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$$\tau^l = \frac{I_l}{I_0}, \tag{1}$$

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I_l - ;

I_0 - .

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2 % (= 0,02).

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0,5°.

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0,5°, = 0,02 ():

$$S_M = \frac{\ln \varepsilon}{\ln \tau} \tag{2}$$

S_M - ;
 ε - ;

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) , ()

:

$$S_P = \frac{S_M}{\ln \frac{1}{\varepsilon}} \ln \frac{k_0}{\varepsilon} \tag{3}$$

$$k_0 = \frac{B_\phi - B_0}{B_\phi} - ;$$

$$B_{\phi} - \dots ;$$

$$B_0 - \dots .$$

(, ,)

:

$$\frac{E_{\text{nop}}}{I_0} = \frac{\varepsilon}{L_{\text{np}}^2} e^{\frac{L_{\text{np}}}{S_M}}, \quad (4)$$

$$E_{\text{nop}} - \dots ;$$

$$I_0 - \dots ;$$

$$L_{\text{np}} - \dots ,$$

;

(2 - 4)

S_M ,

S_p .

1.2

1.2.1

B'_0
 $B_0,$

L,

:

$$B'_0 = B_0 \tau^L + (1 - \tau^L) B_0 \quad (5)$$

τ^L -

L

- ;

(5)

$$B'_\phi = B_\phi \tau^{L_1} + (1 - \tau^{L_1}) B_\phi \quad (6)$$

L -

$$k = \frac{B'_\phi - B'_0}{B'_\phi}, \quad (7)$$

$$B'_0 \quad B'_\phi \quad (5) \quad (6),$$

$$k = \frac{B_\phi \tau^{L_1} - B_0 \tau^L + (\tau^L - \tau^{L_1})B}{B_\phi \tau^{L_1} + (1 - \tau^{L_1})B}, \quad (8)$$

, L = L₁, :

$$k = \frac{(B_\phi - B_0)\tau^L}{B_0 \tau^L + (1 - \tau^L)B} = \frac{k_0}{1 + \left(\frac{1}{\tau^L} - 1\right)\frac{B}{B_\phi}}, \quad (9)$$

k₀ - ,

, . . . B_ϕ = , :

$$k = \frac{B_\phi - B_0}{B_\phi} \tau^L = k_0 \tau^L, \quad (10)$$

(9) (10), ,

(2)

(10),

$$\ln = \frac{1}{L} \ln \frac{k}{k_0},$$

$$(2) = 0,02 (\ln = -3.9),$$

$$S_M = \frac{3,9L}{\ln k_0 - \ln k'} \tag{11}$$

$$0,03, \quad \ln = -3,5,$$

$$S_M = \frac{3,5L}{\ln k_0 - \ln k'} \tag{12}$$

(12),

S_M

$$\delta S_M = \frac{3,5L \left(\frac{\delta k_0}{k_0} + \frac{\delta k}{k} \right)}{(\ln k_0 - \ln k)^2}. \tag{13}$$

$$(1.12) \ln k_0 - \ln k = 3,5 \frac{L}{S_M}, \tag{13}$$

$$\frac{\delta S_M}{S_M} = \frac{1}{3,5} \frac{S_M}{L} \left(\frac{\delta k_0}{k_0} + \frac{\delta k}{k} \right). \tag{14}$$

$$\frac{\delta S_M}{S_M} = 10\%$$

$$\frac{\delta k_0}{k_0} + \frac{\delta k}{k} = \frac{0,35L}{S_M}$$

$$S_M = L \quad S_M = L,$$

$$\frac{S_M}{L} = 10$$

$$\frac{\delta k_0}{k_0} \approx \frac{\delta k}{k} \approx 1,5\% \quad S_M = L \frac{\delta k_0}{k_0} \approx \frac{\delta k}{k} \approx 15\%$$

$$S_M = L$$

$$\frac{S_M}{L}$$

(k ,

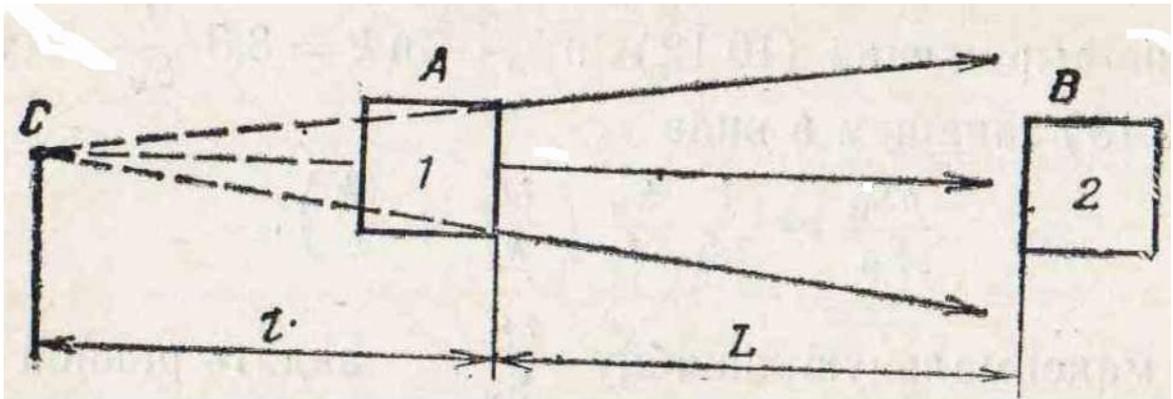
$$k =$$

1.2.2

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L,



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S_{BX} ,

τ_{λ} .

$$f_{\lambda_0} = I_{\lambda} \frac{S_{BX}}{(L+l)^2} \tau_{\lambda}. \quad (15)$$

L

P_{λ}

L,

..

$$f_{\lambda} = f_{\lambda_0} P_{\lambda}^L = I_{\lambda} \frac{S_{BX}}{(L+l)^2} \tau_{\lambda} P_{\lambda}^L. \quad (16)$$

f_{λ}

$f_{\lambda_{\Pi}}$,

$f_{\lambda_{\Pi}}$

$$f_{\lambda_1} = I_{\lambda} \frac{S_{BX}}{(L+l)^2} \tau_{\lambda} P_{\lambda}^L + f_{\lambda_{\Pi}} \tau_{\lambda}. \quad (17)$$

S_{λ}

λ_1

λ_2

$$u_1 = \int_{\lambda_1}^{\lambda_2} (I_{\lambda} \frac{S_{BX}}{(L+l)^2} \tau_{\lambda} P_{\lambda}^L + f_{\lambda_{\Pi}} \tau_{\lambda}) S_{\lambda} d\lambda. \quad (18)$$

u_1

P_{λ} ,

$f_{\lambda_{\Pi}}$,

$f_{\lambda_{\Pi}}$ $f_{\lambda_{\Pi}}$ $f_{\lambda_{\Pi}}$ $f_{\lambda_{\Pi}}$ (\quad) I_{λ} $I_{\lambda} = 0$

$$u' = \int_{\lambda_1}^{\lambda_2} f_{\lambda_{\Pi}} \tau_{\lambda} S_{\lambda} d\lambda. \quad (19)$$

 (18) $(19),$

$$u = u_1 - u' = \frac{S_{BX}}{(L+l)^2} \int_{\lambda_1}^{\lambda_2} I_{\lambda} \tau_{\lambda} P_{\lambda}^L S_{\lambda} d\lambda, \quad (20)$$

$$P = \int_{\lambda_1}^{\lambda_2} P_{\lambda} V_{\lambda} d\lambda, \quad (21)$$

$$P_\lambda - \dots ; \quad \lambda_1 = 0.4$$

$$V_\lambda - \dots \lambda_2 = 0.7.$$

$$V_\lambda = Cl_\lambda \tau_\lambda S_\lambda. \quad (22)$$

$$(20) \quad (21, 22) \quad \tau_\lambda.$$

$$u = \frac{S_{BX}}{(L+l)^2} CP^L, \quad (23)$$

P = I

$$u = u_0 \frac{S_{BX}}{(L+l)^2} C, \quad (24)$$

(23)

$$u = u_0 P^L. \quad (25)$$

:

$$S_M = \frac{\ln \varepsilon}{\ln \tau} = \frac{L \ln \varepsilon}{\ln u_0 - \ln u} \quad (26)$$

$$= 0,03, \ln 0,03 = -3,5, \ln P \quad (25),$$

$$S_M = \frac{3,5 L}{\ln u_0 - \ln u} \quad (27)$$

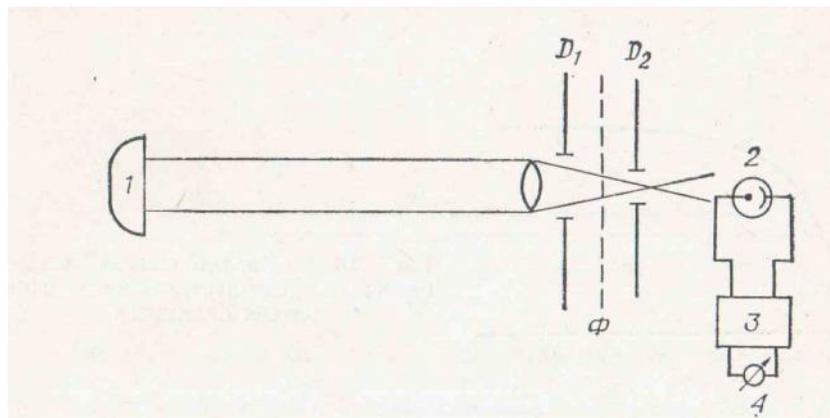
(27),

$$\frac{\delta S_M}{S_M} = \frac{1}{3,5} \frac{S_M}{L} \left(\frac{\delta u_0}{u_0} + \frac{\delta u}{u} \right), \quad (28)$$

$$\frac{\delta u_0}{u_0} \text{ и } \frac{\delta u}{u} - \quad u \quad u_0.$$

S_M

$\frac{S_M}{L}$



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(28) ,

$$\frac{\delta S_M}{S_M} = 10\%, \quad L = 100, \quad S_M = 5$$

$$\frac{\delta u}{u} \quad \frac{\delta u_0}{u_0} \quad 0,3 - 0,4 \%$$

$$S_M = 2 \quad 1 \%$$

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S_y, 4

C_u,

(23) (24),

N N₀,

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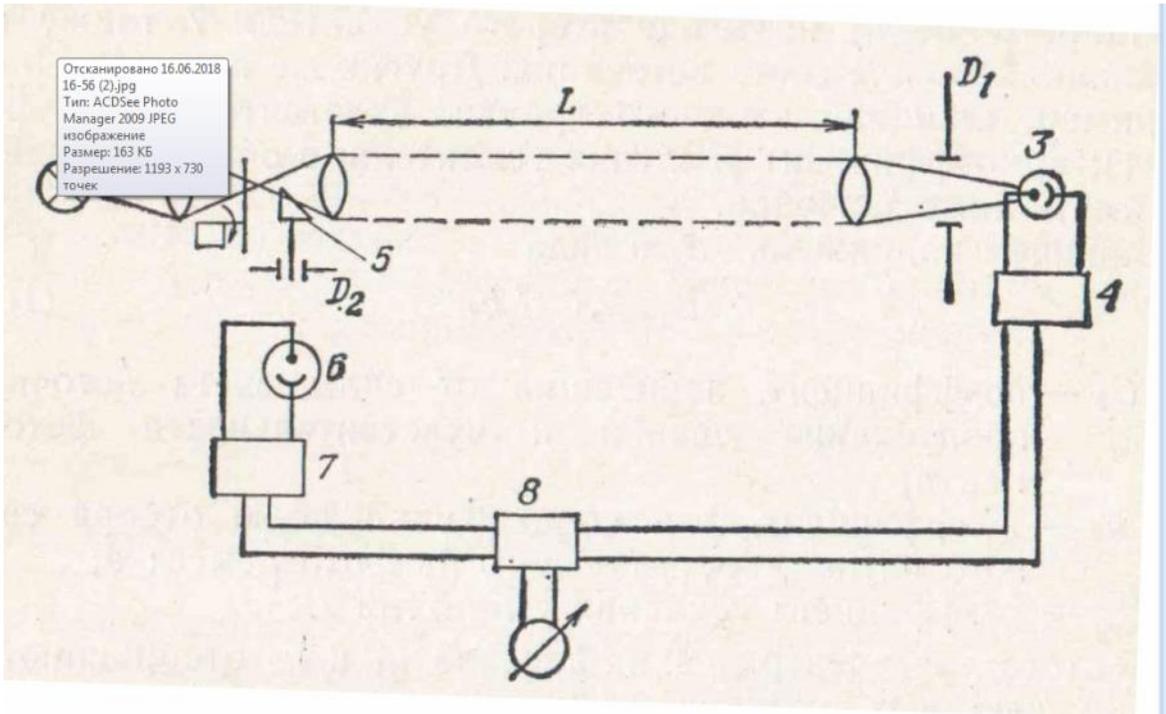
$$N = \frac{S_{BX} S_y}{(L + l)^2 C_u} C P^L, \quad (29)$$

$$N_0 = \frac{S_{BX} S_y}{(L + l)^2 C_u} C, \quad (30)$$

(29)

(30),

$$N = N_0 P^L,$$



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u_1

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(23),

$$u_1 = S_{y_1} \frac{S_{BX}}{(L+l)^2} C_1 P^L, \quad (32)$$

$$\begin{aligned} S_{y_1} &- && 4; \\ S_{BX} &- && ; \\ C_1 &- && , \\ P^L &- && ; \end{aligned}$$

$$u_2 \quad 7$$

$$u_2 = S_{y_2} C_2 k_2, \quad (33)$$

$$\begin{aligned} C_2 &- && , \\ k_2 &- && ; \\ S_{y_2} &- && 6; \end{aligned}$$

$$u_1 \text{ и } u_2$$

$$u_1 \quad u_2 \quad 8$$

(.4),

$$\frac{u_1}{u_2} = \frac{S_{y_1} C_1 S_{BX}}{S_{y_2} C_2 k_2 (L+l)^2} P^L, \quad (34)$$

$$u_1 - u_2 = 0$$

$$P^L = \frac{S_{y_2} C_2 k_2 (L+l)^2}{S_{y_1} C_1 S_{BX}}, \quad (35)$$

$L -$;

1 - (. 1)

(35) 1 2

$k_2,$

$D_2.$

$D_2.$

1.2.3

$$\alpha_p = \int_{2\pi}^{\varphi=0} \rho(\varphi) d\varphi = 2\pi \int_{\varphi=0}^{\pi} \rho(\varphi) \sin\varphi d\varphi \quad (36)$$

$\rho(\varphi) -$

(36),

45°.

95 %

()

I.

$$E = \frac{I}{x^2} e^{-\int_0^x \alpha dx}, \quad (37)$$

$\alpha -$

$$B = E \rho(\pi) \frac{CT}{2}, \quad (38)$$

$$\rho(\pi) = \frac{1}{2} \pi.$$

$$E'_3 = B\omega e^{-\int_0^x \alpha dx}, \quad (39)$$

$$\Phi = E' \tau S_{BX}, \quad (40)$$

S_i ,

$$i_x = \Phi S_i, \quad (41)$$

(37), (40)

$$i_x = \frac{I}{x^2} \omega \tau S_{BX} S_i \frac{CT}{2} \alpha_p f(\pi) e^{-2 \int_0^x \alpha dx}, \quad (42)$$

(42)

(I, ω , T, S_{BX} , S_i , τ),

$\alpha_p f(\pi)$,

$\int_0^x \alpha dx$.

: α_p , $f(\pi)$.

$$(42) \quad I\omega\tau S_{BX} S_i \frac{CT}{2} = \mathcal{k},$$

$$\ln i_x = \ln \mathcal{k} + \ln[\alpha f(\pi)] - 2 \ln x - 2 \int_0^x \alpha dx,$$

$$\bar{\alpha} = \frac{1}{x} \int_0^x \alpha dx = \frac{1}{2x} \ln \frac{\mathcal{k} \alpha f(\pi)}{i_x x^2}, \quad (43)$$

$$\begin{aligned} \alpha & - & , \\ & ; \\ f(\pi) & - & \alpha \end{aligned}$$

(43)

$\bar{\alpha}$:

$$\frac{\delta \bar{\alpha}}{\bar{\alpha}} = \frac{1}{2\bar{\alpha}x} \left(\frac{\delta \mathcal{k}}{\mathcal{k}} + \frac{\delta \alpha}{\alpha} + \frac{\delta f(\pi)}{f(\pi)} + \frac{\delta i_x}{i_x} \right). \quad (44)$$

(44)

$$\frac{\delta S_M}{S_M} = \frac{1}{7} \left(\frac{\delta \mathcal{k}}{\mathcal{k}} + \frac{\delta \alpha}{\alpha} + \frac{\delta f(\pi)}{f(\pi)} + \frac{\delta i_x}{i_x} \right). \quad (45)$$

$$\frac{\delta f(\pi)}{f(\pi)} \quad \frac{\delta \alpha}{\alpha}$$

20 – 30 %.

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$$\frac{\delta S_M}{S_M}$$

10 %.

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Определение видимости (сектора*, в которых учитывается преобладающая видимость, выделены темным фоном)		Минимальная видимость	Преобладающая видимость
1. Четыре сектора Видимость (в метрах) Градусы (приблизительно) 5 000 90 } 180 2 500 90 } 2 000 90 } 1 500 90 }			1 500 2 500
2. Пять секторов Видимость (в метрах) Градусы (приблизительно) 5 000 50 } 270 2 500 90 } 2 000 130 } 1 500 50 } 1 000 40 }			1 000 2 000
3. Шесть секторов Видимость (в метрах) Градусы (приблизительно) 5 000 60 } 190 3 000 50 } 2 500 80 } 2 000 90 } 1 500 70 } 1 000 10 }			1 000 2 500

* Сектора отражают гипотетические ситуации в различных условиях видимости

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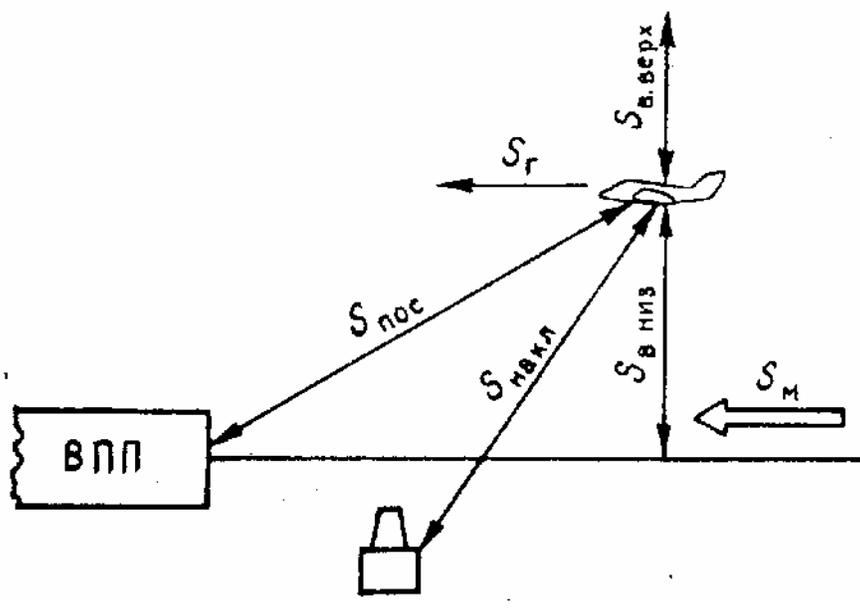
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±1%

MOR : ±5% 50–150 , ±3% 150–450 ,
 ±5% 450–1500 , ±10% 1500–3000 .

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MOR ,

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$$\tau = \exp(-\sigma \cdot l), \quad (3.1)$$

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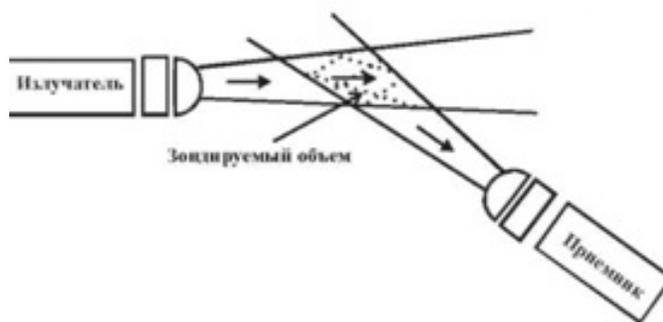
MOR

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$$\frac{\rho(45^\circ)}{\sigma} = 1,45 \quad (3.2)$$



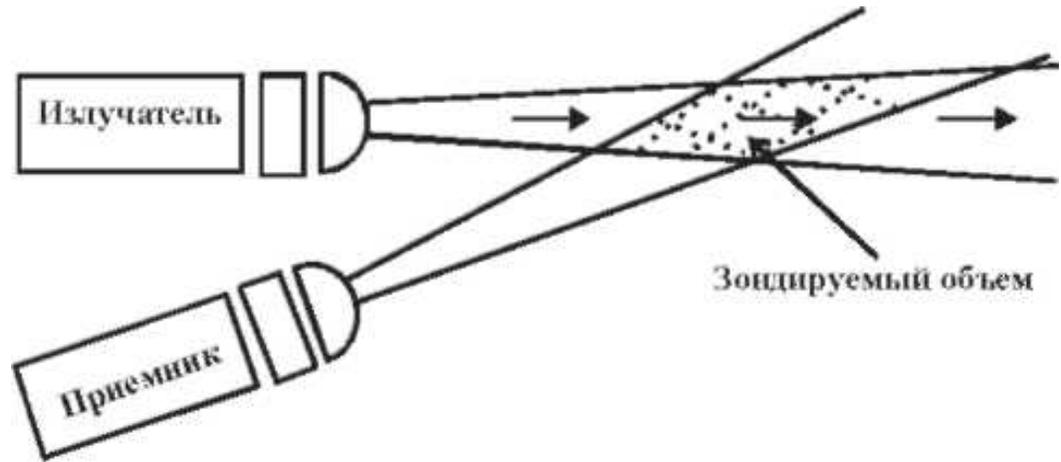
6 —

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 30–45° (. 6).

(. 4).



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MOR,

MOR

-MITRAS

(. 8),

LP11

LR11,

10, 35, 75, 150 200 .



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MITRAS

(MOR)

:

- 7 400 – 10 ;
- 25 1500 – 35 ;
- 50 3000 – 75 ;
- 100 6000 – 150 ;
- 150 8000 200 .

-MITRAS

LP11

LR1

LR11.

MOR

- 7 1500 - 10 35 ;
- 7 3000 - 10 75 ;
- 7 6000 - 10 150 ;
- 7 8000 - 10 200 .

±1%.

±1%.

-MITRASLP 11

() LM11.

4 30000 /

±15%.

-MITRAS:

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(LP11, LR11, LM11),

-50 50° ,

0 100%,

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600 1080 ,

12 / ;

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40° ,

0 100%,

600 1080 ;

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220 ,

50 .

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LP11—

300 ,

LR11 —

250 ,

— 50 ;

- 35 , 35 ,
 10 ;
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 - -MITRAS MOR
 (RVR (RVR-MITRAS))
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 (ASCII) 1,5 ,
 (, DMX21) — 50 ;
 - 10 , 5000 ;
 - -MITRAS
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 MOR,
 : FD12 (. 9
 FD12P, Vaisala (. ,
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 FD12/FD12P
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RS232

DMX50

DD50,



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FD12

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— (MOR) 10 50000 ;

— MOR ±10%

10-10000 , ±20% 10000-50000 ;

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875 ;

— -50 50° , 100%

25° ;

DD50 5 40° , 80% 25° ;

- 220 ±10%,
 50+1,5 , 30 , 130 ;
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 1500 ,
 DMX21 10 ;
 - () , 10 ,
 5000 ,
 2 ;
 - 55 /
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 12 / ;
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 FD12 LM11,
 0 -
 30000 / ² ±10%.

(ASCII).

4.5

LT31

MORLT31

30

MOR

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MOR

(20-10000),

±10 %

MOR , LT31, ±1%,
 ±7 %, 50-1500

MOR PWD, LT31,
 MOR 10-10000
 ±10%.
 MOR LT31 10 .

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MOR

10

MORLT31

PWD

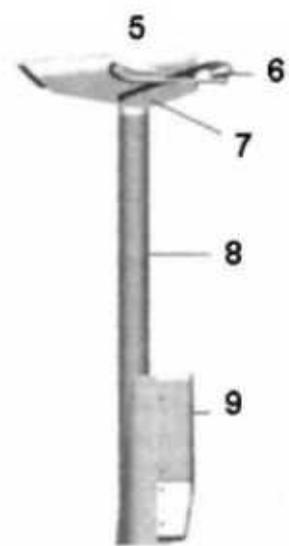
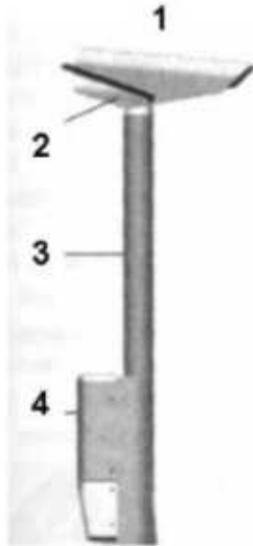
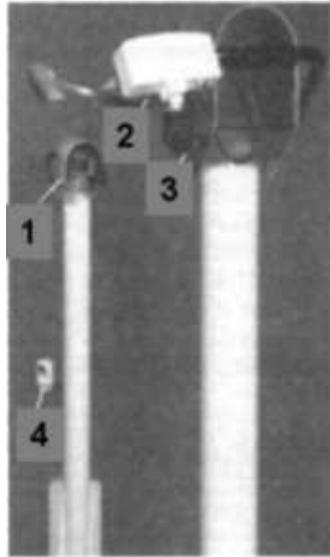
MOR, 1500 MOR
 PWD (±10 %) (20-10000

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MORLT31

LT31,

MOR.



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MORLT31 (. 10)

(3)

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PWD (2),

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LM21 (4).

LT31 -

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: $\pm 15\%$ 60-200 , $\pm 10\%$ 200-3000 , $\pm 20\%$ 3000-6000 .

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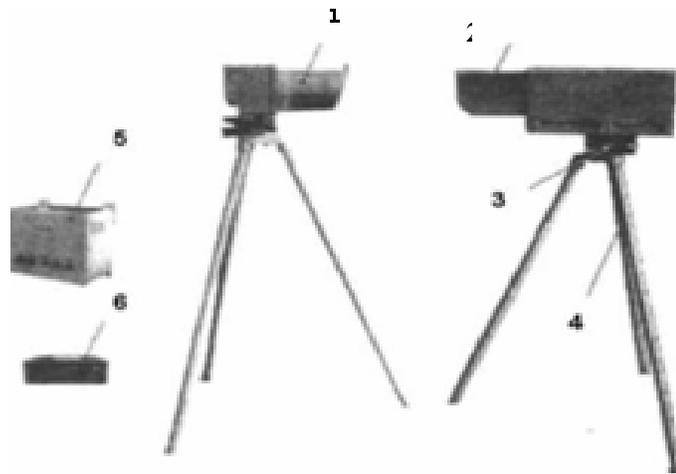
55 / ,

12 / .

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: $\pm 10\%$ 70–150 , $\pm 7\%$ 150–1300 , $\pm 10\%$ 1300–2200 ,
 $\pm 20\%$ 2200–4700 .



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(. 11):

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MOR

700 1080 .

±1 % 0 50 %, ±1,2 % — 50
100 %.

MOR:

,	60-200	200-400	400-1500	1500-3000	3000-8000
%	±15	±10	±7	±15	±20

MOR

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FS11

FS11

Vaisala (),

FD12.

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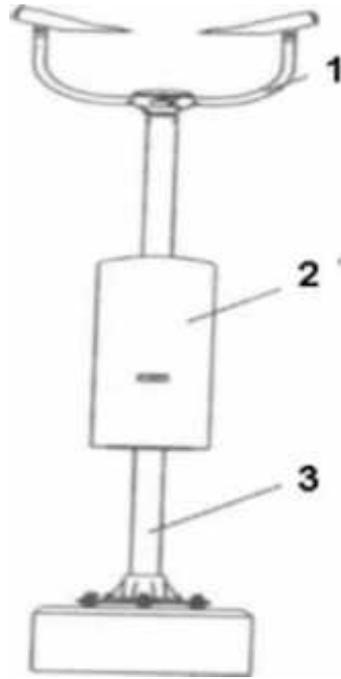
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FS11

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FS11 (. 9)

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10000-75000 .

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(MOR)

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$$F = F_0 \bullet e^{\sigma t} \quad (5.1)$$

$F -$,

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$F_0 -$ $1 = 0;$

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$$\tau = \frac{F}{F_0} \quad (5.2)$$

(9) (10)

$$\tau = e^{-\sigma l} \quad (5.3)$$

0,05, (11)
MOR :

$$MOR = \left(\frac{1}{\sigma}\right) \cdot \ln\left(\frac{1}{0,05}\right) = \frac{3}{\sigma} \quad (5,4)$$

(5,2) (5,4)

(MOR)

0,05,

1.

$$MOR = l \frac{\ln 0,05}{\ln \tau} \quad (5,5)$$

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MOR»

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3, -01 : -1, -2, - Mitras.

FD-12 FD- Vaisala.

5.2

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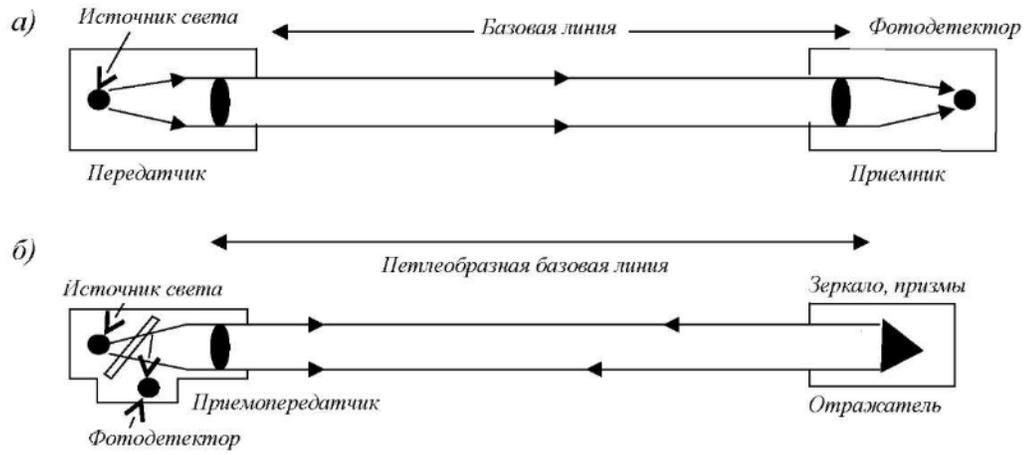
13 [9]:

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13). MOR : (Mitras, Flamingo, « -01») (-1).

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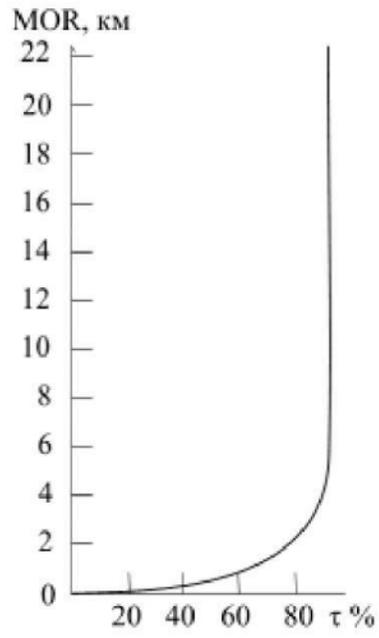


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(14),

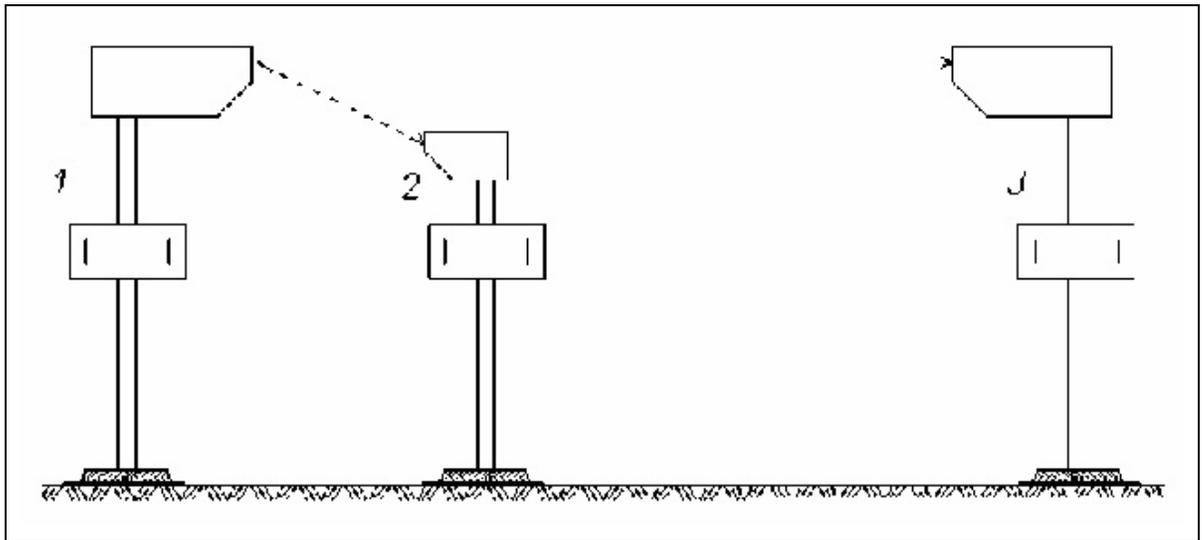
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(%)



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 10 (Mitras), 15 (Flamingo), 20 (-1).

5.5

5.1

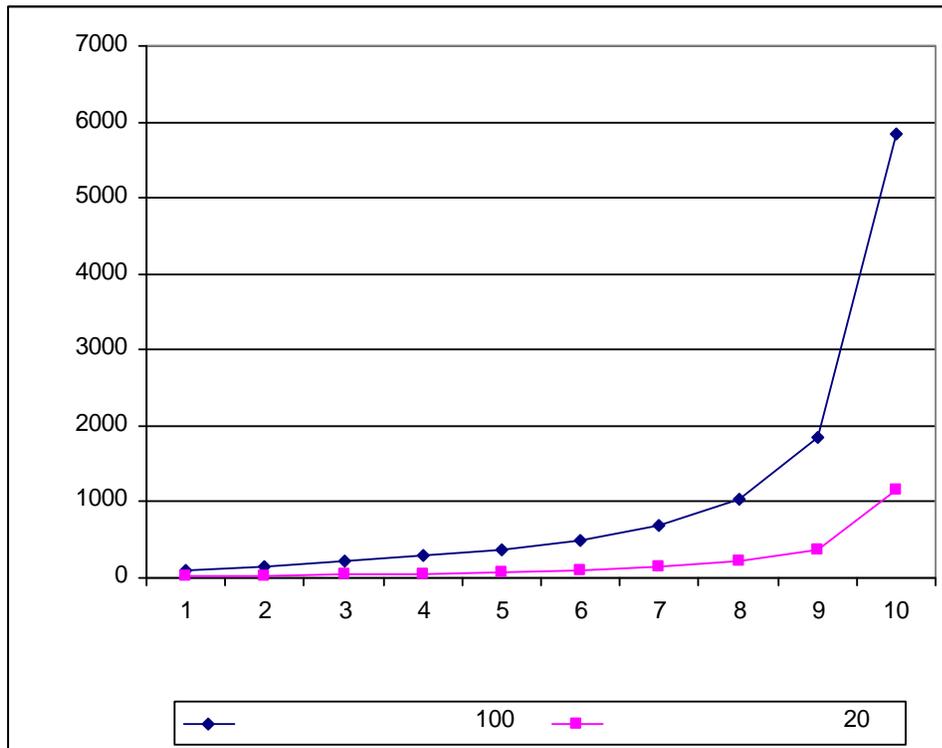
5.1 -

1()

%	200	100	75	50	20	10
0	200	100	80	50	20	10
10	320	160	120	80	30	20
20	430	220	160	110	40	20
30	570	290	210	140	60	30
40	750	380	280	190	80	40
50	1000	500	380	250	100	50
60	1390	700	520	350	140	70
70	2080	1040	780	520	210	100
80	3690	1840	1380	920	370	180
90	11680	5840	4380	2920	1170	580

-2 (20

100)



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$\pm 20\%$ $3/4$, -

$\pm 2\%$;

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1. – 2000,
– . , (Doc 9328 -AN/908) [2]
2. .
3. 2004–
[3]
3. . , 2000 –
– No 8, –
4. () . 1992 . 23,
2 2000
5. . 14
.]5[.
– 2004
6. (-85) 19 , . 2000
7. (.: , 1995– -95).
8. .: , 1994– .
9. [() , MO No.731, 1993–