Slavich

INTERNATIONAL WHOLESALE AND DISTRIBUTION
UAB GEOLA

Forth DIMENSION
HOLOGRAPHICS

U.S. Distributor of Slavich Materials
(812) 988-8212

Emulsions for Holography

TECHNICAL PRODUCT SPECIFICATION AND SALES INFORMATION BROCHURE

AUGUST '98

Slavich

Slavich is a factory of approximately 4000 employees with over twenty years of experience in the field of holography emulsion production. The company was originally formed in 1931 to cater for the extensive Russian photographic emulsion market - a sector where the company retains its world leadership. In more recent times Slavich has diversified into the microelectronics sector where it is now also the largest supplier in the CIS. Slavich has highly modern imported clean-room and ultra-clean-room facilities. The factory is well on the way to international standardisation with ISO9001 certification expected in 1999.

The Holography department at Slavich comprises over 100 employees and as such is the only large factory worldwide to currently produce viable quantities of both film and glass-based Holography materials.

Products

Slavich currently produces both Silver Halide and Dichromated Gelatin emulsions for holography applications. Table 1 summarises all the materials presently available. The green-sensitive VRP-M emulsions are very close analogues to the old Agfa 8E56 products for both Pulsed and CW laser recording. Likewise, the PFG-01 material gives equivalent performance to the Agfa 8E75 product for CW recording. Unfortunately no analogue exists for 8E75 when used with pulsed Ruby radiation.

The PFG-03M emulsion is a super fine grain red sensitive emulsion for superior quality imaging. The PFG-03C material is a panchromatic equivalent to the PFG-03M.

Finally PFG-04 is a long-life Dichromated Gelatin emulsion for blue and green laser recording.

Name of Material	Description
VRP-M	Fine-grained green sensitive holographic plates and film having no anti-halation coating and designed for reflection or transmission hologram recording. Average grain size is 35-40nm, resolving power is more than 3000 lines/mm, spectral sensitivity range includes 488nm,514nm, 526nm, 532nm. The VRP product is identical to VRP-M except for an anti-halation coating designed especially for transmission work.
PFG-01	Fine-grained red sensitive holographic plates and film designed for transmission or reflection hologram recording. Average grain size is 40nm, resolving power more than 3000 lines/mm, spectral sensitivity range 600-680nm (including 633nm, 647nm).
PFG-03M	Ultra fine-grained red sensitive plates and film designed for reflection hologram recording. Average grain size is 8-12nm, resolving power more than 5000 lines/mm, spectral sensitivity range includes 633nm, 647nm.
PFG-03C	Ultra fine-grained panchromatic (full colour) holographic plates designed for colour reflection hologram recording. Average grain size is 8nm, resolving power more than 5000 lines/mm, spectral sensitivity range up to 700nm (457nm, 514nm, 633nm).
PFG-04	Dichromated Gelatin holographic plates designed for phase reflection hologram recording. Resolving power greater than 5000 lines/mm, spectral sensitivity range up to 514nm (457nm, 488nm, 514nm).

Table 1: List of Available Holographic Materials

Acknowledgement

Slavich and Geola are grateful to Sergey Vorobyov who is responsible for the technique of latensification and to Uwe Tillmanns for his work on temporary lamination. We would also like to acknowledge the work of Hans Bjelkhagen and Nicholas Phillips on which much of the chemistry listed in this brochure is based.

The VRP-M and PFG-01 Materials

Characteristic curves for these emulsions, showing spectral sensitivity versus wavelength, are shown in figure 1. The VRP-M light sensitivity (CW radiation) is seen to peak at aproximately 75 microJoules/cm2 and that of PFG-01 (CW radiation) at aproximately 100 microJoules/cm2. Figure 2 shows the optical density after exposure by CW radiation and development versus energy. Grain size characteristics for the VRP-M and PFG-01 emulsions are presented in Figure 3. The diffraction efficiency versus exposure for reflection holograms recorded on PFG-01 (using a CW laser) and on VRP-M (using a pulsed laser) is presented in figure 4. The maximum diffraction efficiency is seen to be >40% for both emulsions. Material life is more than two years.

The VRP-M emulsion may be used equally well with frequency

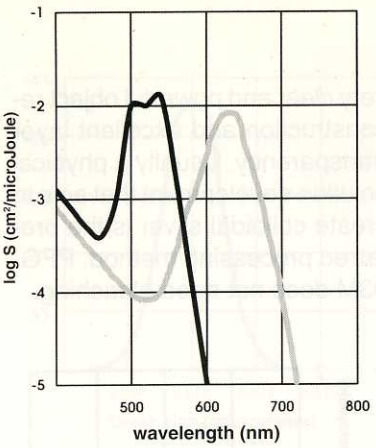

Figure 1: Spectral sensitivity curves for VRP-M (black) and PFG-01 (grey)

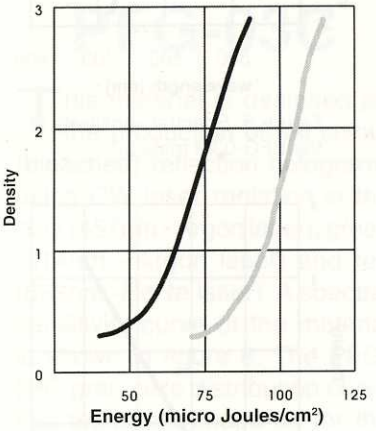

Figure 2: Characteristic curves for VRP-M (left) and PFG-01.

-doubled pulsed Neodymium lasers as with green CW radiation. The PFG-01 emulsion, however, is not sensitive to pulsed radiation from the Ruby laser and as such should be only used with CW sources. Emulsions used with pulsed radiation, should be post-sensitized with the technique of latensification (see section below).

Recommended Chemistry for VRP-M

Table 2 shows a summary of various recommended processing schemes for use with Pulsed Neodymium lasers (526.5nm, 532nm). All these processing recipes work equally with CW Argon for both transmission and reflection holograms; however in this case latensification is usually not necessary and exposure is a little longer. In addition, for CW, you may obtain better results using the CW-C2 developer depending on your colour requirements. Uniform heating in a special oven provides easy colour control across the spectrum for pulsed lasers.

	Mastering Transmission Holograms	Copying (Reflection Holograms) Final Colour Green	Copying (Reflection Holograms) Final Colour Honey-Green	Copying (Reflection Holograms) Final Colour Orange
Exposure	20...40 microJ/cm2	30...50 microJ/cm2	50...70 microJ/cm2	50...70 microJ/cm2
Latensification	Yes	Yes	Yes	Yes
Development	SM-6 2...3min	SM-6 2...3min	M-Pyro+ 3...4min	M-Pyro+ 3...4min
Wash	Water 2...3min	Water 2...3min	Water 2...3min	Water 2...3min
Bleach	PBU-Amidol until clear	PBU-Amidol until clear	PBU-Amidol until clear	PBU-Amidol until clear
Wash	water 10...20mins	water 10...20mins	water 10...20mins	water 10...20mins
Potassium Iodide bath	No	No	No	2mins
Washing	No	No	No	1...2mins
Final Wash	Water with wetting agent 1min	Water with wetting agent 1min	Water with wetting agent 1min	Water with wetting agent 1min
Slow Air Drying	Yes	Yes	Yes	Yes

Table 2: Recommended Chemistry for VRP-M with Pulsed Nd:YLF/YAG Radiation

PBU-Amidol Bleach	
Potassium Persulphate	10.0g
Citric Acid	50.0g
Cupric Bromide	1.0g
Potassium Bromide	20.0g
Amidol	1.0g
Water	to 1.0L
Potassium Iodide Bath	
Potassium Iodide	18.0g
Water	to 1.0L

Table 3: Bleaches and Other Baths

Recommended Chemistry for PFG-01 with CW HeNe and Krypton Radiation

The PFG-01 emulsion can be processed with virtually any chemistry previously applied to the Agfa 8E75 emulsion with the single addition -if necessary- of a post-exposure latensification step before chemical processing. We recommend, in particular, the SM-6 and CW-C2 developers defined in table 4 for both transmission and reflection holograms. Colour control is possible with all the normal.

SM-6 Developer	
Ascorbic Acid	18g
Sodium Hydroxide	12.0g
Phenidone	6.0g
Sodium Phosphate (dibasic)	28.4g
Water	to 1.0L
M-Pyro+ Developer 1 part A + 1 part B	
Part A	
Pyrogallol	20.0g
Phenidone	1.2g
Sodium Metabisulphite	5.0g
Water	to 1.0L
Part B	
Sodium Carbonate	130.0g
Water	to 1.0L
CW-C2 Developer 1 part A + 1 part B	
Part A	
Catechol	20.0g
Ascorbic Acid	10.0g
Sodium Sulphite (anhydrous)	10.0g
Urea	100.0g
Water	to 1.0L
Part B	
Sodium Carbonate	60.0g
Water	to 1.0L
Note: For CW-C2 develop for 2mins at 20C.	

Table 4: Developers

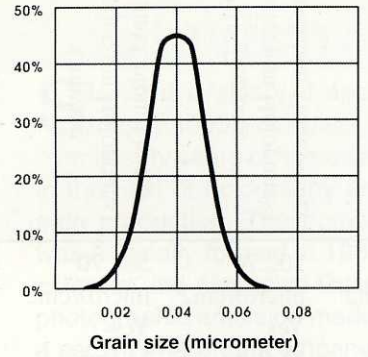

Figure 3: Grain size distribution curve for VRP-M and PFG-01.

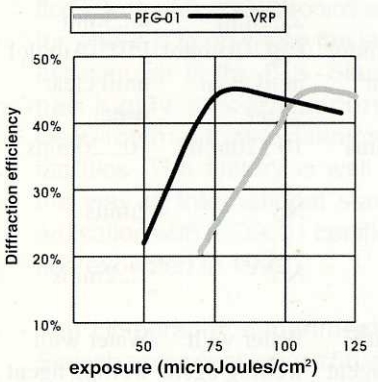

Figure 4: Diffraction efficiency curves for VRP-M and PFG-01.

methods used with the Agfa emulsion including TEA.

Latensification

Unlike Agfa emulsions the Slavich PFG-01 and VRP-M emulsions have peak sensitivities to exposures in the millisecond regime. In order to obtain optimal sensitivity to exposures either much longer or much shorter than this timeframe the simple technique of latensification can be used. Practically speaking this means that some CW laser users and all pulsed laser users will use latensification.

Latensification is usually done directly after the holographic exposure. However before you can apply the process you must work out a latensification time appropriate for your system. This procedure is as follows: Place a 25W lamp with a dark filter (green for VRP-M and red for PFG-01 although white light also works) at a distance of 1m from a test holoplate or film such that its light uniformly illuminates the emulsion. You will need to try several exposure times ranging from 0 to around 4 mins and then look at how the emulsion develops. So start with zero exposure time and then under your normal safelight conditions develop the plate. The plate will darken a little. This is called the fog level. After development put this control plate into a STOP bath, wash it and keep it handy.

Now you must start to make a series of test exposures with small test plates. Start at about 0.5 mins and go up to around 4mins. After each exposure develop your plate and match the darkening of this plate to your control plate. If it is the same you need more exposure so go back again and repeat the process. Stop when you get a result that is just marginally darker than the fog level. This is then the correct latensification exposure for your geometry.

Now that you have discovered the proper latensification time all you must do is after every proper holoplate exposure you must take your plate and illuminate it exactly as described above for the time that you have worked out. Then all processing is as normal. Latensification stabilizes and enhances the latent image formed by the holographic exposure. If required, chemical processing may be done with significant delay after latensification.

PFG-03M

This material is designed for reflection hologram recording using CW radiation in the red spectral range (633nm - HeNe laser and 647nm - Krypton laser). The spectral sensitivity curve of the material is shown in figure 5. Peak emulsion sensitivity is around 1.5-2mJ/cm2. Density versus energy is shown in figure 6 and the grain size distribution curve is shown in Figure 7.

Despite a lower sensitivity than VRP-M and PFG-01, the PFG-03M material has a higher diffraction efficiency and a very high signal to noise ratio. Holograms recorded on this material have a very clear and powerful object reconstruction and excellent layer transparency. Usually a physical solution development that acts to create colloidal silver is the preferred processing method. PFG-03M does not need bleaching.

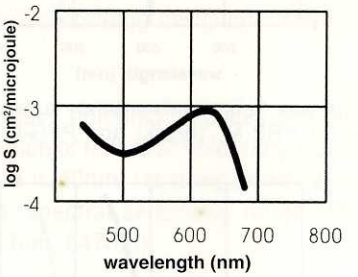

Figure 5: Spectral sensitivity of the PFG-03M material.

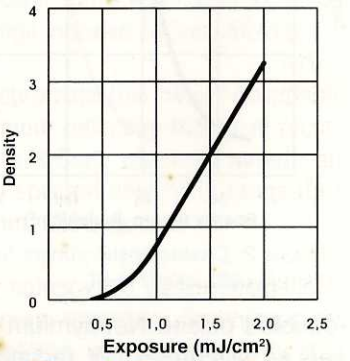

Figure 6: Characteristic curve for PFG03M.

Hardening: 2-3 mins	
Formalin 37%	10ml
Potassium Bromide	2g
Sodium Carbonate	5g
Water	to 1L
Washing:1-2mins	
Wash in running (filtered) water.	
Development in GP-2: 10-15mins	
Concentrated solution	
Methyl Phenidone	0.2g
Hydroquinone	5g
Sodium Sulphite (Anhyd)	100g
Potassium Hydroxide	5g
Ammonium Thiocyanate	9g
Water	to 1L
Work Sol.: 40ml GP-2+1L H20	
Washing: 1-2mins	
Wash in running (filtered) water.	
Fixing: 2mins	
Sodium Thiosulphate (cryst.)	160 g
Potassium Metabisulphate	40 g
Water	to 1L
Washing:1-2mins	
Wash in running (filtered) water.	
Drying: 2mins each bath	
50%,75% and 96% Ethyl Alcohol	

Table 5: Recommended processing for PFG-03M (Reflection Holograms). Note that temperature must be lower than 19°C.

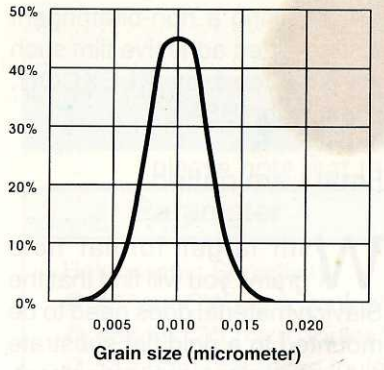

Figure 7: Grain size distribution for the PFG-03M material.

PFG-03C

This material is designed for the production of full colour (bleached) reflection holograms using CW laser radiation in the blue (457nm - Argon laser), green (514nm - Argon laser) and red (633nm -HeNe laser). A spectral sensitivity curve of the material is shown in figure 8. The PFG-03C grain size distribution curve has the same shape as for the PFG-03M material. Diffraction efficiency versus exposure is shown in figure 9. The maximum DE in the blue range is >25% and in the green and red ranges >45%. Sensitivity values are 2mJ/cm2 and 3mJ/cm2 respectively.

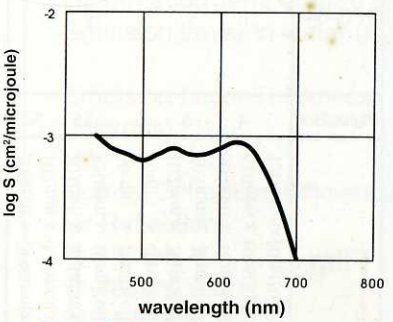

Figure 8: Spectral sensitivity curve for PFG-03C

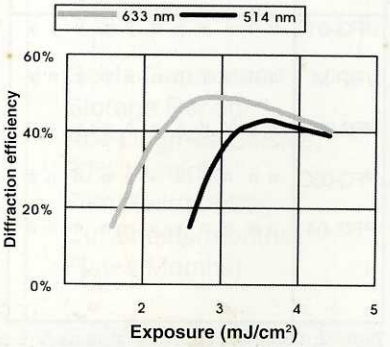

Figure 9: Diffraction efficiency curve for PFG03C.

Hardening: 6 mins	
Formalin 37%	10ml
Potassium Bromide	2g
Sodium Carbonate	5g
Water	to 1L
Washing:1-2mins	
Wash in running (filtered) water.	
Development VRP: 4 - 5 mins	
Concentrated solution	
Sodium Sulphite (Andydrous)	194g
Hydoquinone	25g
Potassium Hydoxide	22g
Methyl Phenidone	1.5g
Potassium Bromide	20g
Potassium Metaborate	140g
1,2,3-Benzotriazole	0.1g
Distilled Water	to 1L
Work Sol.: 1 part of VRP developer + 6 parts water.	
Washing:1-2mins	
Wash in running (filtered) water.	
Bleach in PBU-Amidol: 5 - 8 mins	
Copper Bromide	1g
Potassium Persulphate	10g
Citric Acid	50g
Potassium Bromide	20g
Distilled Water	to 1L
Amidol	1g
Washing:1-2mins	
Wash in running (filtered) water.	
Stop Bath: 2 mins	
Acetic Acid	20g
Water	to 1L
Washing:1-2mins	
Wash in running (filtered) water.	
Bathing :2 mins	
Bathing in distilled water with added wetting agent	
Drying	
Drying in normal conditions.	

Table 6: Recommended processing for PFG-03C (Reflection Holograms).

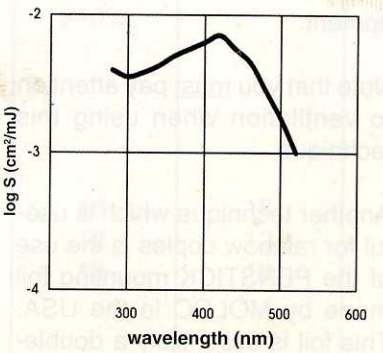

Figure 10: Spectral sensitivity curves for PFG-04.

PFG-04

This material is designed for the recording of reflection Denisyuk-type holograms using CW laser radiation (488nm, 514nm -Argon laser). The material spectral sensitivity curve is shown in figure 10. The sensitivity reaches 100mJ/cm2 in the blue spectrum range and 250mJ/cm2 in the green. Due to its grainless structure, this material has very high resolving power and a diffraction efficiency of >75% (figure 11).

The recommended processing technique of the exposed hologram consists of the following operations:

1). Thermal Hardening after exposure (100C) - Depending on the layer freshness. See figure 12.

2). Cooling to Room temperature.

3). Bathing in running filtered water - 3mins.

4). Bathing in 50% Isopropyl Alcohol solution for 2 - 3 mins.

5). Bathing in 75% Isopropyl Alcohol solution for 2 - 3 mins.

6). Bathing in 100% Isopropyl Alcohol solution for 2 - 3 mins.

7). Drying in a desiccator. (100C) for 60 mins.

8). Emulsion layer preservation using optical anhydrous adhesive and protective glass.

Note that the processing solution temperatures must not exceed 20C for fresh layers. If holograms appear "milky" in colour then the processing solution temperature should be decreased or the thermal hardening period should be prolonged. The material shelf life is 12 months(average observed period).

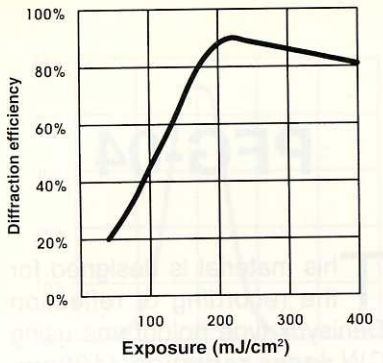

Figure 11: Diffraction efficiency curve for PFG-04.

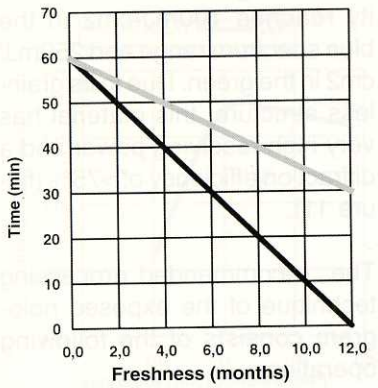

Figure 12. Hardening time for PFG-04 versus Storage Time. The black curve refers to a storage temperature of 18 Degrees Celsius and grey curve to a storage temperature of 4 Degrees Celsius.

Film Substrate

The Slavich film substrate is slightly different to that used on the old Agfa products and as such should be treated, particularly at large format, with different techniques.

Slavich film products are currently made with 150 micron tri-acetate plastic film. This material is deformed less easily than that used with Agfa and can be rolled flatter both as a consequence of the material used and of the fact that the film is thinner than Agfa.

For small format holography you may treat the Slavich film identically to Agfa. All techniques of film holding that worked with Agfa are useable with the Slavich material.

For larger formats (20x30cm and above), however, you will find that just mounting the Slavich film between two glass plates does not ensure adequate film flatness. This is because the thinner TAC film is less rigid than the Agfa product. Consequently you must use one of several techniques of temporary mounting when exposing a Slavich film hologram.

Temporary Lamination

One of the most effective ways of temporary hologram mounting for all types of hologram (with both CW and pulsed lasers) is to use the liquid Tetrachloroethylene which may be found in any dry-cleaning laundry. The technique is as follows:

1). Clean a glass plate for mounting your film on and place this plate horizontally in a well-ventilated area. The plate should be slightly bigger than the actual film.

2). Fill a medical syringe (with no needle - volume depending on the size of film to be mounted) and place a strip of fluid parallel and near to one edge of the glass plate.

3). Apply the film to the glass plate with a mounting roller making sure that you evacuate all the bubbles.

4). Now simply use the glass plate as you would a normal glass holographic plate.

5). After exposure and latensification (if appropriate) simply peel off your film and develop as usual. Any residual liquid on the film will evaporate and in any case will not affect development.

Note that you must pay attention to ventilation when using this technique.

Another technique which is useful for rainbow copies is the use of the PENSTICK mounting foil made by MOLCO in the USA. This foil is essentially a double-sided adhesive that can be removed and reused.

Yet another technique is to use permanent mounting before exposure using a non-birefringent double-sided adhesive film such as produced by FLEXCON, again in the USA.

Final Lamination

With larger format holograms you will find that the Slavich material does need to be mounted to a rigid flat substrate such as a glass or plastic sheet. Whereas, with Agfa, you could just about get away for bigger formats (i.e. 30x40cm) by simply putting the film between two glasses, with Slavich you can't! However, you'll find that the end result ,when you do mount the hologram properly with a double-sided film, is very similar.

Material Sizes

Glass	406 x 609 mm	300 x 406 mm	180 x 240 mm	102 x 127 mm	63 x 63 mm
PFG-01	n	y	y	y	y
VRP-M	y	y	y	y	y
PFG-03M	n	y	y	y	y
PFG-03C	n	y	n	y	y
PFG-04	n	y	y	y	y
Plates/Box	4	6	6	25	30

Film	1200mmx10m(Roll)	610mm x 10m(Roll)	304mm x 10m(Roll)	203mm x 20m(Roll)	102mm x 20m(Roll)	76mm x 20m(Roll)	36mm x 20m(Roll)	350mm x 10m(Roll)	203mm x 254mm(x50)	102mm x 127mm(x50)	200mm x 300mm(x 5)
PFG-01	n	n	n	y	y	n	y	y	y	y	y
VRP-M	n	n	n	n	n	n	n	y	y	n	y
PFG-03M	n	n	y	y	y	n	n	n	y	y	y
PFG-03C	n	n	n	n	n	n	n	n	n	n	n
PFG-04	n	n	n	n	n	n	n	n	n	n	n

Table 7: Material sizes available as standard products. Note y = yes, n= on request.

Summary of Technical Specifications

*please note that the specifications for the PFG-01emulsion will be improved soon.

Parameter	PFG-01*	VRP-M**	PFG-03M	PFG-03C	PFG-04
Holographic Sensitivity					
@ 457nm CW microJoules/cm^2				2000	80000
@ 488nm CW microJoules/cm^2					100000
@ 514.5nm CW microJoules/cm^2		75		3000	250000
@ 526.5nm 30ns pulse with latensification - microJoules/cm^2		75			
@ 633nm microJoules/cm^2	100		1500-2000	3000	
Gamma	>6.0	>6.0	>6.0	>6.0	x
Max Density on Characteristic Curve (D_{max})	<4.0	<4.0	<4.0	<4.0	x
Fog Density (D_0)	<0 .01	<0 .01	<0 .01	<0 .01	x
Resolving Power (R), mm^{-1}	3000	3000	>5000	>5000	Grainless
Max. of Spectral Sensitization, nm	633	530	633	457/514/633	415
Swollen Emulsion Layer Strength after Chemical Processing, H (gm force)	900	900	>50	>50	x
Adhesion between Emulsion Layer and Base after chemical processing (Class A-F)	A-C	A-C	A-C	A-C	x
Deformation Temperature of Emulsion Layer in water (t_{def}),°C	>90°C	>90°C	>35°C	>35°C	x
Emulsion Layer Thickness (microns)	7 to 8	6 to 7	6 to 7	9 to 10	16 to 17
Normal Diffraction Efficiency for Reflection					
@ 457nm, %				>25%	>75%
@ 488nm, %					>75%
@ 514.5nm, %		>40%		>45%	>75%
@ 526.5nm, %		>40%			
@ 633nm, %	>40%		>45%	>45%	
Geola Guaranteed Storage Period At 4 Degrees Celsius, 30% Humidity.					
Film Roll(months)	18	18	18	x	x
Cut Sheets(months)	12	12	6	x	x
Plates(Months)	18	18	12	12	12

** VRP and VRP-M Plates and Films have the same Technical specifications.

Sales & Purchasing Information

International Sales Point

Slavich has appointed Geola uab as an International Sales Coordination office and as an official Stockhouse for all Slavich products. Under Slavich's instructions, Geola is appointing national distributors for all holography products.

Distribution Network

Please contact the Slavich International Sales Office at Geola uab in order to find out which is your nearest and most convenient Slavich distributor. If you do not have an official Geola-appointed Slavich distributor in your country and you would like to buy direct from the Slavich International Sales office at Geola please simply ask us for a quotation regarding your order.

Service

The Slavich International Sales Office at Geola was formed in order to ease the communications interface between the Russian company Slavich and Western Customers. Geola maintains a full-time English-speaking sales staff that are both friendly and easy to communicate with. All Slavich orders are computer tracked so we can keep you informed of exactly what is happening with your order. Our large stock of Slavich material and our direct contact with the Slavich production unit allows us to deliver promptly and efficiently, using whatever transport method you request.

Quality

In addition to the quality checks performed at the Slavich production unit Geola batch samples and verifies all stock held at its premises and all orders from its distributors and clients. In the unlikely event that any Slavich product is found to be defective due to manufacture and this product has been sold through the Slavich International Sales Office at Geola, this product will be replaced free of charge in the shortest possible time.

Non-standard Sizes

Please contact us directly for your non-standard requirements on both Glass and film.

Technical Information

Geola uab is one of the major testing houses for Slavich products. As such we develop and test new chemistries and processing techniques and of course are thoroughly familiar with the technical behaviour of each Slavich product. Most new information that we and other testing houses develop is made available on the Slavich home page at www.slavich.com. If you encounter some problem that is not listed here or in the FAQ section of the home page, you may contact us directly and ask for technical assistance. We will do our best to respond to your enquiry as quickly as we are able.

Feedback

Slavich is committed to the furthering of the Holography industry through the development of new emulsions and the perfection of existing products. Please help us to understand the needs of the market by sending us your comments and suggestions.

Disclaimer

OAO Kompania Slavich and Uab Geola reserve the right to make change without notice to the specifications and material contained herein and shall not be held responsible for any damage (including consequential) caused by the reliance on the materials presented, including but not limited to typographical, arithmetic or listing errors.

Copyright

Slavich,

GEOLA
INTERNATIONAL WHOLESALE OFFICE

Slavich International WholeSale Office,
uab GEOLA,
P.O. Box 343, Vilnius 2006, Lithuania
Tel: +370 2 232 737
Fax: +370 2 232 838
Email: geola@post.omnitel.net

Your Local Representative

Forth Dimension Holographics
2759 Helmsburg St., Nashville, IN 47448
Tel.- (812) 988-8212 Fax- (812) 988-9211
E-mail- hologram4d@aol.com
http://members.aol.com/hologram4d