
PA,GDJE SI LUCE?

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RECONSTRUCTION AND CONVERSION OF "TVORNICA DUHANA ZAGREB" INTO CROATIAN HISTORY MUSEUM

1. PRESENT CONDITION

"Tvornica duhana Zagreb" is the best preserved industrial heritage object in the Croatian capital.

It was built by Rupert Melkus (1833-1891) on a plot which, being situated on the city's edge, was, in accordance with the plan from 1853-1854 "Agram samt Umgebung" used by the army; the regulation basis from 1865 envisaged the construction of Novi Marvinski square, having the function of a cattle fair, but in 1861, railway came to Zagreb, causing the further expansion of the city. The object of "Tvornica duhana Zagreb" was the first object to be constructed on the route between "Kolodvor" (present "Zapadni kolodvor") at the then periphery and the city centre in the vicinity of the brickyard. The regulation of the city in 1887 and further shaping of the space ensue, characterized by construction of grammar-school, general-program secondary school and commercial school in the late 19th ct., followed by construction of city social housing, children's sanatorium and infrastructural facilities between the early 20th ct. and the outset of World War II, followed-up by invitations for tenders for the development of the plot of the former brickyard, construction of "Sokolski dom", Faculty of Engineering and a number of leased buildings. The second half of the 20th ct. was marked by the construction of the Faculty of Engineering, hotel and smaller interpolations.

The building has the shape of a Neo-Renaissance palace with regular window distribution. Construction in stages was originally planned, wherein each stage would represent a single wing with tripartite division of the façade, i.e. two peripheral and one central risalit, however, two similarly shaped wings (northern and eastern) were constructed simultaneously, forming a block in which one wing was positioned at the right angle from the other, giving the object its final L-shaped ground plan. The southern wing was never constructed, although there was room for future development and subsequent interventions were not in line with the original urban development concept, so that the block was never adequately articulated. The space is divided across three floors: basement, ground floor, first floor and attic, having the total surface of almost 10000 m^2. Walls are made from brick, floor structure is brick arches in the basement, system of longitudinal and transversal beams on other floors, resting on cast-iron pillars and walls and wooden roof, all windows are classic wooden windows (double with inter-space). Part of the structure is ruined, but the whole is well preserved or there is possibility of quality reconstruction.

It has continuously served its original function since its construction in 1881-1882 until 2006, with understandable ownership changes due to the length of its exploitation and different social orders. The development of technological processes required the execution of a number of adaptations and expansions, the largest of which were the ones made in 1961 and 1971 when the large two-floor hall and administrative tower were constructed and the building largely devastated to ensure unobstructed functional connections (easier communication of people and machinery) of the old building with extensions. Due to rationalization of operation, the owner decided to relocate production from several into one central location, leaving the factory empty.

The building is an individual protected cultural good and the Ministry of Culture and owner agreed to cooperate, i.e. open a Croatian History Museum in the old object and construct a new, mostly office building at the place of subsequent extensions. Invitation for tenders was published in early 2007 in the organization and execution of the Architects' Association of the City of Zagreb. It was decided that the realization be entrusted to the author team of Ivica Plavec, Žanet Zdenković Gold and Ivan Zdenković.

2. NEW USER

The Croatian History Museum is an institution succeeding the National museum founded in , at the time of awakening of the national awareness, just like Archeological and Natural History museums. Due to its character and different social orders, it was often considered a hindrance by the central government, causing repeated obstructions to its operation from ideological reasons – adoption of decision to close the museum, incorporation of its exhibits into other institutions and similar. That is probably why the museum was never awarded adequate premises, nor had a permanent collection, but has instead been operating as a "tenant" in the most beautiful late Baroque palace in Zagreb Old Town (former Mayor's office) and "Dom likovnih umjetnika" in a comparatively small space which never allowed for the formation of a permanent exhibition and adequate display of museum exhibits, so that its activity is reduced to occasional exhibitions and accompanying publishing activity.

The extensive holdings of the Croatian History Museum include unique materials (over 200 000 exhibits and documents) testifying to the political, economic, social and cultural history of the Croatian people, covering the period from the late Middle Ages to the present. The collected holdings are a source of information and knowledge for different humanistic sciences, primarily history and art history. Auxiliary historical sciences served as the main determinant for the structuring of the holdings and defining of museum collections. The collections of the Croatian History Museum thus represent a unique source for the study of heraldry, sphragistics, vexicology, numismatics, cartography (etc.) in Croatia and Central Europe.

3. APPROACH TO TERMS OF REFERENCE

There is a relatively large number of industrial heritage monuments in Croatia which are deteriorating due to socioeconomic changes, attractiveness of locations to investors (who consider the cultural monument status a hindrance) and neglect of the society. The accommodation of museum-gallery activities into former industrial facilities imposed itself both as the model of salvage of such objects and solution to the spatial problems of certain institutions. Although such solution looks like a winning combination, it is actually plagued by a number of problems familiar to project-engineers and future users alike.

Museums and galleries have very complex spatial-functional requirements stemming from their activity:

- Exhibition and educational activity (communication with the public) – entrance space, informative space and cash desk, souvenir shop, coffee shop, exhibition halls, multimedia halls, pedagogical workshop, reading rooms…
- Protection and preservation of exhibits – adequate storing and safekeeping of exhibits and space reserved for expansion of holdings (with special emphasis on the protection of exhibits to prevent their deterioration under the influence of moisture, light, fire and theft)
- Scientific and expert work – a number of activities including the presentation and study of exhibits, restoration-preparation workshop, administrative service required for the management, maintenance and promotion of exhibition activity, as well as ensurance of conditions for work and expansion of the holdings
- Power drive – ensuring microclimate conditions in premises in which exhibits are stored and displayed, comfortable conditions in work areas and adequate lighting for the exhibition activity, as well as multimedia contents.

Such complex requirements place huge new object design-related requirements before program developers, future users and project-engineers alike, making the conversion of and interventions in the defined cultural monuments almost impossible. The adaptation of the object to modern earthquake protection, fire safety and other local regulations needs to be added to above requirements. All these concerns made the tackling of this task a huge challenge.

From the outset, the project engineers had a clear approach to the conversion of “Tvornica duhana Zagreb” into Croatian History Museum. The majority of their attitudes gained additional strength and were further elaborated. The abandonment of these self-imposed issues was uncompromisingly refused, which was well accepted by representatives of the investor, aware that most of the proposed measures offer higher comfort levels, as well as easier and more cost-efficient exploitation of the object:

- ensure the unobstructed accommodation of all museum contents within the defined volume of the extant building, including the realization of all functional connections
- ensure special conditions required for museum activities (microclimate conditions, lighting, multimedia)
- flexibility and adaptability relating to possible changes in museum technologies
- ensure the adaptation of the extant object to its new use and contemporary safety regulations
- due to large energy needs, act as though new object is being constructed and ensure maximum energy-efficiency both of individual parts of equipment and object as a whole
- recognize the value of cultural heritage and preserve it in its original form
- and try to offer our authorship potential in order to contribute to the positive impression of the old object on new users by favorable, contemporary expression.

Since energy-efficiency is the subject of this gathering, we will now turn our focus on the program of measures we applied in the designing process in quality cooperation with other professions.

4. PROGRAM OF MEASURES FOR INCREASED ENERGY-EFFICIENCY

4.1. THERMAL ENERGY SAVING AND THERMAL INSULATION PROJECT

Since the proscribed conservation requirements prohibit any interventions disrupting the present visual appearance and lining of the circumferential construction elements on the outside and the same applies to the soffits of floor structures of individual parts of the building undergoing reconstruction, such parts are exempted from the proscribed values of the required thermal and sound insulation for the reconstructed construction parts of the building. For the above construction parts, construction-inflicted damage caused by surface or internal condensation was avoided with minimum intervention, by utilization of the extant system of circumferential partitions, with minimum thickening of layers of internal thermal insulation.

For all other extant construction parts of the building, in which interventions improving the physical characteristics were possible, as well as for new circumferential partitions of heated spaces, the requirements relating to heat-diffusion characteristics have been met in accordance with applicable regulations. All circumferential structures of heated spaces have been conceived so as to achieve good thermal protection values, that structures exposed to excessive temperature changes remain stable, surface temperature of circumferential partitions of heated spaces is satisfactory, that no surface condensation forms on internal surfaces of circumferential partitions of heated spaces and that water vapor condensate, which is impossible to dry out, does not form within the composition of circumferential structures.

The newly added construction parts and increase of the volume of the building in comparison with the original condition are minimum, the testing of total heat losses proved to be satisfactory and in accordance with applicable regulations for new buildings, since technical requirements relating to the heat loss coefficient proscribed for new buildings have been met in the reconstructed structures.

All the indoor heated spaces in the building will be heated to the average minimum temperature of +20^{0}C (depot and engine room have independent temperature regulation). Depot and engine room premises equipped with cooling installations have been taken into account in the calculation of the heated volume of the building and ventilation engine rooms have been shut down, although ceiling and wall partitions towards engine rooms have been insulated against heat in the same manner as partitions towards outdoor or unheated spaces. The heating is central with hot water pipe distribution and fan coil devices or radiators serving as heating devices. The cooling of the building is envisaged by fan coil devices. Ventilation, heating and cooling engine rooms are situated in the separate spaces in the attic, in raised roof towers, while other parts of the building occupied by people are thermally-insulated from them.

The bearing structure of the building is the extant system of full-brick walls, with walls of the undercut staircase and warehouse premises made from reinforced concrete. Roof structures above the ground floor are massive full-brick arches and above other floors – extant reinforced concrete ceilings or wooden roof structures strengthened by bracing with monolithic reinforced concrete roof panels or executed with the required sound and thermal insulation lining between floors. Parts of the extant walls in the ground and bed zone by the ground are old brick walls and capillary penetration of moisture into the interior will be prevented by wall impregnation by injection. New basement walls, floors, ceilings and braced parts of the walls in the ground are made from reinforced concrete, with adequate thermal and hydro-insulation. Roof structures are wooden roof structures reconstructed in steel, in the same dimensions, covered with roof tiles or flat fiber cement panels, executed with required sound and thermal insulation lining towards external space, all in keeping with agreement with the competent conservation service. Internal partitions are extant massive full brick walls, roughcast or with additional sound and thermal insulation lining or new light multi-layer gypsum plasterboard partitions.

The extant external full brick walls have internal thermal insulation executed with mineral wool panels, vapor barrier and internal finish in gypsum plasterboard or cement panels. The external side of the wall is the extant facade brick and stone mortar at the base of the walls in the ground. Full brick walls in the ground and at the base of the walls are impregnated by injection to prevent capillary diffusion of moisture (final technology to be agreed with the contractor, at the proposal of project engineer, to ensure quality).

Walls in the ground in the case of extant full brick walls are impregnated by injection and hydro-insulated on the inside with polymer-bitumen hydro-insulation strips, executed with thermal insulation panel lining made from extruded polystyrene and fiber cement panels mounted on substructure removed from the wall. New external walls of the basement near the ground are made from reinforced concrete, hydro-insulated on the outside with single-layer synthetic hydro-insulation strips, with external thermal insulation and mechanical protection made from extruded polystyrene panels. Concrete was set under the new walls of the basement staircase in bays, under the extant full brick walls of the building, hydro-insulated and thermally insulated on the inside, just like parts of full brick walls above.

Walls towards unheated basement premises are made from reinforced concrete, with internal mineral wool panel thermal insulation, vapor barrier and internal finish in cement panels, with substructure of the panels being lined with mineral wool to obstruct thermal bridges. The external part of the wall is extant façade brick and stone mortar at the base of the walls in the ground. Walls towards unheated engine rooms are massive brick walls, roughcast and with added mineral wool thermal insulation, covered with gypsum plasterboards attached to elastic mounted substructure with lined substructure thermal bridges, executed on the side of the wall which is colder during winter. When executing light multi-layer gypsum plasterboard partitions towards engine rooms, triple partition with two air-pockets filled with mineral wool and vapor barrier placed between two layers of gypsum plasterboards was used on the side of the wall warmer during winter, facing the occupied premises. The gable wall towards the neighboring building is double massive full brick wall, structurally fully dilated and roughcast on the inside.
Partition walls dividing occupied spaces and towards halls or other-purpose zones are extant massive partitions made from bilaterally roughcast full brick or new light multi-layer gypsum plasterboard partitions, with single or double substructure being filled with mineral wool panels. Elevator walls are envisaged as reinforced concrete walls with light flexible gypsum plasterboard lining, with substructure filled with soft mineral wool panels.
In new roofs of the ground floor above the basement depot space, external hydro-insulation with synthetic hydroinsulating strips has been executed above the reinforced concrete roof panel, with mechanical protection of the hydro-insulation, protection against roots and appropriate finish layers of flat walkthrough or green roof, with thermal insulation being executed in the ceiling soffit with mineral wool panels protected with gypsum plasterboard panels mounted on elastic substructure, with lined thermal bridges of the substructures and foil for absolute vapor barrier, placed under double gypsum plasterboard ceiling soffit lining. Lining of the ceiling soffit of the depot under unheated facility rooms at the basement level -1 above depot is executed in the same manner.
Flat roof of open-air and roofed-over facilities at attic level is executed as braced reinforced concrete panel on profiled sheet metal and steel beams or as massive reinforced concrete panel with inclined concrete layer above, with vapor barrier, extruded polystyrene panel thermal insulation and hydro-insulation from one-layered synthetic foils, protected sound absorbing foil and finish reinforced concrete bed. In the floor of indoor engine rooms above heated spaces, the execution of layers of flat roof similar to that of outdoor facilities is envisaged, just with a thinner thermal insulation layer and part of thermal insulation in the ceiling soffit, with mineral wool panel thermal insulation, absolute vapor barrier and soffit lining with gypsum plasterboard.
Light sloping roofs above attic are light ventilated roof structures plated on both sides with steel binding girders with "Z" steel profiles, longitudinally filled with mineral wool in two layers with overlap, with internal vapor barrier and gypsum plasterboard ceiling soffit lining, external precipitation barrier and roof tiles or fiber concrete flat panels for diagonal coverage, on double cleats for roof ventilation and leachate water drainage, with corresponding elements for execution of continuous ventilation openings at the level of eaves and ridge of each roof surface, with anti-vermin protection.
Floors of ground surfaces are executed with extruded polystyrene panel thermal insulation and foam sound absorbing polyethylene foils, as part of floor layers placed above the polymer-bitumen strip hydro-insulation and concrete, lightly reinforced bed in floors of the extant building on the ground. In the depot, reinforced concrete foundation panel made from watertight concrete is executed with details of concreting interruption secured with swelling strips, thermal insulation with extruded polystyrene panels and reinforced concrete bed for execution of finishing floor layers above.
Floor structures are, depending on the situation, executed with foam polyethylene sound absorbing foils and final floor cover from lightly reinforced cement screed poured over massive reinforced concrete ceiling panels, wooden ceilings with beams and lining, braced with reinforced concrete panels or on massive ceilings with brick arches and leveled with construction waste and sand. In wooden braced ceilings with reinforced concrete panels above and thinner extant reinforced concrete ceiling panels of floor structures, the execution of additional sound and thermal insulation on ceiling soffit is envisaged, with soffit lining with gypsum plasterboard mounted on elastic substructure filled with soft mineral wool panels.
All structures with breaks from external circumferential structures of heated spaces (thermal bridges – breaks from external walls or ceiling panels between heated spaces and unheated or external spaces) are envisaged as lined with a layer of thermal insulation and vapor barrier on the inside, to insulate thermal bridges. All surfaces of circumferential structures of heated spaces must invariably be executed with thermal insulation, if technically possible and allowed by conservation requirements. The solutions of adequate and efficient breaks or thermal bridge linings must be attached to detailed project documentation.
Windows and doors are envisaged with glazing from double IZO glass with low-E coating, in wooden frames, as double windows in which internal wing would be executed with IZO glass, while external glass would remain

single, thus preserving the original form of the façade and as single: skylights and other glazing and doors with IZO glazing. Thermal radiation protection of all glazed openings with UV foils on external windows and insolation protection elements (textile roller blinds – also required for quality display and presentation of exhibits and preservation thereof) between wings in case of double windows and external textile roller blinds in case of skylights or reflective glazing for external heat radiation reduction.
External doors are extant reconstructed full massive wooden doors and doors between heated spaces and unheated or outdoor facilities or garage are executed as full metal doors with wing filling with mineral wool panels. Glazed walls, windows and doors are installed in the same plane as thermal insulation or overlapped with thermal insulation, so as to avoid line heat losses around openings. High sealing of envisaged metalworks and joinery and low vapor permeability of façade lining could cause excessive increase in humidity and air temperature in frequented spaces, exceeding designed values. To avoid the effect of surface condensation and lingering of spent air in the premises, the proscribed quantity of air circulation in all frequented rooms must be ensured by forced ventilation system ensuring values above the proscribed minimum 0,5 h^{1} air volume exchange, i.e. 1 h^{-1} due to the special utilization regimen conditioned by preservation of exhibits.

4.2. THE PROJECT FOR MECHANICAL INSTALLATIONS (VENTILATION, AIR CONDITIONING, HEATING/COOLING)

VENTILATION

The plant for processing of the air and ventilation is designed as several independent systems depending on the intended purpose of the space, the expected number users, the quality requirements and the prescribed micro-climatic conditions.

THE CONCEPT OF TREATMENT OF THE EXHIBITION SPACES WAS SOLVED IN THE FOLLOWING MANNER:

- The plants for the full air conditioning with a package of the climatic chambers. Plant for processing of the air ensures provision of fresh air, partial coverage of the summer gains and winter losses of the heat, ventilation of the spaces and drainage of the waste air. For every space is also envisaged additional coverage of the summer gains and winter losses by using the parapet fan coils, that are used for heating (60/50 °C), and cooling (6/12 °C), as the four-pipe system equipped for operation with the circulating air.
- The ventilation installations for sanitary spaces and auxiliary spaces.

By its construction, i.e. by its composition, the equipment for processing of the air ensures: provision of the fresh air, filtering of the air, regenerative return of heat from the waste air, facility for recirculation, heating of the air to the required temperature by blowing-in in winter, cooling of the air to the required blowing-in temperature in summer, moistening of the air with water in winter, distribution of the air through the spaces.

Outside the climatic chambers, for the air duct envisaged is fitting of the noise absorbers on the pressure and suction sides, which prevent spreading of the fan noise to the spaces in the construction. Envisaged is fitting of a set of special "PURA" filters in the ventilation supply duct immediately after the climatic chambers.

THE CONCEPT OF TREATMENT OF THE DEPOSITORY WAS SOLVED IN THE FOLLOWING MANNER:

- The plants for the full air conditioning with a package of the climatic chambers. Plant for processing of the air ensures provision of sanitary quantity of the fresh air, partial coverage of the summer gains and winter losses of the heat, ventilation of the spaces and drainage of the waste air. For required maintaining of the constant temperature (coverage of the summer gains and winter losses) in the depository spaces, between 18 and 20 °C and relative humidity between 50 to 60 %, envisaged are two climatic chambers, one operational, the second one as a 100 % backup.

By their construction, i.e. by their composition the climatic chambers ensure: filtering of the air, circulation of the air, heating the air to a required temperature, cooling of the air to a required temperature, moistening of the air by using the steam.

The air intake is on bottom side of the climatic chambers, through an intake mesh, and exhaust is on the upper side, through the duct distribution and exhaust meshes. The processed fresh air within the climatic chambers K-3/O-3 is blown-in directly to the climatic chamber, where it will be mixed with the air from the spaces and where it will be additionally processed.

CONNECTION TO THE ENERGY SUPPLY AND EQUIPPING OF THE CHAMBERS

As the heating medium in the climatic chambers is used hot water 75/55 °C. All climatic chambers are equipped with automatic circuits for independent operation, that controls protection of the electric motors, that monitors pollution of the filters, protects the heater from freezing, controls operation of the pump and the three-way heater valve and all other elements. The monitoring of the operation of all functions is via a CMCS (Central Monitoring and Controlling System).

As the heating media for the climatic chambers used is water heated to 75/55 °C, and as the cooling media used is a mixture of a non-freezing agent and the cool water, at 3/9 °C. Every climatic chamber is equipped with a steam - electro air humidifier, so for that purpose a connection to the waterworks water supply is planned.

The water for humidifying the air in the climatic chambers is prepared in an automatic ion water softener, and by mixing it with the hard water the appropriate water hardness is achieved for the air humidifier water. For the heating period envisaged for the humidifier assembly is a system for automatic removal of mud and a vessel with a dosing pump, for biological treatment of the water. The device operates fully automatically, and its individual functions are automatically transferred to the CMCS.

THE DUCT DISTRIBUTOR, FIRE SHUTTERS AND THE DISTRIBUTION ELEMENTS

Distribution and transport of the air is envisaged through the square and round ducts made of the zinced steel sheets.

Distribution of the processed fresh air in the exhibiting spaces placed on the ground floor is via the distribution elements that ensure so called source flow of the air. The distribution elements are placed in the niches of the window parapets. The basic distributor of the ventilating intake ducts to each of the distribution elements will be in the under the floor duct. Air exhaust is through the ventilating meshes fitted on the duct placed under the ceiling of the ground floor.

Distribution of the processed fresh air through the exhibiting spaces placed on the 1st and 2nd floors is through the exhaust ventilating meshes fitted to the ventilating ducts mounted under the ceiling of the 1st and 2nd floors. The air exhaust is also through the ventilating meshes fitted on the ducts mounted under the ceiling.

To prevent spreading of the flames and smoke through the air distributing ducts, in all passages of the duct through the building construction elements that represent the borders of the fire-fighting sectors, fitted will be the fire shutters of fire resisting capacity 90 or 120, with manual and thermal triggers, powered by the electric motors.

THE GAS HEAT-LINE BOILER ROOM

The boiler room contains the boiler plant with five wall-mounted gas condensation heat-line devices with the related circulation pumps and own automatics needed for the cascade operation. The boiler plant and its corresponding automatics represent an autonomous whole, so to the central monitoring facility are transferred only the data on operating status of the plant or alarms.

All circulation pumps are monitored and controlled by an appropriate DDC regulator. The signalisation of the operating and alarm states is transferred to the building central monitoring and controlling system.

To cater for total thermal needs of the building envisaged is a roof-mounted heat-line boiler room of thermal capacity of 500 kW, 75/55 °C. Envisaged are five wall-mounted gas condensation heat-line devices connected to work together by a hydraulic switch (with the corresponding circulation pumps and the appropriate own automatics that is needed for the cascade mode of operation). The boiler room will be placed in the attic of the building. Envisaged is a device for neutralisation of the condensate from the smoke gasses. For additional safety, but exclusively for the alarm purposes, the electro project envisages a gas detecting device. The operation of all functions will be monitored via the CMCS.

In the secondary hot water circuit are envisaged connectors for the following consumers:

- regulating circuit 60/50 °C to cater for the fan coil heating 342 kW
- regulating circuit 75/55 °C to cater for the radiator heating 29,4 kW
- circulation circuit to cater for the heat-line heaters for the climatic chambers 75/55 °C 184 kW

The regulating circuits consist of a pipe temperature sensor fitted in the incoming pipeline, three-way motor regulation valve and the corresponding DDC regulator, and it regulates the temperature of the incoming warm water heating in relation to the external temperatures.

All circulation pumps are monitored and controlled through the appropriate DDC regulator. Signalisation of the operating and alarm states is transferred to the central monitoring-controlling system of the building.

As a part of the boiler room is also solved filling-up and draining of the hot water pipeline system, with softened water, through a double automatic ion water softener, of 4.1 m^3/h capacity, for neutral exchange. The same water is used to fill other secondary closed systems and is prepared the water for humidifying the air in the climatic chambers, also for adiabatic cooling of the water cooler. By mixing the softened water with the hard water achieved is the water of desired hardness. In addition to the contact water humidifiers, also is envisaged a system for automatic removal of mud and the vessel with the dosage pump for biological treatment of the water.

THE COOLING STATION PLANT 6/12 °C AND 3/9 °C

The cooling station plant is envisaged to cater for the total cooling needs of the fan coils and climatic chambers. As the plant for production of the cooled medium envisaged are two water coolers placed in the building's attic.

The first water cooler has the cooling capacity of 303 kW (6/12°C) and is envisaged to cater for the fan coil cooling of the building, through four-pipe parapet fan coils. The cooling medium is water at 6/12°C.

All climatic chambers are equipped with integrated mechanical cooling, so there is no need for the cooling media at 6/12 °C.

The second water cooler has cooling capacity of 56 kW (3/9°C) and is envisaged to cater for the operation of the climatic chambers air coolers. The cooling medium is a mixture of a non-freezing agent and water, at 3/9°C.

All circulation pumps in the cooling refrigeration are monitored and controlled through a corresponding DDC refrigeration station regulator. Signalisation of the operating and alarm states is transferred to the CMCS.

BUILDING HEATING AND COOLING

Heating and cooling of the exhibition spaces, café, library, souvenir shop, conference hall, office spaces and the documentation centre is envisaged through the four-pipe parapet fan coils attached to the supply system for the cold water at 6/12 °C and hot water at 60/50 °C. The office spaces are the only rooms where opening of the windows is planned, and they will be equipped with sensors for interruptions in the fan coil convectors, when the natural ventilation is used.

Every fan coil device is equipped with a three-speed fan for air circulation.

Heating of the large glass surfaces is envisaged by using the floor mounted fan coils.

The climatic chambers are intended for maintaining the temperature and relative humidity within the required limits, for internal depository spaces.

For all other auxiliary spaces designed is radiator heating at 75/55 °C, as the heating bodies are envisaged the plate compact radiators with the temperature regulation via the radiator valve with the thermo-head.

Four separate split systems are envisaged to cater for the whole year cooling of the electro spaces. All serial devices are inverter type, with ecological cooling medium Freon R-410A.

4.3. ELECTRIC INSTALLATIONS PROJECT

Dissipation of the electric energy has significant impact on the energy efficiency of any building. According to that, selecting the appropriate lighting technology has direct impact on the energy efficiency of the buildings.

The selection is based on the principles of the Directive 2002/91/EU on energy properties of the buildings, and the standard HRN EN 15193:2008 en "Energy property of the buildings – Energy requirements for lighting " that determines the base for calculation of electrical energy consumed for lighting, and the new trends in design, i.e. the design recommendations for Energy certificate for buildings.

According to that standard, the border values for consumption of the electrical energy for the office lighting, at the median light of E_{sr}=500 lx, is max. 40 kWh/(m^2a), and the target value is 25 kWh/(m^2a), i.e. 11 W/m^2 for lighting installed in the office premises.

During the design phase for the electrical lighting certain preconditions must be met:

- the efficient light sources (artificial lighting) are used,
- the daily natural light was used optimally (sunlight),
- the energy efficient switching devices are used,
- care was taken about adequate choice of lights and
- care was taken about adequate choice of the lighting control systems.

THE BASIC LIGHT TECHNICAL CONDITIONS AND STANDARDS

One working space: where the area and type of the visual task are precisely defined, according to HRN EN 12464-1) sets the following requirements and assumptions for the technical lighting solution:

- The lighting oriented towards the target and the task for the individual working station, i.e. high efficiency of the lighting.
- Maximal focus on the quantity and the quality of the light.
- Equipped for the individual user requirements (in relation to his psycho-physical predispositions).
- Efficiency of the direct component of the lighting, i.e. a high value for the vertical lighting component.
- Minimal average lighting amounts to 500 lx on the defined working surface, with minimal uniformity of g1≥0.7, and in the immediate environment of g1≥0.6
- Allowed glare for the reflecting surfaces for the normal office use amounts to UGR 19 (for CAD offices it amounts to UGR 16)
- Optimal control of the reflection with lighting below 1000 cd/m^2 for viewing angles <65°
- Lighting control based on the intensity of the daylight and presence of the user
- Actual value for the maintenance factor must be taken into the consideration (according to the HRN EN 12464-1, amounts to approximately 0.8 for office spaces)

DESCRIPTION OF THE SELECTED LIGHTS, BY PURPOSE

The area for standard exhibition of the lapidarium, on the ground floor, due to the specific characteristics of the ceilings (arches), the lighting solution is by a system with direct lighting, using the reflector halogen lights with DALI electronic pre-connection device (source power of 65W), with the UV and IR filters, while the indirect part is provided by the fluorescent light (of 80 W power), also with the DALI electronic pre-connection device.

All lights use electronic pre-connection devices that are, according to the EU standard EN 50294 which defines the energy efficiency index (EEI), must satisfy at the minimum class CELMA=A3, and the electronic attenuators with the function to regulate the light intensity (dimming - DALI) CELMA=A1.

For all other exhibiting spaces is designed a special light (source FL 4x13W) with the UV-Filter-DB-E (75%).

As the basic accent lighting, designed are the lights with a halogen source, with DALI electronic pre-connection device, rotating by 365°, inclined by 90°, various types of reflectors, adjustable focus for the width of the light cone, lighting level regulation (DIMMER), possibility to change the optics, possibility to fit the shading wings, anti-glare shades, conversion filters, 3200-4000K, oval lenses (30°, 50°, 55-70°), honeycomb shades, soft lenses, UVA and IR filters and colour filters, adapted for electric rail DALI DIM.

For general lighting are selected the lights with new technology for fluo-compact sources, power of 14 and 17 W (replacement for the fluo-compact sources 18 W and 26 W), of the following properties:

- Up to 25% lower energy consumption,
- CO_2 emission is up to 50% lower,
- reduced decrease of the light flux in relation to aging,
- contain less mercury,
- source life time is 19,000 hours,
- lower maintenance costs.

For the office spaces, lecture rooms, rooms and other working spaces designed is the lighting with direct/indirect optics, to meet the light technical requirements L<1000 cd/m^2, i.e. to maximally reduce the glare, and to provide a pleasant working atmosphere.

For the laboratory research and testing spaces, strong rooms for the museum exhibits, restoration spaces, quarantine spaces and museum spaces, designed are the lights with the FC sources 2/49W, with transparent diffusor, dark light raster and UV filters and the DALI dimmable electronic pre-connection devices.

For lighting of the building façade (object front), designed is the LED light with a built-in pre-connection device with high frequency LED sources, high quality optics with possibility of pointing in the desired direction.

The safety lighting is also designed with the LED technology lights.

The advantages of the Led lighting are as follows:

- savings of electric energy of up to 80%,
- long life, 19.000 hours and more,
- does not contain any harmful materials and gases,
- lower dissipation of the electric energy, compared to other sources,
- there is no ultra-violet and no infra-red radiation,
- switching on and off does not impact the length of life,
- immediate light, no gradual increase, due to warming up,
- provides 90% of the daylight

THE LIGHTING CONTROL SYSTEM

The lighting control system is fully automated, with option to define priorities, as well as the option to use personal computers, via a simple Web browser application, with strictly defined permissions and limitations. The lighting control is based on the Luxmate BUS technology, and the connection to the lights themselves is based on the DALI and DSI communications technology.

In all spaces, whose external walls are under influence of the daylight (except the auxiliary spaces) the control is via the automatic systems, depending on the presence of the daylight ("the daylight control"), with facilities for the central and local regulation. The spaces must be sized according to the lighting techniques, so by the routine regulation can be achieved the minimal illumination according to the standards EN 12464.

In addition to the said regulation, also is envisaged the control regarding the temporal dependence and detection of presence of persons.

Also, on each of the floors are envisaged the controlling panels, touch-sensitive and with multi-function buttons to cater for the regulation and controlling of the lighting (central on/off button for simple control, 3 programmed scenarios, regulation of 2 group lighting for control of the larger local spaces).

For smaller spaces with the controlled lighting (DALI), designed are the Touch-dim Bus-buttons (with 2 control channels, 1 control group per channel, 2 scenarios per channel).

Lighting of the staircases, corridors and sanitary nodes is also controlled in the sense of switching on and off regimes (day/night regimes) in combination with the presence detectors.

By using the (daylight control) dimming of the lights, depending on the daylight, achieved can be savings of 30-60%, depending on sizes of the windows.

Also, depending on the technological process of the museum operation (presence of the staff and number of visitors) envisaged is time-dependant control of the lighting system, which will, in combination with the presence detectors achieve additional savings of the electric energy (e.g. lights are switched off at 22:00 hours in the evening, and the basic lighting, so called "welcome scene", is activated in the morning, at the beginning of each working day, plus switching on of the lighting in segments, depending on the presence detectors).

4.4. THE CENTRAL MONITORING AND CONTROL SYSTEM (CMCS)

For the object is envisaged a central monitoring and control system, CMCS, that will provide means to rationalise and balance the consumption of the electric energy, thus increasing the energy efficiency of the object.

The system covers management and control of the operation of the thermo-technical installations (air conditioning, ventilation, heating, cooling, individual room regulation system), electro energy installations (main distributor or for low voltages, diesel aggregate, devices for uninterrupted power supply), control of the operation of lifts and surveillance and lighting control systems and multi-media systems.

The central monitoring and control system is called SCADA, and operates on the Microsoft Windows XP platform.

Used are the standard protocols BACnet, LONMARK, and supported are the interfaces according to the: Ethernet, LON, EIB/KNX, Modbus, M-bus and OPC.

5. THE FINAL CONSIDERATIONS

As it was already emphasised, with understanding and assistance from all co-workers when preparing the project, and especially the representatives from the Investor a number of measures were taken to make this building energy efficient. That would be an exceptional success considering all aggravating circumstances: reconstruction of an old object, the existing volume and layout not suitable for the intended complex contents, exceptionally heterogeneous requirements for the future purposes. However, during a financial crisis, such a project should be understood by the relevant ministries, since it promises economic maintenance and pleasant usage, and could be used as a representative example for similar objects and undertakings. In spring 2011 are expected commencement of the financing, the public procurement procedure, and in summer of this year the work should commence. Let us hope for the best!

<u>Sources</u>:

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<u>Expert work and experience of the co-workers</u>:

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