RSS Optics Cleaning Procedures

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Document Number: SALT-3125AM0005

Version 1.0
26 July, 2010

Change History

Rev	Date	Description
1.0	July 26, 2010	Document origin

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1 RSS Exposed Surfaces

Figure 1 and the table on the following page list the optical surfaces of RSS that might become exposed.

Table Coating Acronyms	
ML	Multilayer
LLNL	Lawrence Livermore National Labs
RGL	Richardson Grating Lab
QG	Queensgate
OS	OptoSigma
STF	Spectrum Thin Films
Table Warnings	
A	Use same techniques as are used for the SAC LLNL mirrors
B	The ONLY acceptable cleaning of the outer surfaces of the etalons is dust removal by using a clean, soft brush or dry gas. No fluid-based cleaning is acceptable.
C	See attached RGL Technical Note 8

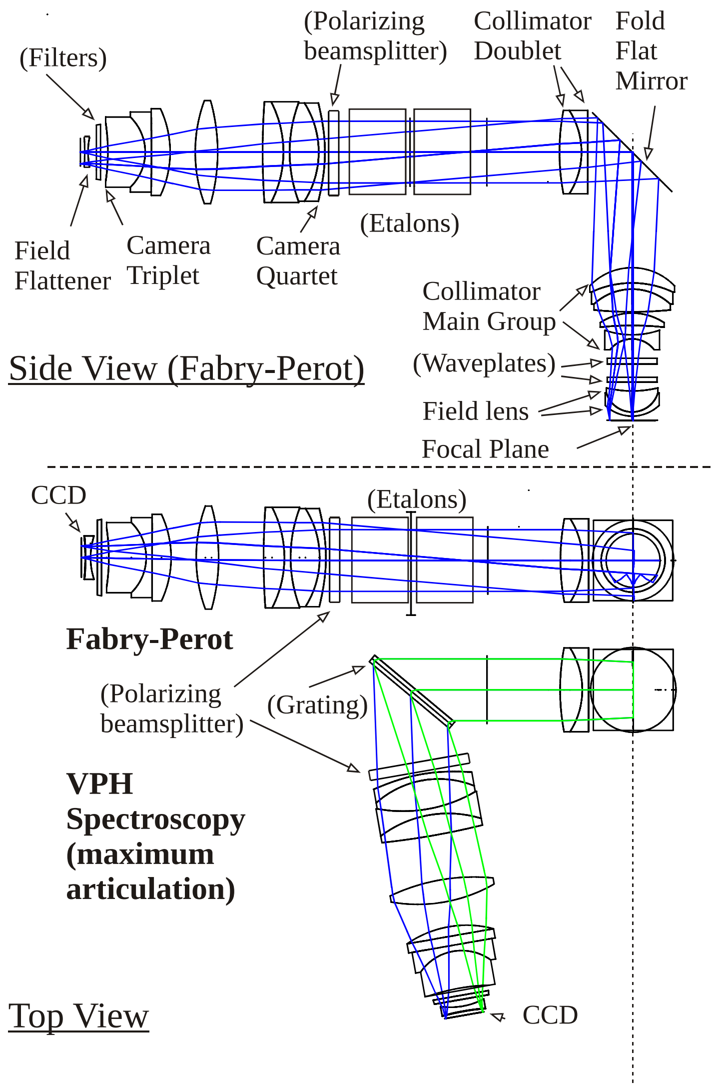

Figure 1. RSS Optical diagram, showing surfaces listed in the table. Elements in parentheses are removable

2 Cleaning Instructions

None of the following applies to sol-gel coatings, which, as a practical matter, cannot be effectively cleaned. The lore is that the surfaces can be flushed with one solvent or another, but you'll probably wish you hadn't due to the streaks that will almost certainly remain. The practical solution is to not contaminate the sol-gel in the first place.

In RSS, the only optical surfaces with sol-gel are the "internal" surfaces in the collimator Main Group and in the Camera, which are not listed in the table. These surfaces would become exposed only if these subsystems needed to be returned to Pilot Group for repair.

RSS Exposed Optics Table

Name	Deployables	Orientation	Material	Coating	Surface	D/ X	Y	Shape	Exposed when:	Warn	Comment
Field Lens		Down	Fused Quartz	MgF2	Convex	130		Round	Expose telescope focal plane		
Field Lens		Up	CaF2	MgF2	Concave	122		Round	Waveplate assy removed		
Halfwave	HWP	Down, Up	Fused Quartz	MgF2	Flat	110	101	Octagon	Waveplate assy removed		Removable
QuarterWave	QWP,QBL,BL	Down, Up	Fused Quartz	MgF2	Flat	65	61	Octagon	Waveplate assy removed		2 Round Blanks
Coll Main Group		Down	Fused Quartz	MgF2	Concave	118		Round	Waveplate assy removed		
Coll Main Group		Up	CaF2	MgF2	Convex	194		Round	Collimator doublet removed		
Fold Flat Mirror		45 deg to Down	Fused Silica	LLNL	Flat	270	195	Rectangle	Collimator doublet removed	A	
Collimator Doublet		Spec Entry	Fused Silica	STF ML	Flat	186		Round	Collimator doublet removed		
Collimator Doublet		Spec Exit	CaF2	STF ML	Convex	186		Round	Collimated space opened		
Etalon 1	MG or HG	Spec Entry, Exit	Fused Silica	QG ML	Flat			Round	Etalon exchange	B	Removable
Etalon 2	LG	Spec Entry, Exit	Fused Silica	QG ML	Flat			Round	Etalon exchange	B	Removable
SR Grating	PG0300	Spec Entry	Fused Silica	Grating	Flat	175	200	Rectangle	Grating magazine removed	C	Removable
	PG0300	Spec Exit	Fused Silica	RGL AR	Flat	175	200	Rectangle	Grating magazine removed		
VPH Grating	PG0900	Spec Entry, Exit	Fused Silica	OS ML	Flat	175	180	Rectangle	Grating magazine removed		
VPH Grating	PG1300	Spec Entry, Exit	Fused Silica	OS ML	Flat	175	210	Rectangle	Grating magazine removed		
VPH Grating	PG1800	Spec Entry, Exit	Fused Silica	OS ML	Flat	175	237	Rectangle	Grating magazine removed		
VPH Grating	PG2300	Spec Entry, Exit	Fused Silica	OS ML	Flat	175	237	Rectangle	Grating magazine removed		
VPH Grating	PG3000	Spec Entry, Exit	Fused Silica	OS ML	Flat	175	237	Rectangle	Grating magazine removed		
Pol Beamsplitter		Spec Entry, Exit	Calcite	OS ML	Flat	187	218	Rectangle	Inserted, coll space opened		Removable
Camera Quartet		Spec Entry	Fused Silica	STF ML	Convex	234		Round	Collimated space opened		
Camera Triplet		Spec Exit	Fused Silica	STF ML	Concave	176		Round	Detector and filter removed		
Clear Filter	PC00000	Spec Entry, Exit	Fused Silica	MgF2	Flat	90	130	Rectangle	Filter exchange		Removable
Order Separator	PC03200	Spec Entry	Schott WG-320	MgF2	Flat	90	130	Rectangle	Filter exchange		
		Spec Exit	Schott –BaK2	MgF2	Flat	90	130	Rectangle	Filter exchange		
Order Separator	PC03400	Spec Entry	Hoya UV-34	MgF2	Flat	90	130	Rectangle	Filter exchange		
		Spec Exit	Schott –BaK2	MgF2	Flat	90	130	Rectangle	Filter exchange		
Order Separator	PC03850	Spec Entry	Schott GG-385	MgF2	Flat	90	130	Rectangle	Filter exchange		
		Spec Exit	Schott –BaK2	MgF2	Flat	90	130	Rectangle	Filter exchange		
Order Separator	PC04600	Spec Entry	Hoya Y-46	MgF2	Flat	90	130	Rectangle	Filter exchange		
		Spec Exit	Schott –BaK2	MgF2	Flat	90	130	Rectangle	Filter exchange		
Interference Filters	PI0xxxx	Spec Entry, Exit	Various Glasses	CS ML	Flat	89	102	Rectangle	Filter exchange		
Fld Flattener		Spec Entry	Fused Silica	STF ML	Concave	90	123	Rectangle	Detector removed		Dewar window

2.1 Universal Don'ts

1). Don't clean a surface with any sort of tissue when dry. You'll scratch even hard coatings. And even if the scratches are immaterial (many are), they'll still be visible.

2). Don't use any sort of tissue on a bare metallic coated (aluminum, gold) surface even if moistened with solvent. If you don't remove the coating outright, you'll leave scratches and marks that will make you wish you had never touched it. At most, you can use a cotton swab and solvent to remove localized specks. Even then...

3). Don't blow with your mouth remove dust, etc. You'll inevitably end up with flecks of spit on the surface.

4). Don't handle anything with your bare hands unless you know you can get the fingerprints off, and you don't mind doing so. Finger prints, if left long enough, are indelible on virtually any coated surface as well as on many bare surfaces.

5). Don't touch your face (to scratch an itch, to cover a sneeze, etc.) with your gloved hand, or you'll have to put on a new glove.

6). Don't use a solvent if the element is mounted in anodized aluminum (or any other material) unless you've tested the solvent for compatibility. Many solvents will leach the dye out of the anodized surface. This is especially true if the "sealing" of the anodizing is poorly done. You can test by moistening a cotton swab with the solvent and rubbing it on a small spot of the material. If you see any change in the material or the color of the cotton swab, you'd best use a different solvent.

2.2 Universal Do's

1). Wear a mask and a hairnet if you will be working over the optical elements.

2). When using a tissue or swab to clean a surface, it must be moistened with some sort of solvent.

3). When using any solvent, try it on a small area first, preferably on the girdle of the element. You're looking to make sure it does not attack the material or coating, and to make sure it doesn't leave a residue. You should also check for compatibility with whatever the lens is mounted in (if it's mounted). Some favored solvents are:

- 200 proof ethanol. It readily cuts most contaminants and attacks very few surfaces. You may be tempted to use 190 proof (it's common), but you'll curse the little water droplets that remain when the alcohol evaporates.

- Acetone. Reagent grade. In a pinch, you can use the hardware store variety, too. Use small amounts and test it first to make sure that any residue—imperceptible in normal cases—is acceptable.

- Methylene chloride. Reagent grade. Make sure this is compatible with all the materials it will contact. If it is, it is by far the easiest, cleanest, and fastest solvent to use.

There are doubtless others.

4). When holding and element for cleaning, hold it close to, preferably against, a supporting work surface. The idea is to minimize the distance of any potential drops.

2.3 The General Process

There are two steps to cleaning a surface. First is to remove the particulates. Second is to removing any remaining contamination.

2.3.1 Removing Particulates

1). A cleaning brush can be very simple and effective for small amounts of particulates. An artist's sable brush is suitable. Make sure it's clean (alcohol, acetone) and dry, and don't allow the metal ferrule that retains the bristles touch the surface you're cleaning. There are also brushes made just for the purpose (Edmund Optics, 38-320).

2). For really dusty surfaces, blow off the worst of the crud before using a brush. Otherwise, you'll end up just redistributing a fair fraction of the particles.

But simple as it sounds and as effective as it can be, "blowing" is fraught with pitfalls:

> A). Use something other than your mouth to do the blowing.
>
> B). "Canned air" from the office supply store (or elsewhere) is a tempting solution, and can work well. It can also be a disaster. Don't tilt or shake the can while blowing or you'll get cold, liquid fluorocarbon on the surface. This will leave an indelible residue, and *will* fracture thermally sensitive materials (e.g. CaF_2, BaF_2, S-FPL51Y) .
>
> C). Compressed air can work, but it, too, can be a disaster. You'll need a "coalescing filter" on the system and must know that it is not already full of oil and condensed water. You'll also need a low pressure regulator and small orifice blow gun (hobby store/website), and will want to practice on an expendable article. It's easy to blow a lens entirely out of your hand.
>
> D). The safest method is unfortunately something of a hassle for occasional cleaning. That is to use a bottle of dry nitrogen. You'll still need the regulator and blow gun (as with the shop air), and it also carries the risk of blowing the lens out of your hand.
>
> E). Cleaning with CO_2 snow (www.co2clean.com, others) is the "sexiest" method. It is also the most expensive (several $k) and again something of a hassle. It can definitely remove particulates, but it's unclear how much better it is than, say, careful use of canned air. And despite some claims of removing organic contaminants, no one has ever seen it remove a finger print. And you need clean liquid CO_2. And there is a risk of fracturing thermally sensitive materials. And you can end up with frostbite if mishandled. Think twice.

3). Another very nice way to remove particulates from surfaces that will tolerate it is a strippable coating (strippablecoating.com). A possible pitfall is compatibility of the surface with the solvent in the coating. Hard coatings are fine. Many bare optical materials are fine. Test it on a small area first. If it works, it will remove all dust, remove at least some of the other crud, and leave no appreciable residue. Drawbacks? You'll need spray equipment, and it's a bit messy to clean up. It's also somewhat time consuming, as you need to apply the coating, let it dry, and then strip it off.

2.3.2 Removing Oils and Other Contaminants:

For this, you'll need some sort of solvent. Don't forget that clean water with a little dishwashing soap can be just fine for surfaces that will tolerate it. This include many common optical glasses, and essentially all of those used in "catalog" lenses for the visible spectrum (e.g., BK-7, B-270, SF5, SF6, SF10, LaK22, BaF10). You'll need to do a final rinse with distilled water or one of the other solvents.

In general, the procedures are easier with the faster drying solvents: water, ethanol, acetone, methylene chloride, in that order.

If you only need to remove a limited number of specks or spots from the element, the procedure is this:

> 1). Moisten a cotton swab (Edmund Optics 56-925) with the selected solvent and gently scrub the spot while turning the swab to keep a clean portion of the swab on the element. Keep your (gentle) scrubbing contained to the smallest area possible while still removing the crud. Throw away the swab as it becomes contaminated. Do this until you've removed the spot, and you'll likely be left with a residue patch where you were scrubbing and the solvent has evaporated.
>
> 2). Moisten a fresh swab, and begin to "sweep" the residue into a smaller and smaller patch. You should be able to reduce the patch to the size of a droplet of the solvent.
>
> 3). You can then either:
>
> - Leave the tiny spot of residue alone.
> - Attempt to remove the spot with a lightly moistened swab that does not leave a droplet on the surface. You'll run the risk of leaving small scratches when you do this.
> - "Drag" the remaining spotlet to the edge of the element with a clean, moistened swab. The idea is to never let the droplet of solvent entirely evaporate until you've worked it all the way to the edge of the element.

For cleaning larger areas, it's best if the element is unmounted to allow unrestricted access to the edge. Otherwise, there is little choice but to use the method above, and this quickly becomes tedious and time consuming. Assuming there is access to the edge, then, the procedure is:

1). Clean the worst spots as described immediately above. Don't bother getting rid of the small residue patches.

2). Fold a lens tissue (Edmund Optics, 58-187) in half an moisten with the selected solvent.

3). Drag the moistened, folded edge of the tissue across the element starting at one edge. This is admittedly difficult to do on concave surfaces, and it will take a little practice. Don't let the tissue become dry. Stop in the middle and remoisten if you must. Large elements will require a slower drying solvent (ethanol).

4). If the element is really dirty, you'll need to refold to the tissue to get a clean edge even before you have entirely wiped across the element. You'll know by noting that the tissue appears dirty or you're leaving streaks. In any case, keep refolding and moistening the tissue as the edge becomes soiled, and don't hesitate to throw it away and use another when needed.

5). The eventual goal is to wipe entirely across the element in one motion with a moistened tissue, and do this without leaving any droplets or streaks. The droplets will inevitably dry into residue specks. You will likely not be able to do this until you have wiped the surface several times to remove all the contamination.

6). For large elements, you'll need to clean the surface with several adjacent strokes. It's a little like using a squeegee on a large window and will require some practice to not leave a residue strip between the strokes.

Appendix A. Surface Relief Grating Surface Cleaning

Richardson Gratings™
A Newport Corporation Brand

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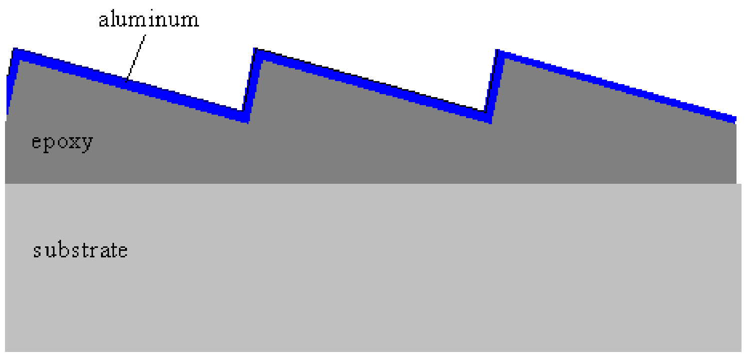
Technical Note 8
HANDLING GRATINGS

A diffraction grating is a *first surface optic*, so its surface cannot be touched or otherwise come in contact with another object without damaging it and perhaps affecting its performance. Damage can take the form of contamination (as in the adherence of finger oils) or distortion of the microscopic groove profile in the region of contact. This Technical Note describes the reasons why a grating must be handled carefully and provides guidelines for doing so.

THE GRATING SURFACE

Commercially available diffraction gratings are replicated optics comprised of three layers: a substrate, an epoxy layer, and (usually) a reflective coating. Each layer meets a different purpose: (1) the metallic layer provides high reflectivity, (2) the epoxy layer holds the groove pattern and groove profile and (3) the substrate (usually glass) keeps the optical surface rigid. *

Figure 1 – Composition of a replica diffraction grating. A section of a standard blazed grating with an aluminum coating is shown. Layer thicknesses are not shown to scale: generally the aluminum film thickness is about 1 micron, and the epoxy layer is between 30 and 50 microns; the substrate thickness is usually between 3 and 100 millimeters.



PROTECTIVE COATINGS

Since the groove profile is maintained by the epoxy layer, rather than the reflective (metallic) coating on top of it, protective coatings such as those that meet the military specification MIL-M-13508 (regarding first-surface aluminum mirrors) do not serve their intended purpose. Even if the aluminum coating itself were to be well-protected against contact damage, it is too thin to protect the softer epoxy layer underneath it. Even "fully cured" epoxy is not very hard, resembling molding clay in its resistance to contact damage. Consequently gratings are not provided with contact-protecting coatings.

GRATING COSMETICS AND PERFORMANCE

Warnings against touching the grating surface notwithstanding, damage to the surface occasionally occurs. Contact from handling, mounting or packaging can leave permanent visible marks on the grating surface. Moreover, some gratings have cosmetic defects that do not adversely impair the optical performance, or perhaps represent the best available quality for a grating with a particular set of specifications. For example, some gratings have 'worm tracks' due to mechanical ruling of the master grating from which the replicated grating was taken, others have coating defects like spit or spatter, and others have 'pinholes' (tiny voids in the reflective coating), &c. The many possible classifications of surface defects and the many opportunities to render the surface permanently damaged conspire

* Since the RSS SR grating is in transmission, the top surface is the epoxy. There is no overlying reflective surface.

to make the surfaces of many gratings look less than cosmetically perfect.

While this damage may be apparent upon looking that the grating, it is not straightforward to determine the effect this damage has on the performance of the grating. Often the area affected by damage or contamination is a small fraction of the total area of the grating. Therefore, only a small portion of the total number of grooves under illumination may be damaged, displaced or contaminated. A damaged or contaminated region on the surface of a grating may have little, if any, noticeable effect on the performance of the optical system because, a diffraction grating is usually used as an integrating optic (meaning that all light of a given wavelength diffracted from the grating surface is brought to focus in the spectral order of interest). In contrast, a lens or mirror that does not focus (say, an eyeglass lens or a bathroom mirror) will show a distortion in its image corresponding to the damaged region of the optic. This familiar experience – the annoying effect of a chip on an eyeglass lens or a smudge on a bathroom mirror – has led many to assume that a similar defect on the surface of a grating will lead to a similar deficiency in performance. The most appropriate performance test of a grating with surface damage or cosmetic defects is not visual inspection but instead to use the grating in its optical system and determine whether the entire system meets its specifications.

Damage to a region of grooves, or their displacement, will theoretically have some effect on the efficiency of the light diffracted from that region, as well as the total resolving power of the grating, but in practice such effects are generally not noticeable. Of more concern, since it may be measurable, is the effect surface damage may have on light scattered from the grating, which may decrease the signal-to-noise (SNR) of the optical system. Most forms of surface damage can be thought of as creating scattering centers where light that should be diffracted (according to the grating equation) is scattered into other directions instead.

UNDOING DAMAGE TO THE GRATING SURFACE

Damage to the microscopic groove profile is, unfortunately, irreversible; the epoxy layer, like molding clay, will retain a permanent imprint. Contamination of the grating surface with finger oils, moisture, vacuum pump oil, &c is also often permanent, particularly if the contaminated grating surface has been irradiated. If you have a damaged or contaminated grating, call the manufacturer to ask for advice, or to have us clean and inspect your grating.

Sometimes surface contamination can be removed partially, and once in a while completely, using a mild unscented dishwashing liquid. Care should be taken not to apply any pressure (even gentle scrubbing) to the grating surface. If contaminants remain, try using spectroscopic-grade solvents; the purity of such solvents should be ascertained before use, and only the purest form available used. The use of carbon dioxide (CO_2) snow, which reaches the grating surface in a sublimed state and evaporates, carrying with it the contaminants, has also been used with some success. The key to cleaning a grating surface is to provide no friction (e.g., scrubbing) that might damage the delicate groove structure.

GUIDELINES FOR HANDLING GRATINGS

- *Never touch the grooved surface of a diffraction grating.* Handle a grating by holding it by its edges. If possible, use powder free gloves while handling gratings.
- *Never allow any mount or cover to come in contact with the grooved surface of a diffraction grating.* A grating that will be shipped should have its surface protected with a specially-designed cover that does not touch the surface itself. Gratings that are not in use, either in the laboratory or on the manufacturing floor, should be kept in a closed box when not covered. Keep any oils that may be used to lubricate grating mount adjustments away from the front surface of the grating.
- *Do not talk or breathe over the grooved surface of a diffraction grating.* Wear a nose and face mask when it is required that you talk over the surface of a grating. Breath spray is particularly bad for reflection gratings, so one should not speak directly over the surface; instead, either turn away or cover the mouth (with the hand or a surgical mask).

FOR FURTHER INFORMATION

For additional information, please contact us.

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