1].

1.2 Technical standards and guidelines

All ventilation considerations are based on European standards and regulations. The EU directive (2004/54/EC) provides the basic requirements. Additional more detailed specifications are made by the RVS. The Austrian guideline (RVS) gives more detailed specifications at component level and detailed information's concerning the operation. In addition to the guidelines the best available techniques are considered.

Since European standards in some cases contain deviating specifications, the ventilation system was designed based on the RVS. The RVS contains the most detailed and extensive specifications on ventilation, operation, and safety. RVS based used has been used both in many tunnels in Europe and for design of tunnels worldwide.

1.3 Ventilation basics

The ventilation basics can be found in in report of detail design of ventilation system [1].

1.4 General Information concerning the ventilation system of main tube

The Llogara tunnel is nearly 6 km long road tunnel used under bidirectional traffic in main tube. The tunnel is equipped with a semi-transverse ventilation system to fulfil the requirements of the European standards. In case of fire smoke can be extracted by using the dedicated exhaust duct. The longitudinal air flow can be controlled by jet fans in carriageway. They push the smoke from both sides to the extraction point with little back-layering taking place, but it might prevent filling up with smoke the whole tunnel section.

The duct is connected to ventilation stations, one each portal. Where each an axial fan is located. Dampers in the false ceiling between the carriageway and the air duct have a standard distance of 100 m. In case of fire the smoke can be punctually extracted in a very efficient way. Air quality and air speed sensors are installed for use in normal operation.

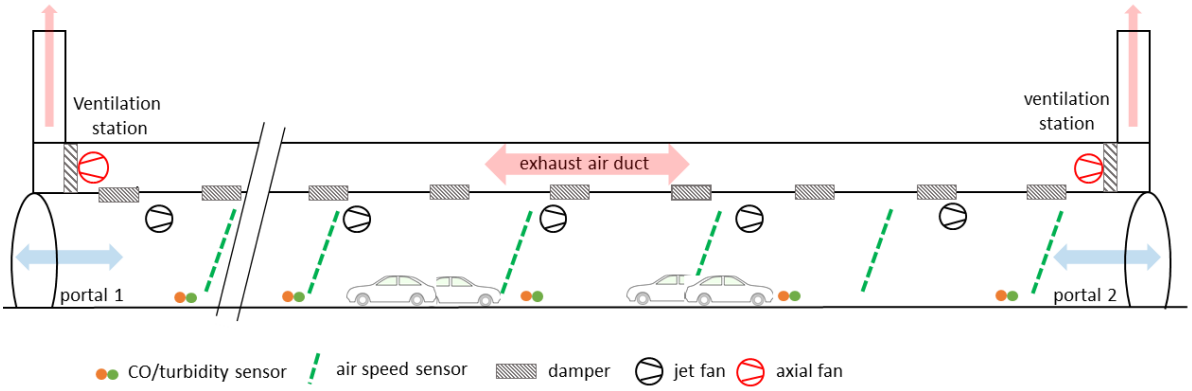


Figure 1: Overview of semi-transverse ventilation system

1.4.1 Ventilation strategy

1.4.1.1 NORMAL OPERATION MODE

Normal operation fundamentally means automatic control of the ventilation system. The ventilation system must be operated according to the principles of economic efficiency and provide consistent air quality. Control of ventilation system is based on measured in-tunnel air quality values (carbon monoxide and turbidity). The ventilation must provide a sufficient air flow to keep the air quality below the threshold values. Monitoring of the ventilation is performed with a closed loop controller in an automatic stage. The average value of the in-tunnel parameter (CO, turbidity) must be compared to the target values. A manual possibility for ventilation control must be provided via

SCADA system. During normal operation jet fans should always operate in pairs (right and left side in each bay together) with same rotational speed to prevent negative influence on road users such as motorcycles.

Two operating modes are required during normal operation:

Stage one "Longitudinal ventilation" (low traffic volume):

System is working as longitudinal ventilation system (without air extraction). This is used during low and medium traffic volume. Air from one tunnel portal will be pushed into the tunnel to dilute the exhaust gases. At bidirectional traffic, the existing flow direction must be maintained. The flow is forced by the jet fans. Axial fans are shut down and all exhaust dampers are closed. The jet fans are activated in actual flow direction. This can be either to north or to south, depending on direction at the moment of request. But all necessary jet fans are activated in same direction.

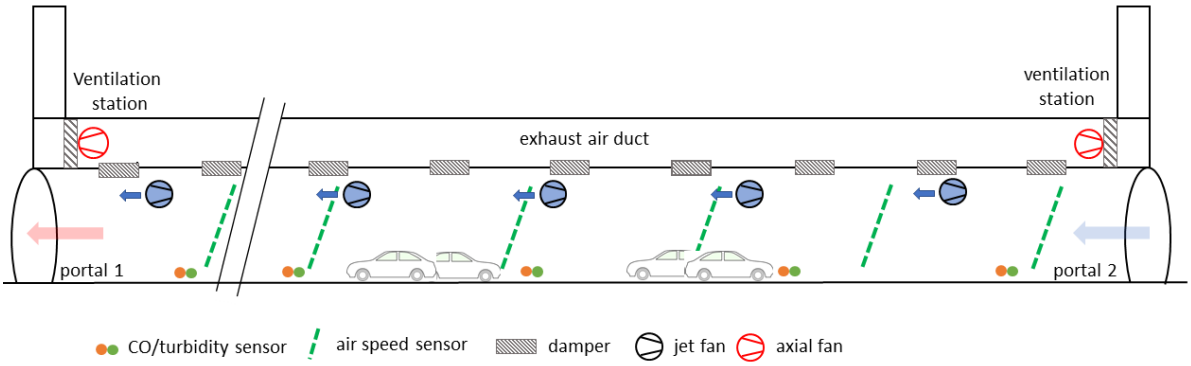


Figure 2: Principle normal operation – stage 1

Stage two "air extraction" (high traffic volume):

System is working as longitudinal ventilation system combined with an air extraction (combined semi-transverse system). This is necessary during high traffic volume or special events with high need of fresh air. Fresh air from both portals will enter the tunnel. The air in highest polluted area is extracted through the air duct. The jet fans provide the right flow to the opened damper (50% from each side).

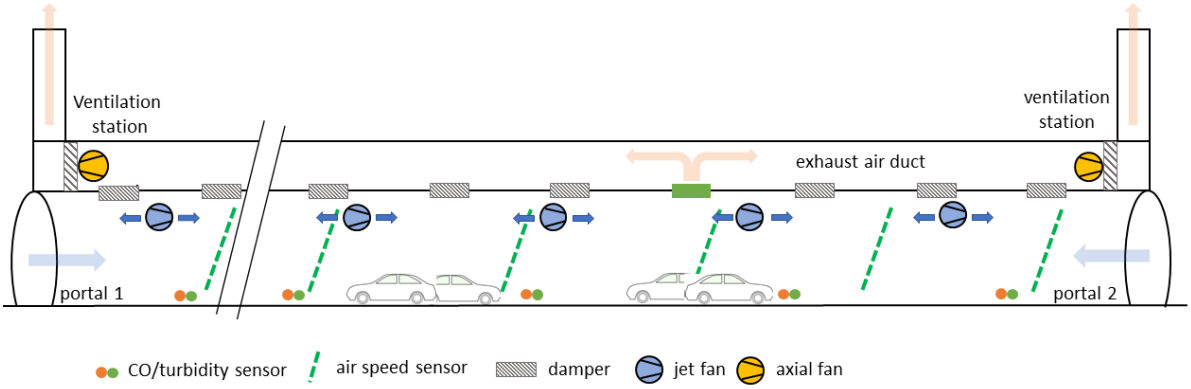


Figure 3: Principle normal operation – stage 2

1.4.1.2 FIRE PROCEDURES

The fire procedures will be done in automatic stages from PLC System (a manual intervention on request must always be possible from the tunnel operator) by one or more closed loop controllers.

In case of fire smoke will be extracted right at fire location through one damper. The nearest to the fire will open, all others will be closed. If the fire location is near the portal only one axial fan is used for extraction. At other locations both fans are used. The volume flow will be split on both fans. The ratio is depending on exact extraction location. A balance between volume flow and pressure rise is needed. The design volume flow can be found in report of detail design [1].

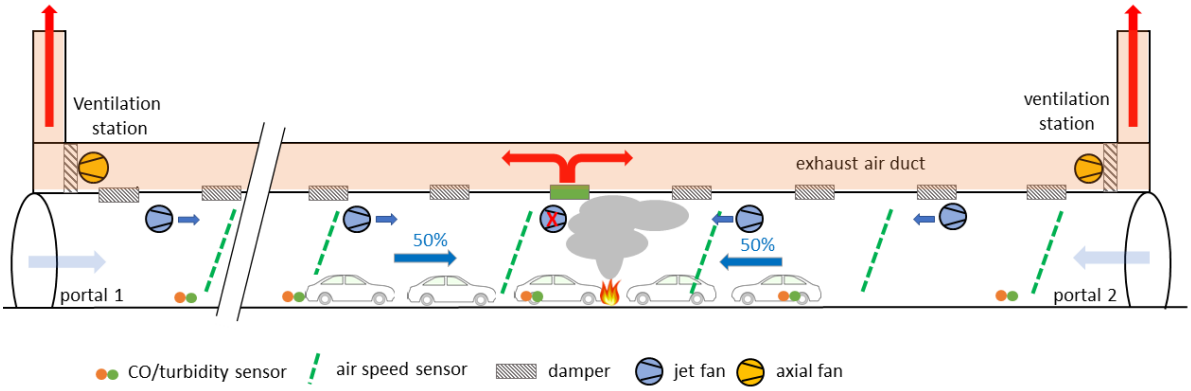


Figure 4: Principal fire ventilation – fire location in middle of the tunnel

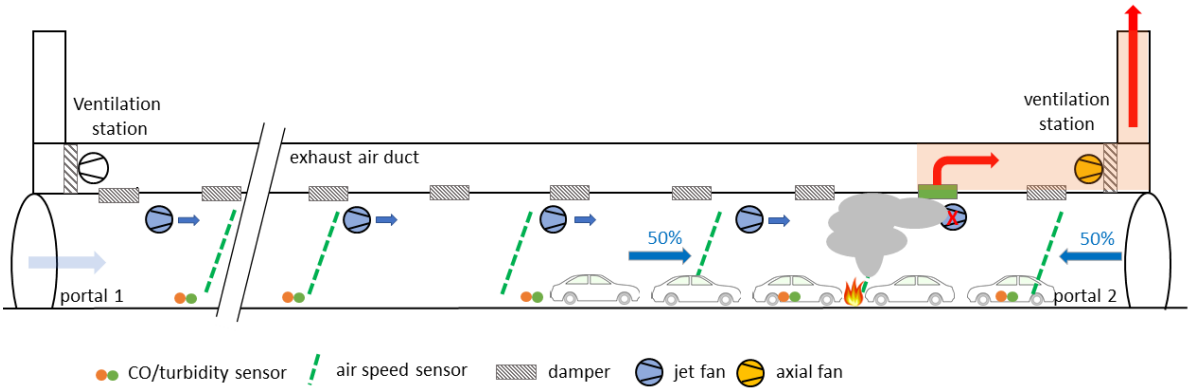


Figure 5: Principle of fire ventilation – fire location within 900 m at portal

During fire procedure the jet fans are necessary to adjust the flow to the damper on both tunnel sides. In situations of high meteorological pressures at one portal, or if the extraction point is located not exactly in the middle of the tunnel or close to a portal, a large part or the volume flow would come from one side. The other part of the tunnel will not be ventilated, or the damper will get overflow from this side. These scenarios will result in uncontrolled smoke spread if no jet fans are used for correction. During fire procedures the jet fans in the direct area of fire or in the possible smoke area must remain switched off to avoid destroying the smoke layer. This must be done automatically by the control system.

To achieve the correct results for fire procedures, it is necessary to detect the fire at the correct location. The location is decisive for the activation of the correct automatic fire incident ventilation procedure. An automatic starting procedure is only allowed if the exact location of the fire is known (stationary location of the fire, no moving fire sources).

Several redundancy procedures are included in the ventilation system to ensure a safe evacuation during fire scenario even if parts of system are down. If a part of the systems fails another component can take over the function with no or a very little loss in safety.

1.5 General information concerning the ventilation system of service tube

Most of time the service tube will ventilate itself by natural ventilation. But in some cases, and during maintenance work inside, a mechanical ventilation system is required get sufficient fresh air inside. A simple longitudinal ventilation system is provided to handle normal operation. Small jet fans, air speed and air quality sensors are installed. No fire scenario is considered.

At the portals of service tunnel gates are installed. During active ventilation in service tunnel (the jet fans are active) the gates must open automatically. On the other hand, to ensure the air supply for air locks during normal and fire operation dampers will be installed beneath these gates.

1.5.1 Basic operating principle of service tube

Normal operation mode (if air lock is used to prevent ingress of dirt, otherwise the system is not running during normal operation):

- Air lock ventilation is activated.
  The jet fans in the service tunnel are deactivated, the ventilation unit of the air lock system extracts fresh air from the service tunnel. The air supply for the cross-passage ventilation is provided through the opened dampers on each portal of service tube. Additionally, the service tube is ventilated from the fresh air flow to the air locks.
    - Dampers on one portal of service tube is open
    - Gates on portals are closed

1.5.2 Maintenance operation mode of service tube:

- Maintenance work
  To guarantee sufficient air quality the gates at the portal will be opened. The flow sensors in the service tube measure the air velocity inside the service tunnel. If the measured velocity is below 1 m/s the jet fans will be activated in direction of actual flow. If bad air quality is detected from the sensor the fans will be activated too.
    - Dampers on both portals of service tube are closed
    - Gates on portals are open

1.5.3 Fire operation mode in main tube:

- Service tube acts as escape route
  The basic procedure corresponds to the normal operation. In this case the jet fans must be deactivated, and the protection damper will be opened. At the same time, it must be ensured that the gates will be closed automatically, if open.
    - Damper on one portal of service tube is opened (depending on fire location)
    - Gates on portals are closed

2. DEFINITIONS

2.1 Priorities

To define the switching order of ventilation equipment, e.g., jet fans, air speed sensors, exhaust dampers, priorities are used. The equipment with the highest priority has the number 1. The lower the priority, the higher the number will be. Equipment with priority number 0 will be kept switched off.

Table 1: Priorities

Priority	Value
0	switched off / don‘t use
1	highest priority
2	second highest priority
3	third highest priority
4	…

2.2 General agreement for coordinates

To achieve a uniform definition, the following agreement is made (for both tubes):

- Ventilation equipment, fire zone etc. are consecutively labeled, starting from the north.
- Direction from north to south is positive (e.g., flow direction in carriageway, jet fan activation)
- Flow direction towards the axial fan is positive.

3. LAYOUT OF THE TUNNELS

3.1 Location of the jet fans

The technical data of the jet fans can be found in the report “detail ventilation design” [1]. The exact position inside the tunnel is listed in Table 2.

Table 2: Location of jet fans – main tube

Tunnelmeter from NP [m]	Jet fan	Block Number
0 (north portal)		
1080.75	JFM 1.1, JFM 1.2	K088
2080.75	JFM 2.1, JFM 2.2	K168
3080.75	JFM 3.1, JFM 3.2	K248
4080.75	JFM 4.1, JFM 4.2	K328
5080.75	JFM 5.1, JFM 5.2	K408
5959.85 (south portal)		

Table 3: Location of jet fans – service tube

TM from north portal [m]	Jet fan
0	north portal
1007	JFS 1.1 / 1.2
2007	JFS 2.1 / 2.2
5012	JFS 3.1 / 3.2
5986.89	south portal

3.2 Location of air quality measurement

The air quality measurement equipment consists of devices for measuring CO (carbon monoxide) and turbidity (extinction of light). The position inside the tunnel is listed in the following tables:

Table 4: Location of air quality sensors – main tube

Tunnelmeter from NP [m]	CO, TR	Block Number
0 (north portal)		
190.00	COM 1,TRM 1	K017
1043.00	COM 2,TRM 2	K085
2043.00	COM 3,TRM 3	K165
3043.00	COM 4,TRM 4	K245
4043.00	COM 5,TRM 5	K325
5043.00	COM 6,TRM 6	K405
5770.00	COM 7,TRM 7	K463
5959.85 (south portal)		

Table 5: Location of air quality sensors – service tube

TM from north portal [m]	Air quality sensor
0	north portal
180	COS 01 / TRS 01
3015	COS 03 / TRS 03
5800	COS 03 / TRS 03
5986.89	south portal

3.3 Location of air speed sensors

There are several flow measuring sections inside the main tunnel. On each location three devices are installed. The distance between the devices is about 15 m. The PLC system can use the device information from three devices at once for permanent plausibility check of these three sensors. If an sensor is faulty it will be excluded from PLC until it is in operation again.

The plausibility check should be done during normal and incident operation. The detailed operation can be seen in chapter 4.2.9. The placement of devices can be seen in the following tables. The measurement equipment in service tube no need of plausibility check is given. The technical data of the equipment can be found in the report “detail ventilation design” [1].

Table 6: Location of air speed sensors – main tube

Tunnelmeter from NP [m]	LG	Block Number
0 (north portal)		
165.00	FSM 1.1	K015
180.00	FSM 1.2	K016
195.00	FSM 1.3	K017
765.00	FSM 2.1	K063
780.00	FSM 2.2	K064
795.00	FSM 2.3	K065
1765.00	FSM 3.1	K143
1780.00	FSM 3.2	K144
1795.00	FSM 3.3	K145
2765.00	FSM 4.1	K223
2780.00	FSM 4.2	K224
2795.00	FSM 4.3	K225
3765.00	FSM 5.1	K303
3780.00	FSM 5.2	K304
3795.00	FSM 5.3	K305
4765.00	FSM 6.1	K383
4780.00	FSM 6.2	K384
4795.00	FSM 6.3	K385
5765.00	FSM 7.1	K463
5780.00	FSM 7.2	K464
5795.00	FSM 7.3	K465
5959.85 (south portal)		

Table 7: Location of air speed sensors – service tube

TM from north portal [m]	Sensor
0	north portal
350	FSS 01
5700	FSS 02
5986.89	south portal

3.4 Location of fire zones

A fire inside the tunnel is detected by the LHD (linear heat detector). In order to allocate the actual position of the fire the LHD is separated in predefined zones. Depending on the triggered fire zone an appropriate ventilation scenario will be chosen (selection of nearest damper, right air flow sensors and jet fans, …). The definition of the fire zones is given in the following table.

Table 8: Location of fire zones – main tube

Tunnelmeter from north portal		dl [m]	Fire zone	Tunnelmeter from north portal		dl [m]	Fire zone
starting at	ending at			starting at	ending at		
0 (north portal)	130.75	130.75	FZ 01	3030.75	3130.75	100	FZ 31
130.75	230.75	100.00	FZ 02	3130.75	3230.75	100	FZ 32
230.75	330.75	100.00	FZ 03	3230.75	3330.75	100	FZ 33
330.75	430.75	100.00	FZ 04	3330.75	3430.75	100	FZ 34
430.75	530.75	100.00	FZ 05	3430.75	3530.75	100	FZ 35
530.75	630.75	100.00	FZ 06	3530.75	3630.75	100	FZ 36
630.75	730.75	100.00	FZ 07	3630.75	3730.75	100	FZ 37
730.75	830.75	100.00	FZ 08	3730.75	3830.75	100	FZ 38
830.75	930.75	100.00	FZ 09	3830.75	3930.75	100	FZ 39
930.75	1030.75	100.00	FZ 10	3930.75	4030.75	100	FZ 40
1030.75	1130.75	100.00	FZ 11	4030.75	4130.75	100	FZ 41
1130.75	1230.75	100.00	FZ 12	4130.75	4230.75	100	FZ 42
1230.75	1330.75	100.00	FZ 13	4230.75	4330.75	100	FZ 43
1330.75	1430.75	100.00	FZ 14	4330.75	4430.75	100	FZ 44
1430.75	1530.75	100.00	FZ 15	4430.75	4530.75	100	FZ 45
1530.75	1630.75	100.00	FZ 16	4530.75	4630.75	100	FZ 46
1630.75	1730.75	100.00	FZ 17	4630.75	4730.75	100	FZ 47
1730.75	1830.75	100.00	FZ 18	4730.75	4830.75	100	FZ 48
1830.75	1930.75	100.00	FZ 19	4830.75	4930.75	100	FZ 49
1930.75	2030.75	100.00	FZ 20	4930.75	5030.75	100	FZ 50
2030.75	2130.75	100.00	FZ 21	5030.75	5130.75	100	FZ 51
2130.75	2230.75	100.00	FZ 22	5130.75	5230.75	100	FZ 52
2230.75	2330.75	100.00	FZ 23	5230.75	5330.75	100	FZ 53
2330.75	2430.75	100.00	FZ 24	5330.75	5430.75	100	FZ 54
2430.75	2530.75	100.00	FZ 25	5430.75	5530.75	100	FZ 55
2530.75	2630.75	100.00	FZ 26	5530.75	5630.75	100	FZ 56
2630.75	2730.75	100.00	FZ 27	5630.75	5730.75	100	FZ 57
2730.75	2830.75	100.00	FZ 28	5730.75	5830.75	100	FZ 58
2830.75	2930.75	100.00	FZ 29	5830.75	5959.85 (south portal)	129.1	FZ 59
2930.75	3030.75	100.00	FZ 30				

In service tube no fire zones are necessary.

3.5 Correction function for flow sensors

During commissioning test the fixed installed velocity sensor must be calibrated. If the deviation of the sensor values is greater than the specification given in the RVS 09.02.31 [2] a correction function is necessary. Hence a linear function f(x)=a*x + b must be implemented to adjust the measured values from each sensor. The values a (gradient) and b (offset) should be displayed at SCADA and made changeable (password-protected) for each sensor.

3.6 Control of axial fans

3.7 Basics

The axial fans are in the ventilation stations at each portal. They are used mainly for fire procedures. Due to the different operation modes of the fans (extraction with one fan only, with two fans and using different dampers for extraction) the fans are equipped with automatic pitch adjustment of blades during operation for controlling the flow rate (operating point). A variable frequency drive is not used. However, the fan is switched on with soft start. The fans must be operated without motor overload.

3.8 Start up procedure

A fan is always started with closed blades (zero delivery position of blades) and at the same time (e.g., at 300 rpm) the damper at axial fan is opened. With the pitch adjustment it must be ensured that the maximum flow rate is reached.

For exhaust dampers where both axial fans are used, the start up of the fans must be parallel.

3.9 Volume flow control

The volume flow control of the exhaust air fans is done by the PLC with a closed loop control. The controller must be designed and optimized by client / manufacturer of axial fan. While controlling the volume flow with pitch adjustment a hysteresis must be considered (e.g.; in a range of ±2.5% no change of blade angles is done) to avoid permantely changing the angle.

3.10 Surge limit monitoring

For safety reasons, a surge limit monitoring system (done with local fan PLC) must be provided. The system must automatically bring back the axial fan into stable operation to avoid stall (stall means a not uniform flow through the impeller. During stall the flow separates from blade shape).

This is done with a prewarning and warning limit. If prewarning limit (calculated with flow rate and blade angle) is reached the blade angle is not increasing anymore. Reaching the warning level means closing the blades to avoid damage caused by aerodynamical vibrations.

3.11 Shaft power monitoring

During operation of axial fans the consumed power must be monitored permanently. If the value exceeds the rated power the blade angle must be reduced.

3.12 Operation direction

Axial fans are only used for extraction.

3.12.1.1 STARTING CYCLES

The maximum number of starting cycles per hour must be considered only for normal operation. The maximum number should be specified by the manufacturer.

3.12.1.2 MINIMUM OPERATING TIME

The minimum running time of the axial fans must be considered. The time is needed to cool down the motor after starting. The time should be specified by the manufacturer (e.g., 6 minutes).

3.12.1.3 MAINTENANCE OPERATION

A maintenance run should be implemented. If the axial fans are activated rarely, a periodic revision run is needed. The maintenance run will grease the bearings and protect them from corrosion. In addition, technical breakdowns are detected before the fans are needed.

The following parameters are suggestions (the final parameters should be specified by the manufacturer):

time interval for activating:	800 h
period of maintenance operation:	10 min

These parameters need to be adjustable by the operator (SCADA – password-protected)

3.12.2 Safety interlock of axial fans

Axial fans may have safety monitoring devices. In the table safety monitoring data and the reaction of the PLC system depending on the operating mode can be seen. All warnings and alarms must be visualized for the operator (SCADA).

Table 9: Possible safety data points of axial fans

status	response at all other operating modes	response at automatic control mode (during fire)
winding temperature warning	switch on motor cooling fan	-
winding temperature alarm	switch off	-
Bearing temperature warning	switch on motor cooling fan	-
Bearing temperature alarm	switch off	-
Stall alarm	Decreasing blade pitch (except during start up)	-
Surge limit warning	Decreasing blade pitch	-
vibration warning	prevent start up	-
vibration alarm	switch off (except during start up)	-
Rotation in wrong direction	≤ -50 rpm prevent start up	-
No exhaust dampers open	blade pitch 0°	-

	(running without volume flow)	
Blade adjustment error	prevent start up	-
Hydraulic system for blade adjustment error	prevent start up	-
Damper for axial fan closed	blade pitch 0° (running without volume flow)	-
Damper for axial fan error	prevent start up	-
Blade angle > 0°	prevent start up	-
Emergency stop button pressed	switch off	switch off
Cooling fan error	prevent start up	-
error anti-condensation heater	prevent start up	-
Exceeding rated power	Decreasing blade pitch	-
prevent start up…if the jet fan is not switched on. If the fan is already in operation, it remains activated. switch off…if the fan is already in operation, it should be deactivated immediately. No start up.		

The final threshold values for warning and alarm should be given by the manufacturer.

4. OPERATING MODES FOR MAIN TUNNEL

4.1 Hierarchy of the operating modes

The following operating modes must be implemented into the PLC/SCADA system:

- Operation mode during maintenance work (system freezed)
- Automatic control mode (during fire)
- Control mode during work in tunnel
- Manual control mode (on site / SCADA)
- Automatic control mode (during normal operation)

To define the hierarchy of the operating modes, priorities are used again. For the definition of the priorities refer to Table 10. The operating mode with the higher priority (lower priority number) can automatically override the one with the lower priority.

Table 10: Hierarchy of the operating modes

Priority	operating mode
1	operation mode during maintenance work (system stopped)
2	automatic control mode (during fire)
3	control mode during work in tunnel
4	manual control mode (SCADA)
5	automatic control mode (during normal operation)

4.2 Automatic control mode (normal operation)

Normal operation fundamentally means automatic control of the ventilation system. The ventilation system must be operated according to the principles of economic efficiency and provide consistent air quality. The ventilation system must provide a sufficient air flow to keep the air quality below the threshold values.

4.2.1 Exhaust dampers

Exhaust dampers must be completely closed during stage one of normal operation mode. If stage two is used one damper is open according to the location of bad air quality. All others are closed. After reaching switch of point of stage 2 the open dampers must be closed again.

Reaching threshold for stage two at sensor:	**Exhaust damper used for extraction:**
COM1 or TRM1	ED04 (single axial fan use)
COM2 or TRM2 or COM3 or TRM3	ED13 (single axial fan use)
COM4 or TRM4	ED31 (with both axial fans)
COM5 or TRM5 or COM6 or TRM6	ED44 (single axial fan use)
COM7 or TRM7	ED55 (single axial fan use)

A maintenance run should be implemented. If the dampers are activated rarely, a periodic revision run is needed. Beneath maintenance reasons technical breakdowns are detected before the dampers are needed.

The following parameters are suggestions (the final parameters should be specified by the manufacturer):

time interval:	one a day
period of maintenance operation:	fully open and close

These parameters need to be adjustable by the operator (SCADA – password-protected)

4.2.2 Control mode according to measured air quality

The aim of the control mode is to maintain the specified air quality values. This will be realised through some specified control elements. The actual air quality gets measured by sensors (CO and turbidity) along the tunnel. These measured values reflect the vehicle emissions, traffic frequency, etc. with a short time delay.

4.2.3 Control parameter normal operation

For the operating mode automatic control during normal operation, a threshold controller or P-controller is sufficient. The controller gets the measured air quality values as actual, but pre-processed values (maximum from all sensor values measured for CO and turbidity). The actual value has to be compared with the sequence chart. If the actual value is higher than the starting point, the switch-on procedure will automatically start the fan(s). Depending on actual air quality values, the controller changes the amount of the required jet fans. The jet fans should always be switched-on/off as pair in each niche.

Starting point stage 1 (switching on a pair of jet fans): 25 ppm CO or extinction of 1.3 x 10^{-3} m^{-1}

(Steps: 2 jet fans; 4 jet fans; 6 jet fans ; 8 jet fans; 10 jet fans).

Starting point stage 2 (switching to combined system): 70 ppm CO or extinction of 5 x 10^{-3} m^{-1}

Remark: A hysteresis must be considered between steps and stages.

Since every tunnel has its own behaviour, these values are suggestions for initial commissioning. They must be adjusted during first month of operation (with traffic) to achieve an economically advantageous operating mode.

The parameters of the jet fan operation must be observed.

4.2.4 Target values for air quality

The following values are the target values for normal operation given by the RVS 09.02.31 [2]

Target value CO	30 ppm
Target value turbidity	4 * 10^{-3} m^{-1}

4.2.5 Treatment of sensor values for air quality

In normal operation, the sensor values (CO, turbidity) must be recorded as real values. These real values must be integrated to 5-minute averages. The 5-minute average value of the in-tunnel parameter (CO, turbidity) must be compared to the target values.

As far as possible, data processing directly at the measuring device should be avoided. To allow a good control quality the response time must be reduced to a minimum. Average values are made in the PLC only.

Due to the fact, that the average value strongly depends on used measuring devices, the 5-minute average should be checked during commissioning and if not applicable adapted.

4.2.6 Threshold values for tunnel closure

The tunnel must be automatically closed if one of the conditions described below are true:

- ≥ 100 ppm CO for more than 10 min
- ≥ 150 ppm CO
- Extinction coefficient ≥ 12 * 10^{-3} m^{-1} for more than 1 min

If a decreasing trend is detected and the respective value remain below the following limits for more than 1 minute the reopening of the tunnel is allowed:

- Either 90 ppm CO or
- extinction coefficient 7 x 10^{-3} m^{-1}

The reopening process of the tunnel needs to be confirmed by the operator.

4.2.7 Selection of flow sensor

In normal operation and stage 1, the flow sensors are not used by the controller. They are only displayed at SCADA for information.

While stage two the air speed sensors are needed to control a uniform flow (50% / 50%) to the open exhaust damper from both sides.

Exhaust damper used:	**Flow sensors used:**
ED04 (single axial fan use)	FSM01 and FSM02
ED13 (single axial fan use)	FSM02 and FSM03
ED31 (with both axial fans)	FSM04 and FSM05
ED44 (single axial fan use)	FSM05 and FSM06
ED55 (single axial fan use)	FSM06 and FSM07

Due to moving traffic inside the tunnel the sensor values need at least a treatment with a 5-minute average. This should be checked during commissioning and if not applicable adapted.

4.2.8 Monitoring of air quality sensors

Since air quality problems (CO and turbidity) can occur suddenly and locally, e.g., due to locally limited pollutant, a comparative plausibility test with the other measuring sensors is not useful.

Therefore, only a lower or higher plausibility limit of the measured values should be provided (offset-

zero, e.g., 4-20 mA). If there are internal status controls, they should be tied-in the PLC.

4.2.8.1 AIR QUALITY SENSOR SELECTION

For the operating mode “automatic control during normal operation”, the maximum of all values measured for CO and turbidity must be used for the controller.

Only at stage two a tracking of the location with the worst air quality is necessary. The allocation sensor to extraction point can be found in chapter 4.2.1.

If all sensors (CO or turbidity) in main tube are faulty are longitudinal ventilation (stage one) is performed with 80 % (4 pairs) of the jet fans. This procedure is switched on automatically to avoid reaching air quality limits.

4.2.9 Plausibility check of air speed sensors

In accordance with RVS 09.02.31 [2], a plausibility check for the flow sensors is essential. Hence, three devices at each location are needed. During operation, an algorithm will check the three sensors against each other at scheduled times. The check should be done in normal and incident operation with a sliding average of 20 to 30 s adaptable during commissioning of the system (control loop input during incident ventilation is different). The three measured values from one location should be within the tolerance value Δu_{PL} = 0.5 m/s for bidirectional traffic.

As soon as the plausibility check of one or more devices is ok again, the status must change to “plausible” and the device can be used again.

The flow measurement values of each location are shown on the SCADA system (seven values for main tube). The flow values of each sensor are used in the PLC only (21 times for main tube). These 21 values can be also seen in a submenu on the SCADA system (for maintenance reasons).

4.2.9.1 PLAUSIBILITY CHECK TESTING PERIOD

The test is suggested at four times a day. To avoid negative influence due to traffic, the following testing times are proposed:

01:00 / 03:00 / 05:00 / 23:00

However, it is necessary to check whether other testing times provide better conditions due to specific traffic conditions. Furthermore, the test must take place while the ventilation system (jet fans and axial fans) is switched off. If fans (either jet or axial fans) are running, the test procedure is skipped until the next scheduled test. The possibility should be given to start the plausibility check manually at SCADA (e.g. after a service at the flow measurement sensors).

4.2.9.2 PLAUSIBILITY LIMITS

Additionally, a lower and higher plausibility limit of the measured values should be provided (offset-zero, e.g., 4-20 mA). If there are internal routines for self-test the result should be tied-in the PLC.

4.2.10 Jet fan selection (with operating hours balancing)

At stage one:

During normal ventilation, the selection of the jet fan depends on the operation status label of each fan. This label is only affected by the operating hours and the operation restrictions (running time before switched off, etc.). The jet fans with the lowest operating hours and the label “switch on is possible” should be chosen first. This procedure gives a operating hour balancing for the jet fans. During stage one jet fans are only switched on (100%) or off (0%). No frequencies in between are used. All jet fans are activated in same direction.

At stage two:

Extraction point:	**Usable jet fans :**
ED04	All jet fans
ED13	All jet fans
ED31	JFM1.1 / JFM1.2 / JFM2.1 / JFM2.2 / JFM4.1 / JFM4.2 / JFM5.1 / JFM5.2
ED44	All jet fans
ED55	All jet fans

During stage two no operating hours balancing is necessary. The jet fans are switched on between allowed minimum rotational speed to maximum (100 %). Jet fans are activated only in direction to the used exhaust damper.

4.2.11 Jet fan operation direction

Refer to chapter 4.2.10

4.2.11.1 STARTING CYCLES

Fans in main tube are equipped with frequency converter. The maximum starting cycles per hour is not limited.

For jet fans without a frequency converter (all fans in service tube) the maximum number of starting cycles per hour must be considered. The maximum number should be specified by the manufacturer (e.g., 6 activations per hour).

4.2.11.2 MINIMUM OPERATING TIME

The minimum running time of the jet fans with and without frequency converters must be considered. The time is needed to cool down the motor after starting. The time should be specified

by the manufacturer (e.g., 10 minutes for fans without frequency converters).

4.2.11.3 FREQUENCY CONTROLLED OPERATION

Not applicable during normal operation at stage one. Jet fans with frequency converter will be switched on (100%) and off and only pairwise.

During normal operation at stage 2 a frequency-controlled operation is used. Some motor speeds can cause vibrations (resonance frequencies). These speeds must be defined by the manufacturer of the jet fans. It is important to ensure that speeds which can cause vibrations are passed through quickly or left out. The minimum usable speed (due to cooling) of the motor has to be defined by the manufacturer of the fan (e.g., 20%).

4.2.11.4 REVERSION OF ROTATION

Due to inertia of the impeller, a jet fan must not be reactivated immediately in reverse after its deactivation from other direction. This would lead to high loads on the fan. A temporal lock must be realized when reversing the direction of rotation. The time constant must be determined by the manufacturer of the jet fans.

4.2.11.5 STAGGERING (OVERCURRENT PROTECTION)

The jet fans must be switched on under consideration of a delay time in order to avoid peak loads. A staggering time of 10 seconds is recommended. The delay time must be determined specifically for the project.

4.2.11.6 MAINTENANCE OPERATION

A maintenance run should be implemented. If the jet fans are activated rarely, a periodic revision run is needed. The maintenance run will grease the bearings and protect them from corrosion. In addition, technical breakdowns are detected before the fans are needed.

The following parameters are suggestions (the final parameters should be specified by the manufacturer):

time interval for activating:	800 h
period of maintenance operation:	10 min

These parameters need to be adjustable by the operator (SCADA – password-protected)

4.2.12 Deceleration of air velocity

No deceleration of flow is required.

4.2.13 Loss of voltage

In the event of power failure, all fans must be switched off and started staggered after return of power. This is used to avoid peak loads caused by simultaneously starting fans.

4.2.14 Safety interlock of jet fans

Jet fans may have safety monitoring devices. In Table 11 safety monitoring data and the reaction of the PLC system depending on the operating mode can be seen. All warnings and alarms must be visualized for the operator (SCADA).

Table 11: Possible safety data points of jet fans

status	response at all other operating modes	response at automatic control mode (during fire)
winding temperature warning	switch off	-
winding temperature alarm	switch off	-
vibration warning	-	-
vibration alarm	switch off	-
error anti-condensation heater	prevent start up	-
error frequency converter	switch off	prevent start up
prevent start up…if the jet fan is not switched on. If the fan is already in operation, it remains activated. switch off…if the fan is already in operation, it should be deactivated immediately. No start up.		

The final threshold values for warning and alarm should be given by the manufacturer.

4.2.15 Cross passages with air lock system

4.2.15.1 Cross passage gate

In the case both cross passage gates from the EQ are opened for more than ten minutes, a warning must be visualized.

4.2.15.2 Cross passage ventilation

During normal operation, the cross-passage ventilation is not working. A maintenance run for the overpressure ventilation should be implemented. The parameters are specified by the manufacturer.

Optional: To avoid dust and dirt to get into the cross passages the air lock ventilation can be activated also during normal operation. This is reasonable during high volume traffic.

4.3 Automatic control mode (during fire)

During fire procedures a semi-transverse ventilation system combined with jet fans in carriageway is used for nearly all fire zones. Only the two fire zones at portals are using a longitudinal ventilation (fire zone FZ01 and FZ59 with flow direction to the outside) as standard procedure.

Several redundancy procedures are included in the ventilation system to ensure a safe evacuation during fire scenario even if parts of system are down. If a part of the systems fails another component can take over the function with no or a very little loss in safety.

- Dampers are multiple redundant – if one fails the next in flow direction will open
- Air speed sensors are multiple redundant – if one section fails the next priority will be used (2 times)
- Jet fans – if one fails the system can perform a fire ventilation but in some cases with few restrictions
- Axial fans – if one or both axial fans fail, a longitudinal ventilation system is performed for all fire zones. The performance of the ventilation is restricted.

4.3.1 Fire detection

To achieve the correct results for fire ventilation, it is necessary to detect the fire at the correct location. The location is decisive for the activation of the correct automatic fire ventilation procedure. An automatic starting procedure is only allowed if the exact location of the fire is known.
The procedure is as follows:

- detection of the fire
- detection of the current flow direction
- allocation of the fire
- selection of appropriate ventilation scenario (fan priority, flow sensor priority,…) acc. to appendix
- (using redundant ventilation system on error)

A fire can be triggered in various ways. These options are staggered by priority, with a higher priority trigger overwriting a lower one. The specifications are given in Table 12.

Table 12: Priorities for activating fire ventilation

priority	trigger
highest	manually by operator „high priority" (e.g. manual movement of fire location, if the fire source is moving from detected location)
second	from linear heat detector (automatic)
third	manually by operator "low priority" (e.g. fire can be seen before LHD is detecting.). This is trigger is automatically overridden by the LHD. Gives a safety to the operator.
fourth	manually only ventilation (e.g. for testing purposes with traffic)

Once an alarm has been triggered by the linear heat detector (second highest priority), follow-up alarms can no longer automatically change the event scenario. It is then up to the operator, if necessary, manually move or reset the event scenario. A routine for moving the location of the fire should be provided for this purpose (highest priority in Table 12).

If the first alarm is triggered by a third highest-priority scenario and subsequently encounters an alarm from the linear heat detector, the system automatically switches to the scenario for this zone.

Note "Highest priority":

The manual movement of the automatic fire alarm is an intervention in the automatic fire control and can have profound consequences. Therefore, the command must be confirmed before execution.

Fire alarm in the service tube:

In service tube no automatic detection system is included.

4.3.2 Exhaust damper selection

Right after triggering a fire in carriageway the fire zone related exhaust damper opens completely (90°). All other dampers must be closed. This can be in parallel but if axial fan is already running stall must be avoided.

Depending on actual flow direction in carriageway the next damper in south or north direction from fire must be used for smoke extraction. If the flow direction to south the next damper to the south must be chosen, at flow to north the next in direction north is used. If no flow sensor signal is available (error) or air speed is 0 the damper which is closer to a portal should be chosen.

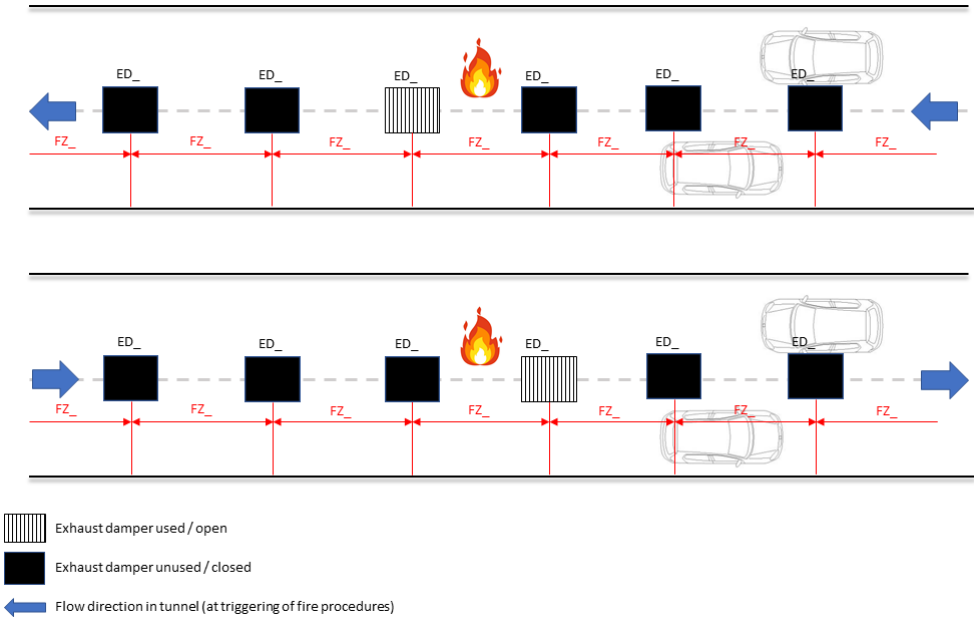


Figure 6: Damper selection for fire procedure

If the related damper fails to open (e.g. due to malfunction) the next one should be opened and used for extraction. All others are closed. Remark choosing a different exhaust damper for extraction could result in a different ventilation procedure (different fans locked, using different air speed sensors). The selection of redundancy should be done until the portal is reached.

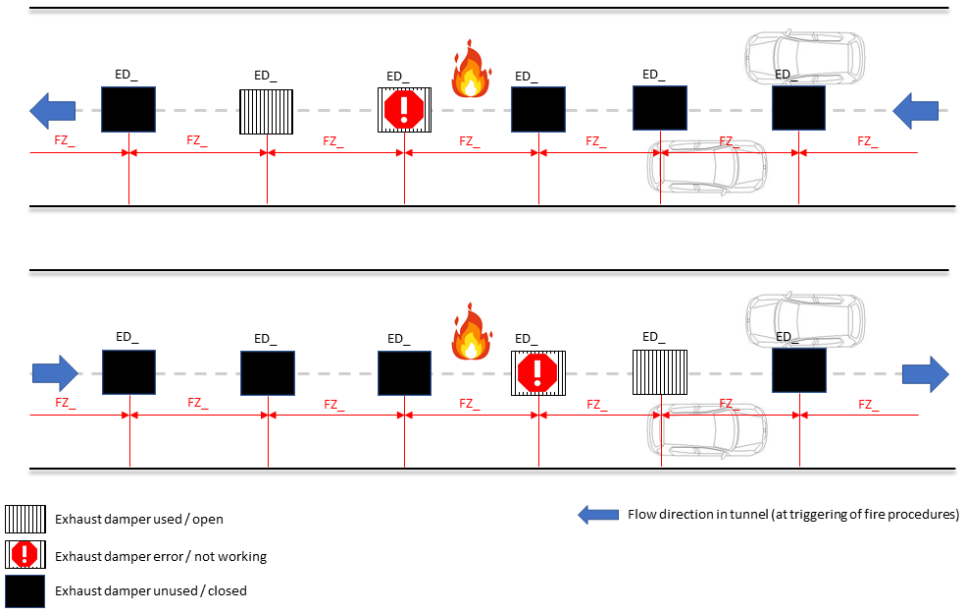


Figure 7: Damper selection for fire procedure - redundancy

In portal area (at fire zone FZ01 and FZ59) an extraction is not possible in any cases. If the flow is to direction inside the tunnel the next exhaust damper is used. If the flow is to the outside a longitudinal ventilation instead of semi-transverse one is used. The smoke is transported through the nearest portal by the jet fans (without extraction of smoke through dampers). In case redundancy is needed in these two fire zones (independent from flow direction) a longitudinal ventilation system is used.

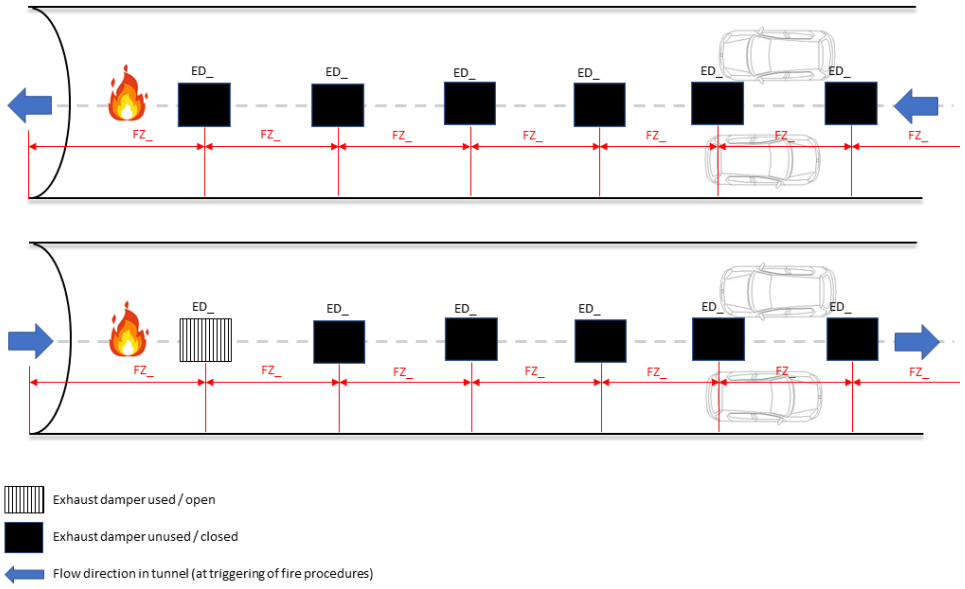


Figure 8: Damper selection for fire protection at portal

4.3.3 Control parameter

For fire ventilation, a PI control loop in a parallel structure must be used. The integrating variable must be limited by "anti-windup" (e.g. conditional integrator). A suitable method is a dynamic limit for the actuating variable. The variable is restricted by the maximum jet fans of the active fire zone. The anti-windup control prevents integration wind-up when the actuator is saturated (all jet fans are already activated).

In addition, a dead band for the PI loop should be considered. The PI loop must have an output dead band to reduce the switching frequency of the jet fans. This is accomplished by modifying the controller to hold its output steady if the change would be small (within the dead band range). The calculated output must leave the dead band before the actual output will change.

To make the commissioning of the controller easier (loop tuning), a visualization ('pop-up') of the controller at SCADA system should be implemented. The input values, output values and the parameters should be displayed and made changeable (password-protected).

An automated method for determining the controller parameters for initial setup is recommended (step function response, inflectional tangent method, Chien-Hrones-Reswick method for 20% overshooting, Ziegler–Nichols or similar).

The final control parameters for a quick and stable controller must be determined during commissioning tests.

4.3.4 Target values for air quality

In case of fire ventilation, the air quality sensors are not considered.

4.3.5 Air velocity during fire

The fire procedures will be done in automatic stages from PLC System (a manual intervention on request must always be possible from the tunnel operator) by one or more closed loop controllers.

4.3.5.1 LONGITUDINAL VENTILATION

In case of fire and using a longitudinal ventilation (fire zones at portals or redundancy mode at other zones) the air velocity inside the tunnel upstream to the fire must be in a **range of:**

1.25 m/s ±0.25 m/s acc. to RVS 09.02.31 in current flow direction

The activation of fans should be, if possible, started from the “cold” side (from upstream - pressure operation) towards the fire location, if the location of the fire allows for this strategy (refer chapter 4.3.10). The velocity-related target values must be reached within 5 minutes after detection of a fire.

4.3.5.2 SEMI-TRANSVERSE VENTILATION

In case of fire smoke will be extracted right at fire location through one damper. The nearest to the fire will open, all others will be closed. If the fire location is near the portal only one axial fan is used

for extraction. At other locations both fans are used together. The volume flow will be split on both fans. The ratio between the fans is depending on exact extraction location. It is a balance between pressure and volume flow.

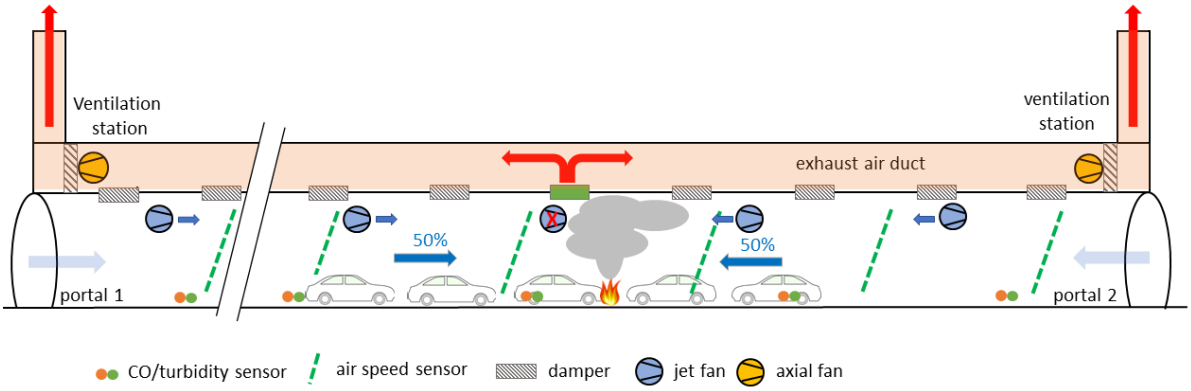


Figure 9: Principle fire ventilation – fire location in middle of the tunnel

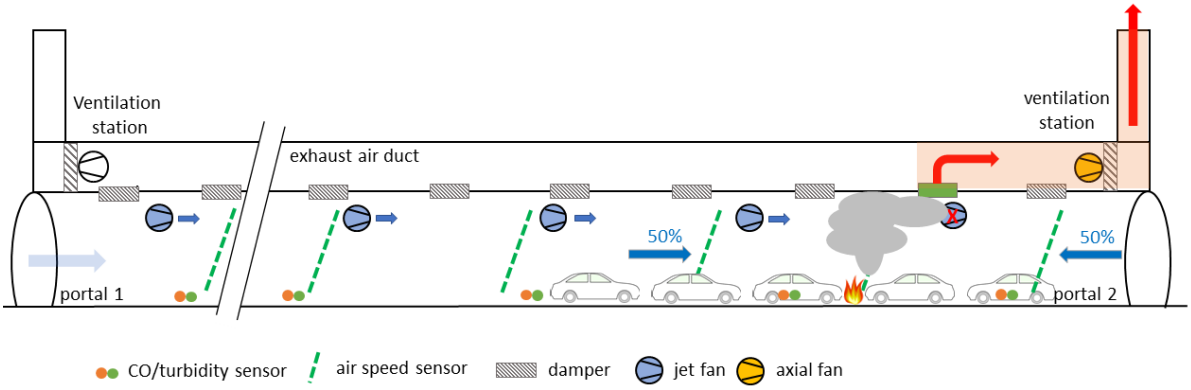


Figure 10: Principle of fire ventilation – fire location near a portal

During fire procedure the jet fans are used to adjust the flow towards the damper from both tunnel sides. The flow (cold gas) from both sides to the damper must be equal. This means, the air speed from the south and from the north is the same. The adjustment of the flow towards the damper is done with the jet fans in carriageway and a controller in automatic stage.

There are two ways to record the actual value on both sides of extraction damper. In most fire zones a sensor each side is available. In some cases (some fire zones and some redundancy cases) only on one side an in-tunnel measurement is possible (the priority table can be seen in appendix).

The given target values (longitudinal flow towards the extraction point and volume flow at damper) must be reached within 10 minutes after fire detection and must be kept within the velocity range during the operation.

Fire zone with two air speed sensors available:

The set value can be calculated (50%) from the sum of both sensors under consideration of correct direction. No consideration of temperature or density is necessary.

Mass flow balance (sensor only on one side available):

A mass flow balance to calculate the air flow from the second side towards the extraction point is necessary. The extracted mass flow at the damper can be calculated from the volume flow and density at the fan(s) and corrected with the expected leakage in air duct (depending on damper location).

The desired air speed at each side can be found under consideration of the density in carriageway, and the cross section. Each air speed sensor is equipped with a temperature measurement. This temperature together with an average barometric pressure inside tunnel gives the density. The required air speed must be calculated permanently, and controller must set this value continuously.

4.3.6 Treatment of sensor values

During incident mode, the sensor values from air speed sensors must be recorded as a sliding average of maximum 10 s.

As far as possible, data processing directly at the measuring device should be avoided. To allow a good regulation quality the response time must be reduced to a minimum. Average values are always built at the PLC.

4.3.7 Selection of flow sensor

The selection of flow sensors must be performed based on the location of the fire (scenario) and the appropriate tables. The flow sensors with the highest priority have the number 1. The lower the priority, the higher the number will be. The selection order of the flow sensors (as input for controller) depending on the location is predefined and different for longitudinal and semi-transverse ventilation.

4.3.7.1 Air speed sensor selection at longitudinal ventilation (at portal area)

Regularly sensor with priority 1 is used. If this sensor is not available (e.g. not plausible) the next higher priority number must be used (as redundancy). If there is no higher priority available all jet fans are switched on (emergency program on failure – no control of air flow). If the value is available again the jet fans are used again for controlling air flow. The priority table can be seen in appendix.

4.3.7.2 Air speed sensor selection at Semi-transverse ventilation

Regularly sensor with priority 1 is used. If this sensor is not available (e.g. not plausible) the next higher priority number must be used. If there is no higher priority available all jet fans are switched off and only smoke extraction is running (emergency program on failure – no control of air flow towards the damper). If value is available again the jet fans are used again for controlling air flow. The priority table can be seen in appendix.

4.3.8 Plausibility check for air quality sensors

Refer to chapter 4.2.8.

4.3.9 Plausibility check of flow sensors

In accordance with RVS 09.02.31 [2] the plausibility check for the flow sensors is essential. Hence, three devices at each location are needed. During fire operation the algorithm will check the three sensors against each other permanently.

Refer to chapter 4.2.9.

4.3.9.1 PLAUSIBILITY CHECK TESTING PERIOD

During fire operation three sensors are checked against each other permanently (e.g. every 5 to 10 s).

4.3.9.2 PLAUSIBILITY LIMITS

Refer to chapter 4.2.9.2.

4.3.10 Jet fan selection

The selection of the jet fans must be performed based on the location of the fire (scenario) and the appropriate fan priority table. The fans with the highest priority have the number 1. The lower the priority, the higher the number will be. The fans with the priority 0 will kept switched off to avoid destroying the smoke layer.

The jet fans are driven by a frequency converter to adjust the motor speed (between minimum and maximum). When the jet fans with priority 1 reach their maximum motor speed (50Hz) the controller must start the next jet fans with the next priority at min. motor speed. If higher thrust is needed again the rotational speed is increased.

The time between starts and stops of jet fans is specified by the controller. There is no deceleration of the air velocity needed. The jet fan selection depends on used ventilation system, longitudinal or semi-transverse. The priority table can be seen in appendix.

4.3.11 Fire in front of the portal (outside tunnel)

In this case a flow velocity of greater than 1 m/s in main tube must be carried out towards the affected portal to prevent smoke from entering the tunnel.

This ventilation scenario must be started manually by the operator since the event cannot be detected automatically (but the program runs automatically after a manual start). Accordingly, the operator is also responsible for the closure of the tunnel. For this event, a separate ventilation program should be provided. The priorities for jet fans and flow measuring devices can be seen in following tables.

Table 13: Jet fan priority table for incident ventilation – in front of tunnel

fire in front of	ventilation direction	Jet fans				
		JFM 1.1, JFM 1.2	JFM 2.1, JFM 2.2	JFM 3.1, JFM 3.2	JFM 4.1, JFM 4.2	JFM 5.1, JFM 5.2
north portal	to north	5 (%)	4 (%)	3 (%)	2 (%)	1 (%)
south portal	to south	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)

%.... Jet fans used with frerquency converter

Table 14: Air speed sensor priority table for incident ventilation – in front of tunnel

fire in front of	ventilation direction	air speed device							set point air speed
		FSM 1	FSM 2	FSM 3	FSM 4	FSM 5	FSM 6	FSM 7	
north portal	to north	0	1	2	3	0	0	0	< -1.0 m/s
south portal	to south	0	0	0	3	2	1	0	> 1.0 m/s

4.3.12 Jet fan operation

The jet fans should always be switched-on/off in pairs (each fan niche).

4.3.12.1 Starting cycles

During fire operation, the maximum starting cycles are not considered.

4.3.12.2 Minimum operating time

During fire operation, the minimum operating time must not considered.

4.3.12.3 Frequency controlled operation

All jet fans are driven by frequency converters. Some motor speeds can cause vibrations (resonance frequencies). These speeds must be defined by the manufacturer of the jet fans. It is important to ensure that speeds which can cause vibrations are passed through quickly or left out. The minimal speed (due to cooling) of the motor must be defined by the manufacturer of the fan.

4.3.12.4 Reversion of rotation

Refer to chapter 4.2.11.4.

4.3.12.5 Staggering (overcurrent protection)

Refer to chapter 4.2.11.5.

4.3.12.6 Maintenance operation

During incident operation no maintenance operation is considered.

4.3.13 Deceleration of air velocity

No deceleration operation is intended.

4.3.14 Loss of voltage

Refer to chapter 4.2.13

4.3.15 Safety interlock of jet fans

Refer to chapter 4.2.14

4.3.16 Cross passages

4.3.16.1 Cross passage gate

If a fire occurs, the gates of the EQ cross passage and the gates at portals of service tube have to close automatically if they are open. If the gates are opened (e.g. from the fire brigade) during fire procedures they need to get closed automatically after 120 s.

4.3.16.2 Cross passage ventilation

Both tubes relate to cross passages (EQ and GQ). These crossings are for exit in case of a fire or other reasons that require an escape. The cross passages are built as air locks separated by walls, one each side. Every air lock will be pressurized by a separate ventilation system. The fresh air needed will be drawn from service tube. In portal area of the service tubes are dampers to provide sufficient fresh air.

With this system the escape routes can be kept smoke-free in all operating situations.

If the egress ventilation is kept permanently active during normal operation, the ingress of dirt and dust can be prevented by increasing the operating costs.

Basic operating principle of the overpressure system:

Normal and maintenance operation mode:

- All doors of GQ/EQ are closed:
  The inverter-controlled fan is operating at a certain speed to create a defined overpressure to the main tube. This prevents contamination by leaks.

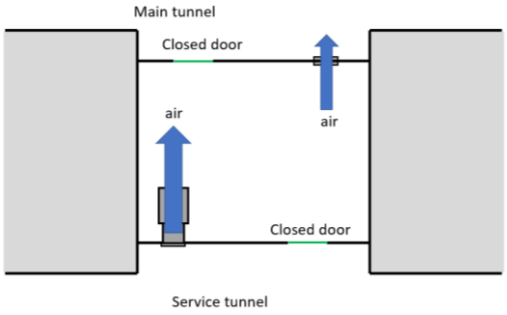


Figure 11: Overpressure mode during normal and maintenance mode

Fire ventilation mode:

- Doors of cross passage are closed (overpressure mode):
  Regulated overpressure between the incident tube and the cross passage is in a range of 30 to 40 Pa. Smoke cannot enter through leakage. The cross passage keeps a safe area, also during fire.
- A door to affected tube is open (minimum velocity mode):
  Fresh air flows through this door (design velocity is 1 m/s with direction to affected tube) to prevent smoke from entering the cross passage. This operating point is set with help of the inverters for the fans. The cross passage remains as safe area.
- An EQ gate is opened:
  While an EQ gate is open, it is impossible to prevent smoke from entering in this passage. In worst case smoke enters the cross passage. The area is not safe anymore. But the second gate prevents smoke from entering the service tube. This tube remains a safe area. Therefore, only one gate should be opened at once.
  If the gate is closed again the cross-passage is flushed with fresh air at the same time.

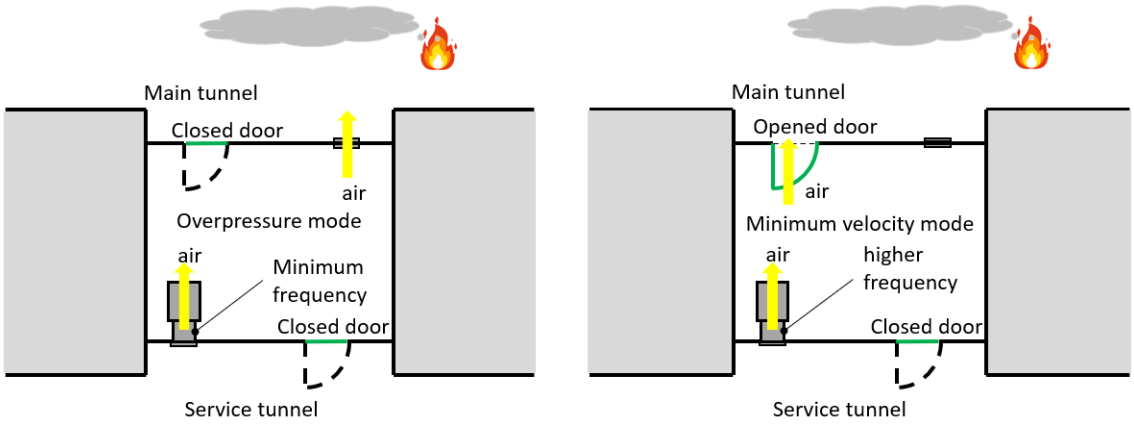


Figure 12: Overpressure and minimum velocity mode during fire procedures

Basically, there are two different operating conditions during a fire. The air lock system starts working together with the activation of the fire alarm at the incident tube.

Case 1: Fire alarm in the tunnel is active and the emergency door of the cross passage is closed:

When the fire alarm is activated the protection dampers on both sides each cross passage opens. After dampers are fully open, the axial fan in the wall of the service tube gets activated low rpm (to define during commissioning tests) of the nominal speed driven by variable frequency. This pushes fresh air through the lock into the event tube. A defined pressure level between the main tube and

the cross passage is maintained by the pressure regulation damper in main tube side wall. Smoke can't enter through possible leakage.

If the open signal of the protection flap from the service tube side is missing, the axial fan starts after a defined time (twice of the regular opening time from the protection flap). In this case a possible damage to the axial fan is accepted.

If the feedback from the protection damper from main tube is missing, the axial fan won't start.

During the commissioning tests the overpressure between the incident tube and the cross passage has to be set in a range of 30 to 40 Pa (without traffic). The required overpressure is set by the speed of the motor of the fan. The minimal speed (due to cooling) of the motor has to be defined by the manufacturer of the fan.

Case 2: The fire alarm in the tunnel is active and an escape door is open:

By activating the door switch (only on main tube side) the axial fan is switched to high rpm (to define during commissioning tests). The air velocity through the open door should be in a range of 1,0 – 1,2 m/s to direction main tube. This prevents smoke from entering the air lock trough opened escape door during escaping.

After all doors are closed, operating case 1 is activated again.

If overpressure in normal operation mode is desired this is done by routines for case 1.

4.4 Manual control mode (SCADA) – from control centre

During manual control mode, the current settings for the automatic control are frozen until a manual setting is carried out. All systems protecting the machines and the entire structure remain active. In case of a fire alarm, the manual control is automatically stopped [2].

All components of the ventilation system must be able to be switched independently on the SCADA via suitable control elements.

There must be the possibility to overwrite, the values of CO, turbidity and air velocity for testing procedures.

Only the fan of the cross-passage ventilation can be switched on and off during manual mode. The activated fan starts with creating the overpressure in the cross passage. The sequence (activating flaps in correct position, etc.) will run automatically. A separate way to activate the flaps is not necessary.

4.5 Operation mode during work in tunnel

During maintenance work in the tunnel, all measurement and control parameters are set to constant values providing good air quality for the personnel carrying out maintenance and inspection work (e.g. on the fire alarm system). The related values to be set must be chosen in accordance with the regulations for occupational safety and health [2].

4.5.1 Air quality during work in tunnel

The operation mode "during maintenance work" correlates with the mode "Automatic control mode during normal operation", except for the target values of air quality:

Target value CO 20 ppm (acc. RVS 09.02.31 [2])

Target value visibility $3 * 10^{-3}$ m^{-1} (acc. RVS 09.02.31 [2])

Additionally, the occupational safety and health guidelines should be considered.

4.6 Manual control mode (SCADA) – on site

Under this operation mode, all automatic monitoring and control activities related to the affected components of the ventilation system are suspended. The selection of this operation mode is permitted only when maintenance and inspection work is being carried out on the components of the ventilation system. In addition, this mode is of highest priority and cannot be suspended - even if there is a fire alarm [2].

All components of the ventilation system must be able to be switched independently on the SCADA via suitable control elements.

This control mode is identical to manual control mode (SCADA) from control centre, but it is used from the local control room at the tunnel.

4.7 Manual control mode (on site)

During manual control mode, the current settings for automatic control are frozen until a manual setting is carried out. All systems protecting the machines and the entire structure remain active. In case of a fire alarm, the manual control is automatically stopped [2].

The relevant components of the ventilation system must be able to be switched independently on site via suitable control elements.

5. SERVICE TUNNEL VENTILATION

Most of time the service tube will ventilate itself by natural ventilation. But in some cases, and during maintenance work inside, a mechanical ventilation system is required get sufficient fresh air inside. A simple longitudinal ventilation system is provided to handle normal operation. Small jet fans, air speed and air quality sensors are installed. No fire scenario is considered.
At the portals of service tunnel gates are installed. During active ventilation in service tunnel (if the jet fans are active) these will be opened automatically. On the other hand, to ensure the air supply for air locks during normal and fire operation dampers will be installed beneath these gates.
Basic operating principle of service tube:
Normal operation mode (if air lock is used to prevent ingress of dirt, otherwise the system is not running during normal operation):

- Air lock ventilation is activated
  The jet fans in the service tunnel are deactivated, the ventilation unit of the air lock system extracts fresh air from the service tunnel. The air supply for the cross-passage ventilation is provided through the opened dampers on each portal of service tube. Additionally, the service tube is ventilated from the fresh air flow to the air locks.
    - Dampers on one portal of service tube is open
    - Gates on portals are closed

Maintenance operation mode (service tube):

- Maintenance work
  To guarantee sufficient air quality the gates at the portal will be opened. The flow sensors in the service tube measure the air velocity inside the service tunnel. If the measured velocity is below 1 m/s the jet fans will be activated in direction of actual flow. If bad air quality is detected from the sensor the fans will be activated too.
    - Dampers on both portals of service tube are closed
    - Gates on portals are open

Fire operation mode:

- Service tube acts as escape route
  The basic procedure corresponds to the normal operation. In this case the jet fans must be deactivated, and the protection damper will be opened. At the same time, it must be ensured that the gates will be closed automatically, if open.
    - Damper on one portal of service tube is opened (depending on fire location)
    - Gates on portals are closed

6. CONDITION MONITORING

The hours of operation must be recorded for every jet fan and axial fan separately. The data is used for maintenance scheduling and for balancing the operating hours (refer to chapter 4.2.10). The value for each fan should be displayed at SCADA. A possibility to reset the counter should also be provided.

7. DATA INTERFACE

7.1 Data export

For commissioning tests, fire tests or other tests, the data export from the PLC/SCADA system has to be provided at any time. The operator must be able to start the data export from the SCADA system. After 24 hours the export stops automatically.
The exported data has to be editable with MS Excel. A .csv file is recommended.
The minimum required data includes:

- real values of all sensors
- operating status of ventilation euipment
- In- and outline of the controller
- Data from the fire detection unit (LHD)
- Values of air quality sensors (CO and turbidity)
- Feedback from the ventilation euipment

All data must be stored with a continuous time stamp (maximum every 2 seconds) and without averaging.

8. INDEX

8.1 Documents used

[1] Llogara tunnel - Detail design of tunnel ventilation system, BE2020FB16_1, Balda GmbH
[2] RVS 09.02.31 Tunnel, Tunnelausrüstung, Belüftung, Grundlagen, Ausgabe 1. Juni 2014 [ventilation basics]
[3] RVS 09.02.32 Tunnel, Tunnelausruestung, Belüftung, Luftbedarfsberechnung, Ausgabe 1. Jänner 2020 [calculation of fresh air demand]
[4] RVS 09.02.22, Tunnel, Tunnelausruestung, Betrieb und Sicherheit, June 2014

8.2 Index of tables

8.3 Index of figures

9. Appendix – Priority table for longitudinal ventilation

event in fire zone	flow direction at event (and jet fan activation direction)	Priority of jet fans (variable frequency and pairwise)					priority of air speed sensors							set point air speed
		JFM 1.1, JFM 1.2	JFM 2.1, JFM 2.2	JFM 3.1, JFM 3.2	JFM 4.1, JFM 4.2	JFM 5.1, JFM 5.2	FSM 1	FSM 2	FSM 3	FSM 4	FSM 5	FSM 6	FSM 7	
FZ 01	to north	5	4	3	2	1	0	1	2	3	0	0	0	-1.0 to -1.5 m/s
	to south	changing the flow direction to north					changing the flow direction to north							
FZ 02	to north	5	4	3	2	1	0	0	1	2	3	0	0	
	to south	changing the flow direction to north					changing the flow direction to north							
FZ 03	to north	5	4	3	2	1	0	0	1	2	3	0	0	
	to south	changing the flow direction to north					changing the flow direction to north							
FZ 04	to north	5	4	3	2	1	0	0	1	2	3	0	0	
	to south	changing the flow direction to north					changing the flow direction to north							
FZ 05	to north	5	4	3	2	1	0	0	1	2	3	0	0	
	to south	changing the flow direction to north					changing the flow direction to north							
FZ 06	to north	5	4	3	2	1	0	0	1	2	3	0	0	-1.0 to -1.5 m/s
	to south	5	4	3	2	1	0	0	0	0	3	2	1	1.0 to 1.5 m/s
FZ 07	to north	5	4	3	2	1	0	0	1	2	3	0	0	-1.0 to -1.5 m/s
	to south	5	4	3	2	1	0	0	0	0	3	2	1	1.0 to 1.5 m/s
FZ 08	to north	5	4	3	2	1	0	0	1	2	3	0	0	-1.0 to -1.5 m/s
	to south	5	4	3	2	1	0	0	0	0	3	2	1	1.0 to 1.5 m/s
FZ 09	to north	5	4	3	2	1	0	0	1	2	3	0	0	-1.0 to -1.5 m/s
	to south	0	4	3	2	1	0	0	0	0	3	2	1	1.0 to 1.5 m/s
FZ 10	to north	0	4	3	2	1	0	0	1	2	3	0	0	-1.0 to -1.5 m/s
	to south	0	4	3	2	1	0	0	0	0	3	2	1	1.0 to 1.5 m/s
FZ 11	to north	0	4	3	2	1	0	0	1	2	3	0	0	-1.0 to -1.5 m/s
	to south	0	4	3	2	1	0	0	0	0	3	2	1	1.0 to 1.5 m/s
FZ 12	to north	0	4	3	2	1	0	0	0	1	2	3	0	-1.0 to -1.5 m/s
	to south	0	4	3	2	1	0	0	0	0	3	2	1	1.0 to 1.5 m/s
FZ 13	to north	5	4	3	2	1	0	0	0	1	2	3	0	-1.0 to -1.5 m/s
	to south	0	4	3	2	1	1	0	0	0	0	3	2	1.0 to 1.5 m/s
FZ 14	to north	5	4	3	2	1	0	0	0	1	2	3	0	-1.0 to -1.5 m/s
	to south	0	4	3	2	1	1	0	0	0	0	3	2	1.0 to 1.5 m/s
FZ 15	to north	5	4	3	2	1	0	0	0	1	2	3	0	-1.0 to -1.5 m/s
	to south	5	4	3	2	1	1	0	0	0	0	3	2	1.0 to 1.5 m/s
FZ 16	to north	5	4	3	2	1	0	0	0	1	2	3	0	-1.0 to -1.5 m/s
	to south	5	4	3	2	1	1	0	0	0	0	3	2	1.0 to 1.5 m/s
FZ 17	to north	5	4	3	2	1	0	0	0	1	2	3	0	-1.0 to -1.5 m/s
	to south	4	5	3	2	1	1	0	0	0	0	3	2	1.0 to 1.5 m/s
FZ 18	to north	5	4	3	2	1	0	0	0	1	2	3	0	-1.0 to -1.5 m/s
	to south	4	5	3	2	1	1	0	0	0	0	3	2	1.0 to 1.5 m/s
FZ 19	to north	4	5	3	2	1	0	0	0	1	2	3	0	-1.0 to -1.5 m/s
	to south	1	0	4	3	2	2	1	0	0	0	0	3	1.0 to 1.5 m/s
FZ 20	to north	4	0	3	2	1	0	0	0	1	2	3	0	-1.0 to -1.5 m/s
	to south	1	0	4	3	2	2	1	0	0	0	0	3	1.0 to 1.5 m/s
FZ 21	to north	4	0	3	2	1	0	0	0	1	2	3	0	-1.0 to -1.5 m/s
	to south	1	0	4	3	2	2	1	0	0	0	0	3	1.0 to 1.5 m/s
FZ 22	to north	4	0	3	2	1	0	0	0	0	1	2	3	-1.0 to -1.5 m/s
	to south	1	0	4	3	2	2	1	0	0	0	0	3	1.0 to 1.5 m/s
FZ 23	to north	4	5	3	2	1	0	0	0	0	1	2	3	-1.0 to -1.5 m/s
	to south	1	0	4	3	2	2	1	0	0	0	0	3	1.0 to 1.5 m/s
FZ 24	to north	4	5	3	2	1	0	0	0	0	1	2	3	-1.0 to -1.5 m/s
	to south	1	0	4	3	2	2	1	0	0	0	0	3	1.0 to 1.5 m/s
FZ 25	to north	4	5	3	2	1	0	0	0	0	1	2	3	-1.0 to -1.5 m/s
	to south	1	5	4	3	2	2	1	0	0	0	0	3	1.0 to 1.5 m/s
FZ 26	to north	4	5	3	2	1	0	0	0	0	1	2	3	-1.0 to -1.5 m/s
	to south	1	5	4	3	2	2	1	0	0	0	0	3	1.0 to 1.5 m/s
FZ 27	to north	4	5	3	2	1	0	0	0	0	1	2	3	-1.0 to -1.5 m/s
	to south	1	4	5	3	2	2	1	0	0	0	0	3	1.0 to 1.5 m/s
FZ 28	to north	4	5	3	2	1	0	0	0	0	1	2	3	-1.0 to -1.5 m/s
	to south	1	4	5	3	2	2	1	0	0	0	0	3	1.0 to 1.5 m/s
FZ 29	to north	3	4	5	2	1	0	0	0	0	1	2	3	-1.0 to -1.5 m/s
	to south	1	2	0	4	3	3	2	1	0	0	0	0	1.0 to 1.5 m/s
FZ 30	to north	3	4	0	2	1	0	0	0	0	1	2	3	-1.0 to -1.5 m/s
	to south	1	2	0	4	3	3	2	1	0	0	0	0	1.0 to 1.5 m/s
FZ 31	to north	3	4	0	2	1	0	0	0	0	1	2	3	-1.0 to -1.5 m/s
	to south	1	2	0	4	3	3	2	1	0	0	0	0	1.0 to 1.5 m/s
FZ 32	to north	3	4	0	2	1	3	0	0	0	0	1	2	-1.0 to -1.5 m/s
	to south	1	2	0	4	3	3	2	1	0	0	0	0	1.0 to 1.5 m/s
FZ 33	to north	3	4	5	2	1	3	0	0	0	0	1	2	-1.0 to -1.5 m/s
	to south	1	2	0	4	3	3	2	1	0	0	0	0	1.0 to 1.5 m/s
FZ 34	to north	3	4	5	2	1	3	0	0	0	0	1	2	-1.0 to -1.5 m/s
	to south	1	2	0	4	3	3	2	1	0	0	0	0	1.0 to 1.5 m/s
FZ 35	to north	3	4	5	2	1	3	0	0	0	0	1	2	-1.0 to -1.5 m/s
	to south	1	2	5	4	3	3	2	1	0	0	0	0	1.0 to 1.5 m/s
FZ 36	to north	3	4	5	2	1	3	0	0	0	0	1	2	-1.0 to -1.5 m/s
	to south	1	2	4	5	3	3	2	1	0	0	0	0	1.0 to 1.5 m/s
FZ 37	to north	3	4	5	2	1	3	0	0	0	0	1	2	-1.0 to -1.5 m/s
	to south	1	2	4	5	3	3	2	1	0	0	0	0	1.0 to 1.5 m/s
FZ 38	to north	3	4	5	2	1	3	0	0	0	0	1	2	-1.0 to -1.5 m/s
	to south	1	2	4	5	3	3	2	1	0	0	0	0	1.0 to 1.5 m/s
FZ 39	to north	2	3	4	5	1	3	0	0	0	0	1	2	-1.0 to -1.5 m/s
	to south	1	2	3	0	4	0	3	2	1	0	0	0	1.0 to 1.5 m/s
FZ 40	to north	2	3	4	0	1	3	0	0	0	0	1	2	-1.0 to -1.5 m/s
	to south	1	2	3	0	4	0	3	2	1	0	0	0	1.0 to 1.5 m/s
FZ 41	to north	2	3	4	0	1	3	0	0	0	0	1	2	-1.0 to -1.5 m/s
	to south	1	2	3	0	4	0	3	2	1	0	0	0	1.0 to 1.5 m/s
FZ 42	to north	2	3	4	0	1	2	3	0	0	0	0	1	-1.0 to -1.5 m/s
	to south	1	2	3	0	4	0	3	2	1	0	0	0	1.0 to 1.5 m/s
FZ 43	to north	2	3	4	5	1	2	3	0	0	0	0	1	-1.0 to -1.5 m/s
	to south	1	2	3	0	4	0	3	2	1	0	0	0	1.0 to 1.5 m/s
FZ 44	to north	2	3	4	5	1	2	3	0	0	0	0	1	-1.0 to -1.5 m/s
	to south	1	2	3	0	4	0	3	2	1	0	0	0	1.0 to 1.5 m/s
FZ 45	to north	2	3	4	5	1	2	3	0	0	0	0	1	-1.0 to -1.5 m/s
	to south	1	2	3	5	4	0	3	2	1	0	0	0	1.0 to 1.5 m/s
FZ 46	to north	2	3	4	5	1	2	3	0	0	0	0	1	-1.0 to -1.5 m/s
	to south	1	2	3	5	4	0	3	2	1	0	0	0	1.0 to 1.5 m/s
FZ 47	to north	2	3	4	5	1	2	3	0	0	0	0	1	-1.0 to -1.5 m/s
	to south	1	2	3	4	5	0	3	2	1	0	0	0	1.0 to 1.5 m/s
FZ 48	to north	1	2	3	4	5	2	3	0	0	0	0	1	-1.0 to -1.5 m/s
	to south	1	2	3	4	5	0	3	2	1	0	0	0	1.0 to 1.5 m/s
FZ 49	to north	1	2	3	4	5	2	3	0	0	0	0	1	-1.0 to -1.5 m/s
	to south	1	2	3	4	0	0	0	3	2	1	0	0	1.0 to 1.5 m/s
FZ 50	to north	1	2	3	4	0	2	3	0	0	0	0	1	-1.0 to -1.5 m/s
	to south	1	2	3	4	0	0	0	3	2	1	0	0	1.0 to 1.5 m/s
FZ 51	to north	1	2	3	4	0	2	3	0	0	0	0	1	-1.0 to -1.5 m/s
	to south	1	2	3	4	0	0	0	3	2	1	0	0	1.0 to 1.5 m/s
FZ 52	to north	1	2	3	4	0	1	2	3	0	0	0	0	-1.0 to -1.5 m/s
	to south	1	2	3	4	0	0	0	3	2	1	0	0	1.0 to 1.5 m/s
FZ 53	to north	1	2	3	4	5	1	2	3	0	0	0	0	-1.0 to -1.5 m/s
	to south	1	2	3	4	0	0	0	3	2	1	0	0	1.0 to 1.5 m/s
FZ 54	to north	1	2	3	4	5	1	2	3	0	0	0	0	-1.0 to -1.5 m/s
	to south	1	2	3	4	0	0	0	3	2	1	0	0	1.0 to 1.5 m/s
FZ 55	to north	changing the flow direction to south					changing the flow direction to south							1.0 to 1.5 m/s
	to south	1	2	3	4	5	0	0	3	2	1	0	0	
FZ 56	to north	changing the flow direction to south					changing the flow direction to south							
	to south	1	2	3	4	5	0	0	3	2	1	0	0	
FZ 57	to north	changing the flow direction to south					changing the flow direction to south							
	to south	1	2	3	4	5	0	0	3	2	1	0	0	
FZ 58	to north	changing the flow direction to south					changing the flow direction to south							
	to south	1	2	3	4	5	0	0	3	2	1	0	0	
FZ 59	to north	changing the flow direction to south					changing the flow direction to south							
	to south	1	2	3	4	5	0	0	0	3	2	1	0	

10. Appendix – Priority table for semi-transverse ventilation

used exhaust damper	priority air speed sensors north side of damper							priority of air speed sensors south side of damper							Priority of jet fans (variable frequency and pairwise)					axial fan(s) used for extraction	
	FSM 1	FSM 2	FSM 3	FSM 4	FSM 5	FSM 6	FSM 7	FSM 1	FSM 2	FSM 3	FSM 4	FSM 5	FSM 6	FSM 7	JFM 1	JFM 2	JFM 3	JFM 4	JFM 5	fan north	fan south
																				(x) fan is used	
ED01	1. mass flow balance							0	1	2	3	0	0	0	5	4	3	2	1	x	
ED02	1. mass flow balance							0	1	2	3	0	0	0	5	4	3	2	1	x	
ED03	1. mass flow balance							0	1	2	3	0	0	0	5	4	3	2	1	x	
ED04	1. mass flow balance							0	1	2	3	0	0	0	5	4	3	2	1	x	
ED05	1	2. mass flow balance						0	0	1	2	3	0	0	5	4	3	2	1	x	
ED06	1	2. mass flow balance						0	0	1	2	3	0	0	5	4	3	2	1	x	
ED07	1	2. mass flow balance						0	0	1	2	3	0	0	5	4	3	2	1	x	
ED08	1	2. mass flow balance						0	0	1	2	3	0	0	5	4	3	2	1	x	
ED09	1	2. mass flow balance						0	0	1	2	3	0	0	0	4	3	2	1	x	
ED10	1	2. mass flow balance						0	0	1	2	3	0	0	0	4	3	2	1	x	
ED11	2	1	3. mass flow balance					0	0	1	2	3	0	0	0	4	3	2	1	x	
ED12	2	1	3. mass flow balance					0	0	1	2	3	0	0	0	4	3	2	1	x	
ED13	2	1	3. mass flow balance					0	0	1	2	3	0	0	5	4	3	2	1	x	
ED14	2	1	3. mass flow balance					0	0	1	2	3	0	0	5	4	3	2	1	x	x
ED15	2	1	3. mass flow balance					0	0	0	1	2	3	0	5	4	3	2	1	x	x
ED16	2	1	3. mass flow balance					0	0	0	1	2	3	0	4	5	3	2	1	x	x
ED17	2	1	3. mass flow balance					0	0	0	1	2	3	0	4	5	3	2	1	x	x
ED18	2	1	3. mass flow balance					0	0	0	1	2	3	0	4	5	3	2	1	x	x
ED19	2	1	3. mass flow balance					0	0	0	1	2	3	0	4	0	3	2	1	x	x
ED20	2	1	3. mass flow balance					0	0	0	1	2	3	0	4	0	3	2	1	x	x
ED21	3	2	1	0	0	0	0	0	0	0	1	2	3	0	4	0	3	2	1	x	x
ED22	3	2	1	0	0	0	0	0	0	0	1	2	3	0	4	0	3	2	1	x	x
ED23	3	2	1	0	0	0	0	0	0	0	1	2	3	0	4	5	3	2	1	x	x
ED24	3	2	1	0	0	0	0	0	0	0	1	2	3	0	4	5	3	2	1	x	x
ED25	3	2	1	0	0	0	0	0	0	0	0	1	2	3	4	5	3	2	1	x	x
ED26	3	2	1	0	0	0	0	0	0	0	0	1	2	3	3	4	5	2	1	x	x
ED27	3	2	1	0	0	0	0	0	0	0	0	1	2	3	3	4	5	2	1	x	x
ED28	3	2	1	0	0	0	0	0	0	0	0	1	2	3	3	4	5	2	1	x	x
ED29	3	2	1	0	0	0	0	0	0	0	0	1	2	3	3	4	0	2	1	x	x
ED30	3	2	1	0	0	0	0	0	0	0	0	1	2	3	3	4	0	2	1	x	x
ED31	0	3	2	1	0	0	0	0	0	0	0	1	2	3	3	4	0	2	1	x	x
ED32	0	3	2	1	0	0	0	0	0	0	0	1	2	3	3	4	0	2	1	x	x
ED33	0	3	2	1	0	0	0	0	0	0	0	1	2	3	1	2	5	4	3	x	x
ED34	0	3	2	1	0	0	0	0	0	0	0	1	2	3	1	2	5	4	3	x	x
ED35	0	3	2	1	0	0	0	3. mass flow balance					1	2	1	2	5	4	3	x	x
ED36	0	3	2	1	0	0	0	3. mass flow balance					1	2	1	2	3	5	4	x	x
ED37	0	3	2	1	0	0	0	3. mass flow balance					1	2	1	2	3	5	4	x	x
ED38	0	3	2	1	0	0	0	3. mass flow balance					1	2	1	2	3	5	4	x	x
ED39	0	3	2	1	0	0	0	3. mass flow balance					1	2	1	2	3	0	4	x	x
ED40	0	3	2	1	0	0	0	3. mass flow balance					1	2	1	2	3	0	4	x	x
ED41	0	0	3	2	1	0	0	3. mass flow balance					1	2	1	2	3	0	4	x	x
ED42	0	0	3	2	1	0	0	3. mass flow balance					1	2	1	2	3	0	4	x	x
ED43	0	0	3	2	1	0	0	3. mass flow balance					1	2	1	2	3	5	4	x	x
ED44	0	0	3	2	1	0	0	3. mass flow balance					1	2	1	2	3	5	4	x	x
ED45	0	0	3	2	1	0	0	2. mass flow balance						1	1	2	3	5	4		x
ED46	0	0	3	2	1	0	0	2. mass flow balance						1	1	2	3	4	5		x
ED47	0	0	3	2	1	0	0	2. mass flow balance						1	1	2	3	4	5		x
ED48	0	0	3	2	1	0	0	2. mass flow balance						1	1	2	3	4	5		x
ED49	0	0	3	2	1	0	0	2. mass flow balance						1	1	2	3	4	0		x
ED50	0	0	3	2	1	0	0	2. mass flow balance						1	1	2	3	4	0		x
ED51	0	0	0	3	2	1	0	2. mass flow balance						1	1	2	3	4	0		x
ED52	0	0	0	3	2	1	0	2. mass flow balance						1	1	2	3	4	0		x
ED53	0	0	0	3	2	1	0	2. mass flow balance						1	1	2	3	4	5		x
ED54	0	0	0	3	2	1	0	2. mass flow balance						1	1	2	3	4	5		x
ED55	0	0	0	3	2	1	0	1. mass flow balance							1	2	3	4	5		x
ED56	0	0	0	3	2	1	0	1. mass flow balance							1	2	3	4	5		x
ED57	0	0	0	3	2	1	0	1. mass flow balance							1	2	3	4	5		x
ED58	0	0	0	3	2	1	0	1. mass flow balance							1	2	3	4	5		x