

THE PAST, PRESENT AND FUTURE OF THE LIGHTING EQUIPMENT IN DOBŠINÁ ICE CAVE

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Abstract: Presentation of special technical informations based on our own design and installation of cave lighting equipment (CLE) in the Dobšiná Ice Cave and others caves and their comparison with some CLEs of other caves. They shoul'd help us to plan the new CLE's more friendly and inoffensiv to the caves enviroment in the future. Recomeded and "forbidden" lamps, suitable luminairs, design, installation, control and operation of CLE's. Something about the use of colours and the light effects. The fight against old lampsflora.

Keywords: ice, cave, light, lampsflora

INTRODUCTION

The cave lighting equipment (CLE) is one of the most important technical equipment in the cave. It enables the visitors to observe the beauty and dimensions of rooms, variety of colours and shapes and safe move throught the cave.

- DOBŠINÁ ICE CAVE (Slovak Republic)
- Elderly, present and future lighting equipments
- < 1887 - Torches, candles, oil lamps
- 1887 - 1st electric light - Arc or incandescent lamps
- 1960 - LI/LH - Incandescent and halogen lamps
- 1980 - HPM - High pressure mercury vapour lamps
 - FL - Fluorescent (linear)
- 1998 - HPH - High pressure metal halide lamps
 - FL(C) - Fluorescent (linear/compact)
- 2007 - HPH - High pressure metal halide lamps (electronic ballast)
 - FL(C) - Fluorescent (linear/compact; electronic ballast)
 - LED - Light emitting diode
 - + Colour - little show in suitable room
 - + Scenes - some scenes in 2-3 suitable places
 - + Control - more smaller circuits, more sofisticated control

Do we need realy the light in the cave?

The caves alone don't need any light and any visitors too!!!

YES or NO , open for the visitors or visible only for the speleologist?

The answer for the showcaves is very simple, in the others very difficult.

To prepare a cave to a showcave it is quite complicated and it is allways drastic interference into her ecosystem. To avoid full destruction, we must work extremely sensitivly so that way we avoid the bad light influence. We collected special technical informations from a lot of showcaves during last 2 years. These helped us to make some decisions about the light influence on the lamps-

flora (LF) growing in the caves and will help us to plan the new CLE more better and inoffensiv to the caves enviroment.

The most important informations collected:

- Quantity of luminaires
- Total power of CLE [kW]
- Number of switched circuits
- Type of lamps used in CLE
- Average operation time of CLE [hours/day]
- Length of visitorspath with CLE [m]
- Number of visitors in a year
- Average temperature [°C]
- How much lampsflora is in the cave: none – less – medium – a lot
- And some others additional questions

1ST RESULTS

We've got the informations from:

	Caves with incandescent lamps	Length of visitors paths [m]	Caves with discharge lamps	Length of visitors paths [m]
CLEs planed by COMLUX	15	12 000	1	360
Other CLEs	40	30 000	14	8 030

Also altogether from 70 caves with 50 000 m visitors paths.

The answers were mostly usefull, some quite poor too – depending from the skill of the persons and his knowledge about the CLE. Unfortunately the datas of about 15 caves aren't completely. We know, it wasn't easy to fill our questionnaire, we achieved the best results in the caves visited by ourself.

What did we see?

Quality of CLE	incandescent lamps	discharge lamps
Excellent	9	1
Good	16	4
Medium	20	3
Bad	3	2
Awfull	2	4

As we can see, only 10 % CLEs with incandescent lamps are bad or awfull, while 43 % CLEs with discharge lamps failed into this categorie!

The result is, that it is necessary to pay higher attention to plan and install of CLEs with discharge lamps!

PRINCIPAL RULES of ESTHETIC is TO SHOW THE NATUR and it means:

- NO FUNNY COLOURLIGHT
- we HANDLE CAREFULLY with LIGHT and SOUND EFFECTS

Important are

ESTHETIC NEEDS on ROOM and OBJECT LIGHTING

TECHNOLOGICAL EQUIPMENT
FINISHING TAUCH of INSTALLATION
ENVIRONMENT PROTECTION (ECOLOGIE)
during the installation (destruction of cave)
while at work of CLE (light and heat)

SAFETY of persons and objects
sensitiv INSTALLATIONS and OPERATING KOST
easy CONTROL and MAINTENANCE

THERE IS NO STANDARDS OR RESTRICTIONS about the light quality and quantity in the showcaves.

PRACTICAL EXPERIENCE:

ILLUMINANCE of SHOWOBJECTS,

like in stagelighting lies between 10 and several 100 lx - mostly directlight.

For the SAFETY on the PATHS and DANGEROUS POINTS

(steps, low profile, ...) are suitable about 2 lx (minimum 0,1 lx) - mostly indirect, sometimes with special luminaires.

EMERGENCY LIGHT,

mostly with guide carrying the torch, (seldom with special luminaires).

“WHITE” v.s. “COLOURLIGHT “

WHITE!!!

If we'd like to show to visitors the beauty of natur, we need the light with very good Ra and Tc:

karst caves Tc max. till 4000 K (neutral white)
optimum 3000 K (warm white)
Ra minimum 80
ice caves Tc optimum 4000 K, sometimes til 6000 K (day white)
Ra minimum 80

COLOUR only if we'd like to make a SHOW in the cave, but for this reason we don't need the cave indeed!!!

What has the positive influence on growing of LF?

1. LIGHT EXPOSITION = $\Phi \times t$
2. HEAT but isn't enough alone (can only dried the cave)
3. LIGHT and HEAT EXPOSITION 2 = EXPOSITION x K or + K
4. 1 and/or 3 combine with something else (humidity, etc.)??? There must be a limit value of EXPOSITION, under which the LF doesn't exist!!! BUT WHICH ONE??? Certainly some preferred wavelenghts too (question for biologist???)

Where:

- Φ - luminous flux affected the lighted surface
- t - time, the influence period of luminous flux
- K - heath coefficient (amplify factor of EXPOSITION)

What can we do to avoid the grow of LF?

Prevention - today's the moustly effective method.

1. Minimalize Φ it means, less illuminance (but there is a treshold value for acceptable sight), dynamic of light, more lamps of less power, bigger distance from the objects, suitable positions and aiming of floodlights.
2. Minimalize t it means, short controlled parts, no standstill light of paths. (RESTRICT VISITORS QUANTITY!!!???)
3. Minimalize K it means to use the lamps with less heat-production, what means high efficiency (lm/W), FL and HPH instead LI/LH today (if possible), LEDs as main light source in the foreseen future.
4. To eliminate the “bad” wavelenghts from lamps spectrum. It's quite speculateve matter, because if we take some wavelenghts from visible spectrum, we get practically the colour light!

2nd RESULTS

Technical datas of cave lighting equipments (CLE)						
	CAVE	Schwitched circuits	Average daily operation time [h]	[W/m]	[lm/m]	[lm.hours/m/day]
A	Caves with incandescent lamps, planed by COMLUX			45	680	1200
B	Caves with discharge lamps, planed by COMLUX			10	670	1300
A	Other caves with inc. lamps - summ			25	400	1600
B	Other caves with dis. lamps - summ			15	1100	4800

While other CLEs with LI/LH have mostly less illuminance, they run longer and have more EXPOSITION!
The other CLEs with discharge lamps have to much illuminance and very much EXPOSITION!!!

EXTREMS						
A	Caves with incandescent lamps	1	10	81	1750	8000
B	Caves with discharge lamps	1	8	37	2230	17820

Recomended values for CLEs with incandescent lamps						
A	OK	> 5	< 2	< 60	< 900	< 1800
A	???????	> 1	< 4	< 100	< 1500	< 6000
A	BAD till CRITICAL !!!!!	1	> 4	> 100	> 1500	> 6000

Recomended values for CLEs with discharge lamps						
B	OK	> 5	< 2	< 15	< 900	< 1800
B	???????	> 1	< 4	< 25	< 1500	< 6000
B	BAD till CRITICAL !!!!!	1	> 4	> 25	> 1500	> 6000

The mostly mistakes of CLEs are:
 insufient quantity of switched circuits (extremely only 1 for the whole cave),
 to long operating time - 3 till 8 hours in a day,
 to much luminous flux by CLEs with discharge lamps,
 use of HPS lamps,
 THERE IS NO EXISTANCE OF ANY "WIZZARD" LAMPS
 (they give us a lot of harmless light - no LF growing)!!!

The lamps	Ra	for CLE
LI - incandescent lamp, reflector lamp	100%	OK
LH - halogen lamp	100%	OK
FL - linear fluorescent lamp	80%	OK
FLC - compact fl.lamp, compact fl.lamp with reflector	80%	OK
HPH - metal halide lamp (high pressure)	80%	OK
LED - light emmiting diode	80%	OK
HPM - high pressure mercury vapour lamp	60%	???
HPS - high pressure sodium lamp	30%	NO
LPS - low pressure sodium lamp	0% !!!	NO

Recommended lamps:

LI	- incandescent and	- less efficient, but small, cheap
LH	- halogen	- and easy to handle.
FL/FLC	- fluorescent (linear/compact)	- good but sometimes to big.
HPH	- high pressure metal halide (with electronical ballast)	- good but specific start - and reignition behavior.
LED	- light emitting diode	- seems to be the lamp of the future, (efficiency about 20 lm/W today, 50 till 80 lm/W in the future expected), efficient, small, very long life, easy to handle.

“Forbidden” lamps:

HPM	- high pressure mercury vapour	- bad Ra, lm/W, start and reignition
HPS	- high pressure sodium	- bad Ra, (Tc), start and reignition (you don't see LF in this light!!!)
HPL	- low pressure sodium	- Ra = 0 (no colours visible)!!!

ONE MORE TIME THE SUMMARY – we shoul'd avoid:

the change of colour of the objects caused by:

to much light,
colour light,
light with the bad colour rendering .

the damage of the objects by:

row installation,
IR - light (heat)
UV - light.

OUR TOOLS:

less light,
luminaires with less power,
lamps with less heat production,
suitable positions and aiming of luminaires,
sophisticated controll system: smaller controlled circuits, shorter operating time of CLE

Fight against the „old“ lampsflora (MEMENTO- some photos will be presented)

Difficult and no tender: mechanical

chemical – several possibilities
optical – UV lamps

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REFERENCES

Bibliographic references:

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Authors own planings of CLE and questionnaire about CLEs in other 55 caves.