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Department of Technology and Environment

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Key words

Technical specification of signal lamps

In this technical specification of signal lamps, the signal lamp specification that is currently used has been updated. This specification is used as the definition when ordering new signal lamps, in their acceptance test and when adjusting currents/voltages of new types of signal lamps.

For this specification it has been collected the data created in the context of developing interlocking, analyzed the lamp requirements in the Finnish Interlocking Requirement (FIR) specification and gathered tacit knowledge from the people who have been participating in the developing of the existing signal lamps.

Technical Director Markku Nummelin

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The guideline is approved by electronic signature.
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FURTHER INFORMATION
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1 Introduction

Signal lamp is an important component in the signalling device system. It affects overall safety of the system and therefore accurate specification of its properties is needed. The signal lamp also has great influence for usability of the signalling device system as lamp failures are traditionally the largest or nearly the largest failure mode of signalling devices.

The signal lamp is a wearing part as the lamp has a limited lifespan. To avoid frequent change of the lamps, it has been strived to maximize the life by various means. However, it is done at expense of other lamp properties whereupon, in practice, the entirety is aimed to be optimized.

LEDs are about to replace light bulbs in lighting usage but in signalling device technology, LED is not directly suitable as a replacer for light bulbs without large-scale modifications in the interlocking circuits. Therefore in interlocking systems light bulbs will be used as signal lamps still for several decades – until the last interlocking using light bulbs has been replaced with a new one. The LED signal lamps are used in the new interlocking device types.

This guideline is written by VR Track Oy as a workteam of Juuso Matikainen, Tero Sorsimo and Lassi Matikainen. From the Finnish Transport Agency Veli-Matti Kantamaa has participated in the work.

2 List of lamps

The specification applies to the signal lamp types of one- and two-filament bulbs which are listed in the table 1.

Table 1. List of signal lamps which this specification applies to.

Type	Item number	Number of filaments	Nominal voltage (V)	Nominal power (W)
12 V 25 W	128067-6-0	1	12	25
12 V 20/20 W	128068-4-0	2	12	20+20
12 V 10/10 W	128069-2-0	2	12	10+10

Lamps of the model 12 V 25 W are used in the main signals and distant signals of the all-relay interlocking. The interlocking models in which the lamps of type 12 V 25 W are used include e.g. Siemens SpDrS60, Siemens DrS, Salama VR-76, the interlocking of Ganz and the electronic interlocking equipped with relay-based field element control modules. This lamp type is also in use in various line block systems.

Lamps of the model 12 V 20/20 W are used in all interlocking types. In the computerized interlocking the lamps are used in all units of the main and distant signals. In the relay interlocking and in the relay-based block systems the lamp type is used in the red units.

12 V 10/10 W signal lamps are used in shunting signals of the computerized interlockings. An example of an interlocking which uses 12 V 10/10 W lamp type is Siemens SIMIS-C

3 Requirements of signal lamps

3.1 General requirements

The structure and operation of the signal lamps must be in accordance with the Finnish electrical safety regulations, the guidelines of the Finnish Transport Agency and the regulations of the Finnish Transport Safety Agency. The lamps need to be designed and made in such a way that when replacing and using the lamps, the electrical work safety regulations can be considered. The standards listed in Table 2 need to be considered in manufacturing of the lamps.

The same electrotechnical and lighting technical requirements apply to the main filament and auxiliary filament in double filament lamps.

Table 2. The standards to be considered

EN 50125-2	Railway applications. Environmental conditions for equipment. Part 2: Fixed electrical installations
EN 50125-3	Railway applications. Environmental conditions for equipment. Part 3: Equipment for signalling and telecommunications
DIN ISO 2859-1:2014-08	Annahmestichprobenprüfung anhand der Anzahl fehlerhafter Einheiten oder Fehler (Attributprüfung) - Teil 1: Nach der annehmbaren Qualitätsgrenzlage (AQL) geordnete Stichprobenpläne für die Prüfung einer Serie von Losen
SFS-EN 60061-1/A2	Lamp caps and holders together with gauges for the control of interchangeability and safety - Part 1: Lamp caps
SFS-EN 60432-1/A2	Incandescent lamps. Safety specifications. Part 1: Tungsten filament lamps for domestic and similar general lighting purposes
DIN 6163-4:2011-07	Farben und Farbgrenzen für Signallichter - Teil 4: Signallichter der Eisenbahn

3.2 Environmental requirements

The signal lamps must endure variation of temperature according to EN 50125-3 class T2. The signal lamps must endure the relative air humidity according to EN 50125-3 class T2. The signal lamps must endure pulse shaped $\Delta P \pm 2kPa$ changes in air pressure.

3.3 Geometric requirements and tolerances

The signal lamp specific geometric requirements with their tolerances are defined in Attachments 1-3. The bulb sockets must be in accordance with standard SFS-EN 60061-1/A27.

3.4 Lighting technical requirements and tolerances

The signal lamp specific light technical requirements with their tolerances are defined in attachments 1 to 3. To fulfill the specification of average lifetime, 50 % of the lamps must be lit on nominal values of the nominal lifetime. To fulfil the acceptable lifetime of individual lamps, the lifetime of a lamp is allowed to be as maximum 30 % less than the nominal lighting time of the lamp. The light coming through colour glass of the signal lamp needs to be in accordance with standard DIN 6163-4:2011-07.

4 Test procedure of signal lamps

An acceptance test is performed for all the new lamp batches to verify whether the lamps fulfill the requirements of the order. From each lamp batch a sample is randomly selected to be tested following AQL procedure. Before beginning the test of the lamps, the lamps are stored in a cool place for several hours to reveal potential micro fractures in the glass of the lamp. The more specific content of the tests is described in the next chapters.

4.1 Quality standards

In the acceptance test both qualitative and quantitative properties are tested and they are specified in the next chapters. The qualitative characters are divided in four classes based on their importance. The quantitative characters are found in their own chapter.

4.1.1 Qualitative failure modes, class 1

These characteristics may cause hazards for the installer of the lamps.

Table 2. Qualitative failure modes, class 1

Class 1	
1.1	False information or wrong identifiers on a lamp or on a separate package
1.2	Fault in bulb socket connections, contact pins connected to wrong filament
1.3	Lamps conductors are not insulated (danger of external short circuit)
1.4	Short circuit in bulb socket

4.1.2 Qualitative failure modes, class 2

Based on these characteristics individual lamps are unusable with high probability.

Table 3 .Qualitative failure modes, class 2

Class 2	
2.1	Glass bulb is cracking (glass bulbs broken in transportation are not counted in these)
2.2	Glass socket is damaged badly, rejected, as the lamp is not lit
2.3	Glass socket has broken off
2.4	Lamp is not lit or it breaks during one minute after turning on

4.1.3 Qualitative failure modes, class 3

Based on these characteristics individual lamps are unusable in certain circumstances.

Table 4. Qualitative failure modes, class 3

Class 3	
3.1	Solders in socket space
3.2	Solders of socket are defective (yet, the lamp is lit)
3.3	Contact interferences (Loose connection)

4.1.4 Qualitative failure modes, class 4

These characteristics diminish the appearance of the lamps.

Table 6. Qualitative failure modes, class 4

Class 4	
4.1	Stamps or package of lamps are imperfect or unclear
4.2	Blackening in glass bulb caused by degassing flux (slight yellowness of glass bulb is acceptable)
4.3	Glass bulb is dirty

4.1.5 Quantitative characteristics

All the quantitative characteristics need to be assessed separately. Lamp specific characteristics and tolerances are found in attachments in lamp specific specifications.

Table 5. Quantitative characteristics

Quantitative characteristics	
5.1	Bulb external measures
5.2	Bulb internal measures
5.3	Rigidity of socket fixing and glass bulb (at least 3 Nm according to SFS-EN 60432-1)
5.4	Initial power
5.5	Luminous flux at start
5.6	Conservation of luminous flux after 300 hour use
5.7	Minimum lifetime of individual lamps
5.8	Average lifetime

4.2 Acceptable quality limit (AQL)

AQL system which is accordant with the standard DIN ISO 2859-1:2014-08 is used for the acceptance test of the signal lamps. The sample sizes to be tested are determined based on AQL tables which are found in Attachment 4.

As test limit, the general test limit II is used despite in test of individual life where the test limit is the general test limit I.

Table 6. Properties to be tested on the test limit II

Class or character	Failure mode	AQL value (Test limit II)
Class 1	Sum of class 1 mode failures	Not accepted*
Class 2	Sum of class 2 mode failures	0.65
Class 3	Sum of class 3 mode failures	1.5
Class 4	Sum of class 4 mode failures	4.0
5.1	Bulb external measures	2.5
5.2	Bulb internal measures	0.65
5.3	Rigidity of socket fixing and glass bulb (at least 3 Nm according to SFS-EN 60432-1)	1.5
5.4	Initial power	4.0

*) If there is even one such product found in the test batch which has got a mode 1 failure the client has the right to reject the inspected batch.

Table 7. Properties to be tested on test limit I

Character	Failure mode	AQL value (Test limit I)
5.5	Luminous flux at start	1.5
5.6	Luminous flux after 300 hours of use	10
5.7	Minimum life of individual lamps	1.5

In testing of quantitative characteristics, only lamps which have fulfilled other qualitative requirements can be used. The supplier needs to accept the complaint if the client has detected based on AQL values that the selected test sample does not fulfil the conditions of the order.

4.3 Inspection of physical properties

Before inspecting internal geometric requirements the lamp needs to be lit for 1 hour time with the voltage U_n * 1,1 (110% of the nominal voltage). Measures of the bulbs will be inspected in upright position so that the socket of the bulb is downwards. Measures of the electrodes and the filaments and their fitting in tolerances are inspected by lighting the glass bulb and by comparing the silhouettes to a scale on the background. Other valid measuring methods are also accepted.

The lamp specific geometric measures are defined in Attachments 1 to 3. In the measurement of the internal and external geometrics as a reference point is used the upper surface of the lug of the bulb socket with BA20d socket and in measurements of the bulbs with B22d socket the upper edge of the round pin of the socket.

In the rigidity test of the fixing of socket and glass bulb needs to be taken care of that the glass has been cleaned from dirt and grease and the lamp is fastened properly. When testing the duration of torque the load needs to be increased steadily without any jerks.

4.4 Realization of electrical properties

In testing of life one lit test is performed to find out the realization of the condition of the minimum life of individual lamps and the realization of the average life. The life test is performed in upright position, the socket of the lamp downwards. The current used for testing of each signal lamp is given in Attachments 1 to 3. The duration of the test is as maximum 140 % of the nominal lifetime. The range of variation during the test can be ±1.0 %. The short power surges shall not exceed 2 % of the definite test current. In life test the changing rhythm is 11.5 hours on and 0.5 hour off. In two-filament bulbs the initial power is tested with an auxiliary filament but life of the spare filament is not tested.

4.5 Inspection of light technical properties

The Finnish Transport Agency decides about testing of light technical properties before sending an invitation to tender concerning signal lamps. The measurement procedure is written into the invitation for bids. An alternative is to include measurement of light technical properties in purchase in accordance with this guideline or the Finnish Transport Agency can decide to order, with its own cost, light technical measurements from an impartial measurement laboratory which is competent for the task in question.

Before inspecting the light technical properties the lamp needs to lit for 1 hour with the voltage U_n * 1.1 (110% from the nominal voltage). The currents/voltages used in testing are found lamp specifically in Attachments 1 to 3. Test current/voltage is set before performing the test. In two-filament bulbs light flux of the spare filament is not tested.

5 Adjustment of signal lamps

When changing lamp type to a lamp of another producer in an interlocking which is in use, voltage of the new lamp will be inspected by measuring it from the bulb socket. The signal lamp circuit is adjusted in most of the interlockings manually based on the voltage which is aimed indirectly to achieve optimal adjustment value of the current regarding to the interlocking type.

When ordering a new lamp batch, a current/voltage graph is drafted from each lamp type in order that the lamp circuit can be adjusted correctly in the place of use. In the table 10 there is described the lamp type specific set value of current and a column for the regulating value of voltage derived from it. Voltage/current graphs are drawn based on the average of measurement results of 10 lamps. Current variation of an individual lamp cannot be higher than ±10 % of the average. In the Attachment 1 there is an example of the U/I graph of a 12 V 25 W lamp where are drawn lines of voltage level definition corresponding to the set value of current.

Table 8. Nominal currents and an example of defining the voltage

Lamp type	12V 25W	12V 20/20W
Set value of current [A]	2.00	1.58
Voltage read from U/I graphs [V]	n_1	n_2

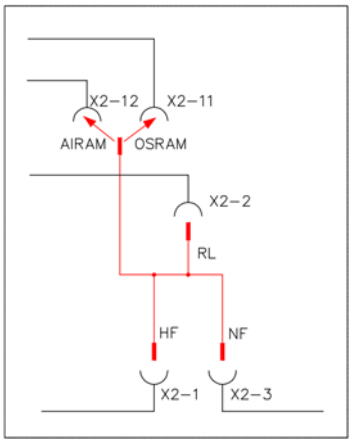
5.1 All-relay interlocking and electronic interlocking equipped with relay-based field element control modules

In all-relay interlocking adjustment of lamp voltages is done with the help of series resistors. The lamp voltages are adjusted with the values derived from current/voltage graph to correspond with the nominal currents. The lamp voltage is measured from the socket of the bulb.

5.2 Simis-C computerized interlocking

The lamp circuit is adjustment-free but when the lamp type changes it may be needed to change the signal lamp outputs to adjust the voltage. Actual accurate adjustment cannot be done and does not need to be done. The voltage level which corresponds to 1.58 A current with the lamp type in question is aimed to be achieved with the transformer output. The required voltage level can be found out from the voltage/current graph which has been drafted for the lamp type in question (see the example concerning another lamp type in Attachment 1).

The voltage going to the signal lamps can be selected from the transformer output of GRUMO/FAHRMO module from connectors x2-11 and X2-12 (see Picture 1 below). There are two voltage levels from which to select and the lower of them has been used for AIRAM lamps which were used previously. The wiring of the connector is in that case X2; 1-2-3-12.



Picture 1. Voltage adjustment of Simis C signal module

The transformer output for AIRAM lamps is based on the measurements that were done and the lamp values which were derived from the measurements. The lamp values have been used to find the optimum value among luminous flux and lifetime. Transfer of the output x2:12→x2:11 raises the lamp voltage by 10%.

However, the lamp voltage is largely dependent on the length of the secondary cable. The length of the trunk cable also affects the voltage. Typically, the lamp voltage for day use is 10.8 – 11.5V. It needs to be ensured with a jumper connection that the voltage is inside the preceding range as close to the voltage that corresponds to 1.58 A current as possible.

It is possible to do adjustment of signal voltages when the lamp type changes also on the entire area of the interlocking by changing outputs of the main signal transformer of in the power supply respectively.

5.3 Bombardier Ebilock 850 computerized interlocking

The element control module of the interlocking adjusts the lamp circuit to the constant current of 1.58 A with the day voltage (with the night voltage 1.19 A). Thus, the change of lamp type does not cause need for adjusting the lamp circuits. In this interlocking type only such lamp types can be used which produce sufficient light flux with this 1.58 A current.

5.4 Thales ESTW L90 5 interlocking

The adjustment of the lamp circuit is done by modifying outputs of the signal transformer. The aim is to get the voltage level as close as possible to the corresponding nominal current of the current/voltage graph.

Typically the lamp voltage value for the day voltage is 10.8 – 11.5V. With adjusting the voltage outputs it shall be ensured that the voltage is inside the preceding range as close as possible but over the voltage corresponding to the current of 1.58 A.

Table 9. Lamp transformer outputs of Thales interlocking

Primary side	Secondary side
Red – Blue: 198 V	Green – White: 11 V
Brown – Blue: 220 V	Orange – White: 11.7 V
Black – Blue: 242 V	Violet – White: 12.2 V
	Yellow – White: 12.8 V
Black = common, Green/Yellow = earth	White = common

References

/1/ Deutsche Bahn, Qualitätsbedingungen Signalglühlampen – Lampen für Eisenbahn-Signaltechnik mit Signaloptiken der Bauform (specification of DB's signalling lamps)

/2/ Deutsche Bahn, Technische Anforderungen an eine neu zu entwickelnde Jahres-Signalglühlampe (DB's lamp specific specification)

/3/ The Finnish Transport Agency, signalling lamp specification published on 2006

/4/ The Finnish Transport Agency, Ratatekniset ohjeet (RATO) part 6. Turvalaitteet (Railway technical guidelines, signalling devices)

/5/ Suomen asetinlaitevaatimukset 2010 – Ulkolaitevaatimukset v1.3 (Finnish interlocking requirements, outdoor equipment requirements)

/6/ Schweizerische Bundesbahnen, AM-EB-SK L 72 – Signallampen (specification of SBB's signal lamps)

/7/ Schweizerische Bundesbahnen, I-AT-SAL L 74 – Lastenheft – Signallampen Typ LongLife (SBB's lamp specific specification)

/8/ Interviews (Mauri Kakkonen, VR Track Oy; Jukka Saha, RR Management Oy; Arto Laurila, VR Track Oy; Pentti Koskinen, VR Track Oy)

/9/ ABB:n tarkastetut selostukset - Funktionsspecifikation för signalutdel, SIBVRC (Inspected reports of ABB)

/10/ Email Arto Kemppainen, Siemens Osakeyhtiö

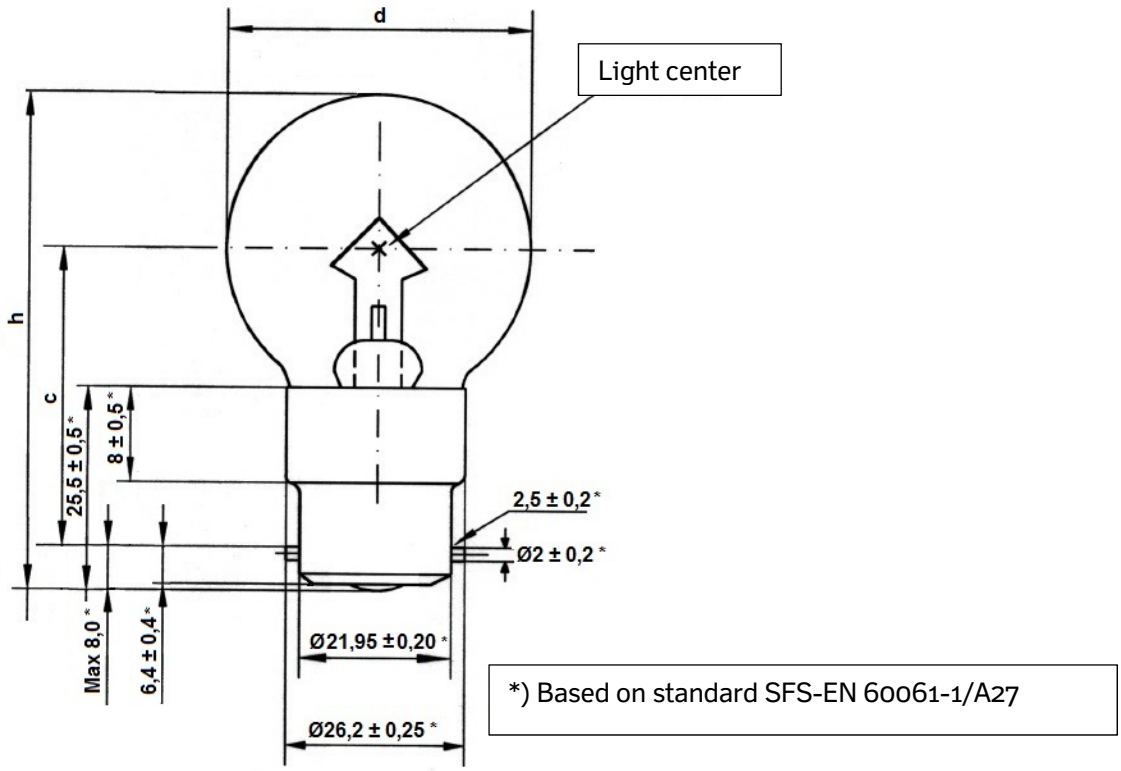
/11/ Email Frank Sterna, Thales Deutschland

12 V 25 W

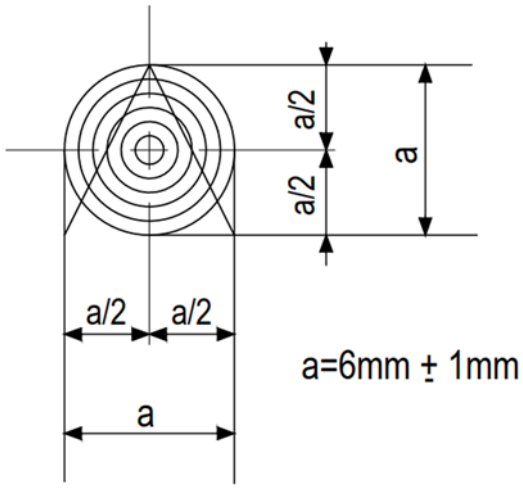
1 Geometric measures and tolerances

Table 1. Measures and tolerances of 12 V 25 W lamp

External measures		
Socket		B22D
Diameter of glass bulb [mm]	d	max 45.5
Height of bulb [mm]	h	max 76
Distance of light core from top of socket pin [mm]	c	44 ± 0.5



Picture 1. 12 V 25 W signal lamp



Picture 2. Specification of light center of 12 V 25 W signal lamp

2 Electrotechnical and light technical data

Table 2. Electrotechnical and light technical parameters of 12 V 25 W lamp

Parameters		Nominal values
Current on nominal voltage	[A]	2.08
Nominal voltage U_n	[V]	12
Nominal power	[W]	25
Luminous flux	[lm]	>270
Luminous flux after 300 hours of use in relation to nominal value	[%]	80
Average life time on nominal voltage	[h]	6000
Minimum life time of individual lamps in the test	[h]	4200
Initial power	[W]	22.5 – 27.5

3 Example of lamp voltage/current graph

12 V 20/20 W

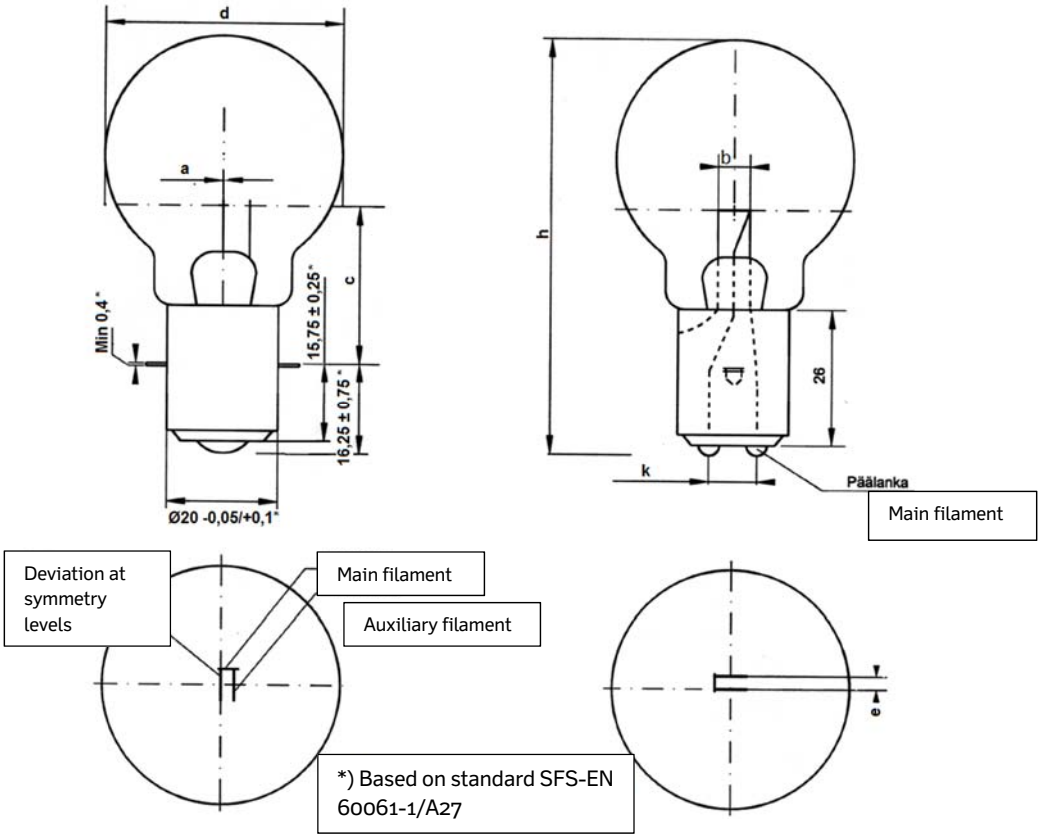
1 Geometric dimensions and tolerances

Table 1. Inner measures and tolerances of 12 V 20/20 W lamp

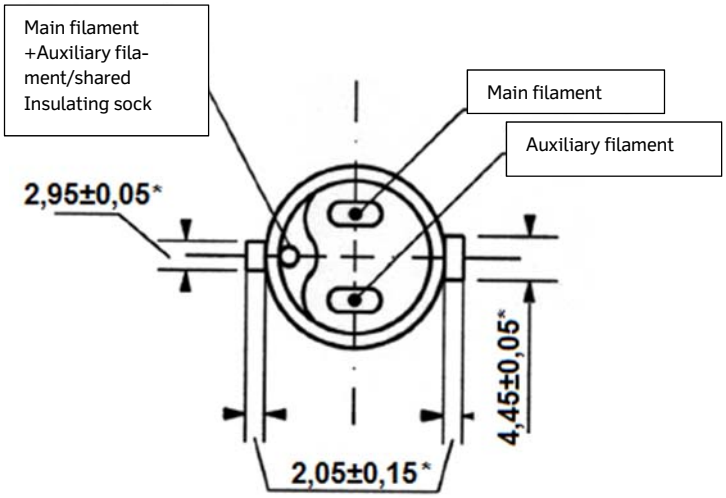
Inner measures [mm]		Main filament	Auxiliary filament
Distance from center line	a	0 ± 0.3	
Filament length	b	6 ± 0.5	6 ± 0.5
Distance to filament from lug of the socket	c	30 ± 0.5	30 ± 0.5
Distance between the filaments	e	2.5 ± 0.5	

Table 2. Exterior measures and tolerances of 12 V 20/20 W lamp

External dimensions		
Socket		BA20d
Diameter of glass bulb [mm]	d	max 45.5
Lamp height [mm]	h	max 79
Distance of contact surfaces [mm]	k	9.5 ± 0.5



Picture 1. 12 V 20/20 W signal lamp



Picture 2. The socket of 12 V 20/20 W signal lamp

2 Electrotechnical and light technical data

Table 3. Electrotechnical and light technical parameters of 12 V 20/20 W lamp

Parameters		Nominal values
Current on nominal voltage	[A]	1.67
Nominal voltage U_n	[V]	12
Nominal power	[W]	20
Luminous flux	[lm]	>230
Luminous flux after 300 hours of use in relation to nominal value	[%]	80
Average life time on nominal voltage	[h]	6000
Minimum life time of individual lamps in the test	[h]	4200
Initial power	[W]	18.0 – 22.0

12 V 10/10 W

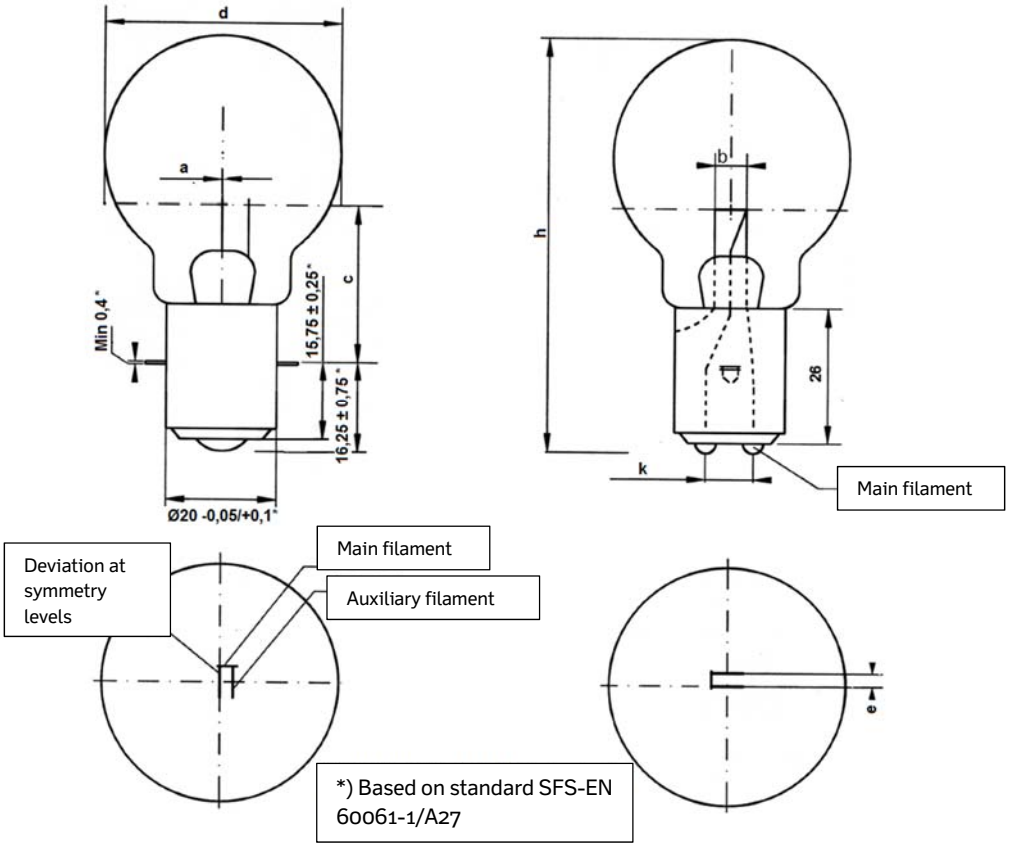
1 Geometric dimensions and tolerances

Table 1. Inner geometric measures and tolerances of 12 V 10/10 W lamp

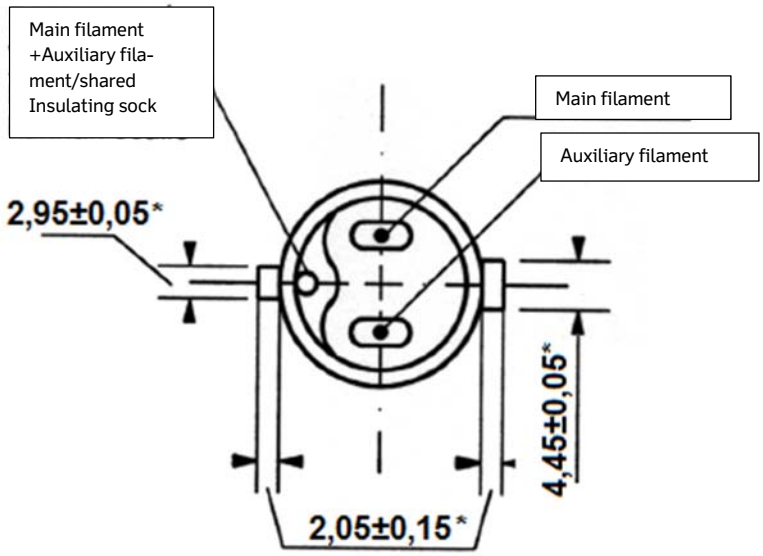
Inner measures [mm]		Main filament	Auxiliary filament
Distance from center line	a	0 ± 0.3	
Filament length	b	6 ± 0.5	6 ± 0.5
Distance to filament from lug of the socket	c	30 ± 0.5	30 ± 0.5
Distance between the filaments	e	2.5 ± 0.5	

Table 10. External measures and tolerances of 12 V 10/10 W lamp

External dimensions		
Socket		BA20d
Diameter of glass bulb [mm]	d	max 45.5
Lamp height [mm]	h	max 79
Distance of contact surfaces [mm]	k	9.5 ± 0.5



Picture 1. 12 V 10/10 W signal lamp



Picture 2. The socket of 12 V 10/10 W signal lamp

2 Electrotechnical and light technical data

Table 3. Electrotechnical and light technical parameters of 12 V 10/10 W lamp

Parameters		Nominal values
Current on nominal voltage	[A]	0.83
Nominal voltage U_n	[V]	12
Nominal power	[W]	10/10
Luminous flux	[lm]	>90
Luminous flux after 300 hours of use in relation to nominal value	[%]	80
Average life time on nominal voltage	[h]	6000
Minimum life time of individual lamps in the test	[h]	4200
Initial power	[W]	9.0 – 11.0

AQL-tables

Table 1. Determination of sample size

Batch size	Specific inspection limits				General inspection limits		
	S-1	S-2	S-3	S-4	I	II	III
2 – 8	A	A	A	A	A	A	B
9 – 15	A	A	A	A	A	B	C
16 – 25	A	A	B	B	B	C	D
26 – 50	A	B	B	C	C	D	E
51 – 90	B	B	C	C	C	E	F
91 – 150	B	B	C	D	D	F	G
151 – 280	B	C	D	E	E	G	H
281 – 500	B	C	D	E	F	H	J
501 – 1200	C	C	E	F	G	J	K
1201 – 3200	C	D	E	G	H	K	L
3201 – 10000	C	D	F	G	J	L	M
10001 – 35000	C	D	F	H	K	M	N
35001 – 150000	D	E	G	J	L	N	P
150001 – 500000	D	E	G	J	M	P	Q
>500001	D	E	H	K	N	Q	R

Table 2. Determination of acceptance limits

Code letter of batch size	Sample size	Acceptable Quality Limit, AQL													
		0.65		1.0		1.5		2.5		4.0		6.5		10	
		Acc	Rej	Acc	Rej	Acc	Rej	Acc	Rej	Acc	Rej	Acc	Rej	Acc	Rej
A	2	⇩		⇩		⇩		⇩		⇩		0	1	⇩	
B	3									0	1	⇕			
C	5							0	1	⇕		⇕		1	2
D	8					0	1	⇕		⇩		1	2	2	3
E	13			0	1	⇕		⇩		1	2	2	3	3	4
F	20	0	1	⇕		⇩		1	2	2	3	3	4	5	6
G	32	⇕		⇩		1	2	2	3	3	4	5	6	7	8
H	50	⇩		1	2	2	3	3	4	5	6	7	8	10	11
J	80	1	2	2	3	3	4	5	6	7	8	10	11	14	15
K	125	2	3	3	4	5	6	7	8	10	11	14	15	21	22
L	200	3	4	5	6	7	8	10	11	14	15	21	22	⇧	
M	315	5	6	7	8	10	11	14	15	21	22	⇧			
N	500	7	8	10	11	14	15	21	22	⇧					
P	800	10	11	14	15	21	22	⇧							
Q	1250	14	15	21	22	⇧									
R	2000	21	22	⇧											

Tämä asiakirja on allekirjoitettu

Lista allekirjoittajista

Allekirjoittaja	Todennus
Veli-Matti Kantamaa 26.04.2017 15:01:09	**Proxy** 26.04.2017 15:01:00
Markku Nummelin 26.04.2017 16:05:11	**Proxy** 26.04.2017 16:05:07