Photoprocessing of Radiographic Industrial Films in Cupric Borohydride Physical Developers

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Abstract. The research has been carried out to study the changes of the main photographic characteristics of radiographic industrial films under the image intensifying in the solution of cupric borohydride physical developer (CBD).
Some experiments were made on radiographic industrial PT-1 and PT-K films and samples with less surface silver concentration obtained from the emulsions for these films.
The main advantage of film processing in CBD compared with other ways of image intensifying is that it enables to produce an ultimate neutral grey image.

One of the most widespread methods of nondestructive testing involves the use of radiographic industrial films. Of all X-ray materials the above mentioned films have the highest metal silver concentration in the emulsion layer. It is common knowledge that if the surface concentration of silver in the layer is not sufficient, it results in the decrease of photosensitivity, contrast and maximum density of the image produced.

We are offering the way of extra photographical development of radiographic industrial materials in CBD that enables to compensate the defects mentioned above in case of the reduced concentration of silver in the emulsion layer, while in case of the normal silver concentration in emulsion layers it results in substantial increase of sensibility and the gradient of these materials. Thus, it gives opportunity to reduce the exposure radiation dose and to raise the method productivity. Within the framework of our research experiments have been carried out on PT-1 and PT-K radiographic industrial films and laboratory samples with different concentration of silver, the samples being made from emulsions for these films.

The photographical development of the films which had been exposed to X-rays (the voltage on the tube being 60 kilowatt) was made in accordance with the methods shown in Table 1. The composition of solutions used for development is shown in Table 2.

Tab.1. Methods of film photographic development

№№ of opera-tions	Operation name	Operation time (in min.)	Solutions temperature (degrees C)
1	Exposing to X-rays PT-K PT-1	 2 1	 -
2	Development, «Roentgen-2»	4-8	20±0,5
3	Rinsing in water	0,1	15±5,0
4	Fixation	10	20±2,0
5	Washing	10	15±5,0
6	Bleaching	1-2	20±0,5
7	Washing	2	15±5,0
8	Intensifying in CBD	2-6	20±1
9	Washing	5	15±5.0
10	Drying	Up to com-plete drying	30±5,0

Tab.2. The composition of solutions used for photographic development.

Cupric bleacher composition	Cupric borohydride developer (CBD) composition:
- copper sulphate(+2) hydrate– 100 g -sodium chloride – 100 g - sulphuric acid 10% - 250 ml - water up to 1000 ml	Solution A - copper sulphate(+2) hydrate - 25 g - trilon B - 42 g - boric acid - 22 g - natrium hydrate - 23g - water up to 1000 ml Solution B -natrium borohydride – 0,5 g -0,5N natrium hydrate solution -100 ml.

Tab.3. The kinetics of the PT-K film development in CBD

№№ of steps	Development time (in min.)	$S_{0,85}$, p^{-1}	G	D_0, Б	R, мм $^{-1}$	
					Before Intensify-ing	After intensify-ing
1*	-	7,0	4,2	0,06	160	-
2	2	11,0	4,6	0,05	160	160
3	4	16,0	4,4	0,04	160	175
4	6	13,0	4,0	0,12	160	135

Footnote:
* -the film sample without intensifying

Tab.4. The kinetics of the PT-1 film development in CBD

№№ of steps	Development time (in min.)	$S_{0,85}$, p^{-1}	G	D_0, Б	R, мм $^{-1}$	
					Before intensify-ing	After intensify-ing
1*	-	30	3,9	0,05	120	-
2	2	50	4,5	0,04	120	120
3	4	70	4,2	0,04	120	135
4	6	45	3,8	0,15	120	-

Footnote:
* -the film sample without intensifying

Tab.5. The effect of surface silver concentration on sensitometric and structure-metric characteristics of the PT-K film when developing it in CBD

№№ of items	Surface concentration of Ag in the layer, g/m^2	$S_{0,85}$, p^{-1}	G	D_0, Б	R, мм $^{-1}$	
					Before intensify-ing	After ** intensify-ing
1*	11,5	7,0	4,2	0,06	160	-
2	8,0	11,0	4,6	0,05	145	160
3	4,6	9,0	4,4	0,04	145	175

Footnote:
* -the film sample without intensifying
** - processing time in CBD is 4 min.

Tab.6. The effect of surface silver concentration on sensitometric and structure-metric characteristics of the PT-1 film when developing it in CBD

№№ of items	Surface concentration of Ag in the layer, g/m^2	$S_{0,85}$, p^{-1}	G	D_0, Б	R, мм $^{-1}$	
					Before intensifying	After ** intensifying
1*	13,5	30	3,9	0,05	120	-
2	7,7	50	4,5	0,04	120	120
3	4,0	40	4,2	0,03	120	145

Footnote:

* -the film sample without intensifying

** - development time in CBD is 4 min.

Thus, as we can see from Tab.3 and 4, the radiation sensitivity, the gradient and the resolving capacity of the PT-K and PT-1 films increase when the time of development in CBD is extended. This fact results in improving the quality of nondestructive testing and enables to reduce the radiation time. The qualitative characteristics obtained while experimenting on films with less silver concentration exceed the similar characteristics of industrial films (Tab. 5, 6). Hence, we have grounds to recommend to reduce silver concentration in the surface layer substantially, provided that radiographic industrial films are to be extra processed in CBD.