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# **Direct Simulation Monte Carlo Prediction Of On-Orbit Contaminant Deposit Levels For HALOE**

Michael S. Woronowicz  
*ViGYAN, Inc., Hampton, Virginia*

Didier F. G. Rault  
*Langley Research Center, Hampton, Virginia*

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### **ABSTRACT**

A three-dimensional version of the direct simulation Monte Carlo method is adapted to assess the contamination environment surrounding a highly detailed model of the Upper Atmosphere Research Satellite. Emphasis is placed on simulating a realistic, worst-case set of flowfield and surface conditions and geometric orientations for the satellite in order to estimate an upper limit for the cumulative level of volatile organic molecular deposits at the aperture of the Halogen Occultation Experiment (HALOE). Results pertaining to satellite environment are presented regarding contaminant cloud structure, cloud composition, and statistics of simulated molecules impinging on the HALOE aperture, along with data related to code performance. Using procedures developed in standard contamination analyses, along with many worst-case assumptions, the cumulative upper-limit level of volatile organic deposits on the HALOE aperture over the instrument's 35-month nominal data collection period is estimated at about 13,350Å.

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**NOMENCLATURE**

|                 |                                          |
|-----------------|------------------------------------------|
| CCM             | Coarse Cartesian Mesh                    |
| CLAES           | Cryogenic Limb Array Etalon Spectrometer |
| $CO_2$          | carbon dioxide                           |
| DSMC            | direct simulation Monte Carlo            |
| FCM             | Fine Cartesian Mesh                      |
| $FNUM$          | ratio of real to simulated molecules     |
| $GMW$           | gram molecular weight                    |
| HALOE           | Halogen Occultation Experiment           |
| HGA             | High Gain Antenna                        |
| IM              | Instrument Module                        |
| LDEF            | Long Duration Exposure Facility          |
| MLI             | Multi-Layered Insulation                 |
| MMS             | Multi-mission Modular Spacecraft         |
| $Ne$            | neon                                     |
| NEPS            | Nadir Energetic Particle Spectrometer    |
| $O$             | monatomic oxygen                         |
| SP              | Solar Panel                              |
| SI              | International System of metric units     |
| SSPP            | Solar/Stellar Positioning Platform       |
| $SWF$           | species weighting factor                 |
| $T$             | absolute temperature [ $K$ ]             |
| UARS            | Upper Atmosphere Research Satellite      |
| $V_x, V_y, V_z$ | directed velocities                      |
| $X, Y, Z$       | coordinate directions                    |
| ZEPS            | Zenith Energetic Particle Spectrometer   |
| $l$             | length scale [ $\text{\AA}$ ]            |
| $n$             | number density [ $m^{-3}$ ]              |
| $t$             | relative temperature [ $^{\circ}C$ ]     |
| $\Delta t$      | time increment [ $sec$ ]                 |
| $\Omega$        | solid angle [steradians]                 |
| $\alpha$        | HALOE azimuth angle                      |

|              |                                                          |
|--------------|----------------------------------------------------------|
| $\beta$      | angle describing UARS-Sun relationship                   |
| $\theta$     | HALOE elevation angle                                    |
| $\tau$       | period [ <i>min</i> ]                                    |
| $\dot{\phi}$ | mass flux rate [ <i>gm/cm<sup>2</sup>/sec</i> ]          |
| $\omega$     | exponent in power-law viscosity-temperature relationship |

**Subscripts:**

|          |                        |
|----------|------------------------|
| $j$      | species index          |
| $s$      | satellite condition    |
| $ss$     | steady state condition |
| $\infty$ | freestream condition   |

## 1.0 INTRODUCTION

The Upper Atmosphere Research Satellite (UARS) was designed to collect data on various aspects of Earth's upper atmosphere to help characterize global atmospheric changes that are thought to be occurring. Figure 1 depicts the UARS model used in this investigation. One instrument carried on board the currently-operational satellite is the NASA Langley Halogen Occultation Experiment (HALOE). During each sunrise and sunset experienced by the satellite, the HALOE instrument peers at the Sun through the atmosphere and measures solar infrared energy absorption over a range of wavelengths. With this information, vertical distributions for concentrations of trace gases such as  $HF$ ,  $HCl$ , and  $O_3$  are deduced.<sup>1</sup>

In order to obtain precise measurements, HALOE optical surfaces must be kept extremely clean. Experience shows that even minute amounts of contamination can seriously degrade the spectral transmissivity and reflectivity of optical surfaces.<sup>2</sup> Although atmospheric density is extremely low at the satellite orbit altitude of 600 km, there are many potential sources of contamination contained on board UARS itself, ranging from light gases to heavy, long-chain polymers. Volatiles outgassed from certain materials used in satellite construction, gases vented from the interior of the satellite and cryogenically-cooled experiments, and effluents exhausted from attitude thrusters, all contribute to a gas cloud that envelops the vehicle.

Previous analyses have indicated that the cumulative level of deposits on critical HALOE optical surfaces over its nominal 35 months of operation could exceed maximum acceptable levels by over an order of magnitude.<sup>3</sup> While UARS instrument managers specified a goal of no more than 100 Å of cumulative deposits at the HALOE aperture, analyses predicted for its original set of orientations that it would receive about 32,170 Å.<sup>3</sup> A recommended change adopted in stowing positions for HALOE reduced that estimate to about 6188 Å.<sup>3</sup> These analyses utilized SPACE2<sup>4</sup> and MOLFLUX,<sup>5</sup> which are standard engineering codes developed for estimating fluxes on target surfaces due to outgassing. These codes either assume no inter-molecular collisions within the gas cloud or employ first-collision theory.

Because of the important effect of contamination on the success of the HALOE data collection effort, detailed characteristics of the gas cloud in the vicinity of the HALOE aperture are needed to accurately estimate incident contaminant fluxes and to help define criteria for optimal operation of the instrument. In order to facilitate this goal, a study of the contamination environment surrounding UARS was performed using the direct simulation Monte Carlo (DSMC) technique.<sup>6,7</sup>

This report describes details of the investigation, emphasizing methods used and assessment of input data and assumptions. First, a discussion of issues important to satellite contamination is presented, followed by a general description of the DSMC method and preprocessors specifically developed to handle various necessary input conditions and geometric orientations required for the investigation. This discussion is then followed

by a description of specific data pertinent to contamination of the HALOE instrument on board UARS. Results include simulated flowfield species number density maps describing the overall gaseous environment surrounding UARS, and statistical details regarding the fluxes intercepted at the HALOE aperture. Also, results regarding predictions of cumulative contaminant deposit levels are presented and interpreted, and code performance statistics are mentioned.

## **2.0 CONTAMINATION ISSUES**

Satellites tend to surround themselves with their own artificial atmosphere through surface outgassing, equipment venting, and attitude thruster firing. This artificial atmosphere typically has very low density, and its overall distribution is usually anisotropic and non-Maxwellian. It is composed of species having a wide range of molecular weights, including massive, long-chain, volatile organic compounds, and is characterized by a wide range of concentrations, with some important species present only at trace levels.

The molecular flux of contaminants incident on a spacecraft surface has traditionally been subdivided into two categories: direct and return flux. Freestream or outgassing molecules directly impinging on a critical target surface that may have encountered prior collisions with other surfaces, but no intermolecular collisions with other gas species, belong to the direct flux. Outgassing molecules having undergone intermolecular collisions before reaching the target surface belong to the return flux. Direct flux computation is relatively straightforward for diffuse surfaces (geometric viewfactors or particle tracing), but return flux computation, which requires an integrated knowledge about the contaminant cloud structure and collision physics, is intrinsically more complex. It also requires that a relatively large computational domain surround the satellite to ensure that the simulation satisfactorily accounts for virtually all molecules which can return to the vehicle surface, regardless of how far they ventured away from the satellite before being scattered back.

The physics involved in contamination processes, such as surface desorption, reflection, absorption, adsorption, etc. are very complex. The experimental database is presently insufficient to devise accurate models to simulate mechanisms such as surface outgassing (flux magnitude as a function of surface temperature and material composition, emitted angular velocity distribution, and species composition), surface deposition and polymerization (effects of ultraviolet radiation, atmospheric monatomic oxygen flux, and surface material), and surface reflection (momentum and energy accommodation, reflected angular velocity distribution). Reliable estimates of the contamination environment surrounding future spacecraft will therefore require improving the present state of knowledge. The molecule-based DSMC algorithm is readily amenable to incorporate new physical models as these become available. DSMC could therefore be used to evaluate these models and foster new research in this field.

### **3.0 NUMERICAL TOOLS**

In this section, the method used to investigate HALOE on-orbit instrument contamination is presented, along with preprocessing routines developed to assimilate data concerning geometric configurations and outgassing required to provide detailed simulations. First, a general description of the DSMC method is presented, followed by a brief presentation describing the various preprocessing routines used, many of which have been specifically developed to handle outgassing emission data.

#### **3.1 DSMC METHOD**

The direct simulation Monte Carlo method has been steadily gaining acceptance as an approach to solving problems related to fluid dynamics when the effects of rarefaction become important and the gaseous medium no longer behaves as a continuum.<sup>8</sup> In contrast to the approach of Computational Fluid Dynamics (CFD), where the gas is treated as a continuum mathematical fluid, macroscopic flowfield properties are calculated based on the interactions of many thousands or millions of particles that behave as molecules at the microscopic level.<sup>8</sup>

In the DSMC method, the simulated flowfield volume is discretized into a network of subcells, and the ensemble of particles constituting the gas is allowed to develop in time, where time is discretized into small increments over which the processes of molecular collisions and molecular motion are decoupled. The subcells are used to help identify nearest-neighbor prospective collision partners. The flowfield evolves in time from an initial, specified configuration, and once it reaches steady state, cumulative statistics on the gas are kept by the computer for small numbers of subcells grouped together to form cells. By specifying the intermolecular potential governing the behavior of collisions between the simulated molecules, or "particles," and by using concepts of kinetic theory and statistical mechanics to sample the flowfield at the subcell or cell level, one can establish macroscopic flowfield characteristics.

Although the true intermolecular potential for most interactions are unknown, a number of simple models are available which give reasonably accurate macroscopic behavior. The potential commonly used in contemporary DSMC applications is the Variable Hard Sphere (VHS) model.<sup>8</sup> In this model, the hard-sphere assumption of uniform, isotropic scattering is retained, but collision cross-sections become proportional to the relative velocities between molecules.<sup>8</sup> The VHS model has been employed in this investigation.

The DSMC outgassing model has been widely used in other applications,<sup>9,10</sup> and is assumed to be valid in this investigation. It assumes that molecules of an outgassing species are emitted from specified surfaces at given rates, with velocities sampled from a drifting Maxwellian velocity distribution at a given temperature.

The DSMC code used in the present study was devised by Bird<sup>11</sup> and modified by Rault.<sup>6,7,12</sup> High com-

putational efficiency is achieved with this code through the use of an unstructured cell network overlaid on a cubic Cartesian subcell mesh. Two levels of subcells are employed in this particular code. A fine scale mesh (FCM) is used to resolve high flowfield gradients that often occur near windward-side surfaces, and a coarser mesh (CCM) is used farther away to conserve computational resources and to improve statistically-based calculations in regions where overall density levels are low. The individual subcells at the FCM level are referred to as "pixels." When available, comparisons between results generated with this code and experimental measurements regarding surface and flowfield properties for flows around a wide variety of vehicles have yielded excellent agreement.<sup>12,13</sup> The code has recently been optimized for vector architecture supercomputers, and has been complemented with a set of utilities for diagnosis, preprocessing, postprocessing, and grid adaptation.<sup>12</sup> Grid adaptation of the cell network with respect to certain variables can enhance resolution of flowfield phenomena as well as surface fluxes.

Special coding has been developed to collect information regarding particles striking the HALOE aperture. Such data include particle velocity, position where the aperture plane has been struck, species type, etc. In order to distinguish molecules belonging to the direct flux or the return flux, a parameter has been added to the run code to store the number of surface and intermolecular collisions each particle encounters prior to reaching the aperture. An additional parameter, storing information identifying the originating surfaces of these outgassed molecules, helps indicate which surfaces dominated the influence of volatile species fluxes at the aperture plane.

A novel additional capability featured in this simulation is the introduction of a parallel processing technique to separate the flowfield into two domains. This option allows higher resolution in the inner domain, combined with a larger outer domain for computing return flux, than would be possible if the resources of only a single computer were available. Implementation of this technique is discussed further in Section 4.2.

## **3.2 PREPROCESSOR ROUTINES**

### **3.2.1 Geometry Definition**

To define and input the inherently complex geometry of typical satellites, the interactive three-dimensional CAD preprocessor developed by Rault is used.<sup>6,7</sup> This preprocessing utility relies on the fact that even a very complex body geometry can be decomposed into a series of simple geometric primitives, such as spheres, cylinders, planes, etc. or portions thereof.<sup>6,7</sup> The current set of 16 basic primitives is presented in Table 1. UARS is modeled using 385 of these primitive subelements, and the resulting geometric model is displayed in Fig. 1. Also shown in the figure is the relative coordinate system used in this investigation, and details of the HALOE instrument in Figs. 1b-1d. As described in Ref. 6, properties of these subelements are entered

into the preprocessor code through an input file. Typical input data are presented in Table 2. After listing data associated with the overall configuration of the flowfield volume, a series of fields describe the type of each subelement, its dimensions, location, and orientation. Since the DSMC code assumes SI units, use of any other system requires conversion using the "scale" factor. In Table 2, lengths had been measured and entered in inches, requiring "scale" to be set to 0.0254.

Other entries displayed in Table 2 also require further explanation. Certain types of geometric elements can be completely described by quadratic functions. These elements are categorized under "quadrics," and are handled analytically by the DSMC code. Other planar surfaces, such as rings and disks, where limits cannot adequately be described by quadrics, are simply referred to as "planes," and are stored as a number of points with high resolution. This resolution must be higher than that used to discretize the surfaces for incorporation into the DSMC code for high fidelity.<sup>11,12</sup> In this study, these two groups encompassed all types of subelements used. In other studies, nonplanar surfaces of arbitrary complexity are defined in similar fashion to the rings and disks used here.<sup>12</sup>

Since subassemblies or components constituting the satellite are represented in the code by groups of geometric subelements, these subelements may be linked by a common "component number." Defining a unique color to represent each component number can be useful in geometry visualization to highlight or otherwise distinguish individual components. References to "limit planes" in Table 2 pertain to the fact that these surfaces are discretized within the DSMC framework and replaced by small cubes.<sup>11</sup> Along certain edges where surfaces should intersect, small gaps may occur as a result of the discretization process. This problem occurs most frequently where surfaces intersect at oblique angles. Since the flowfield cell network is built up in layers from surfaces, these gaps will allow the interior to be filled with flowfield cells, which consumes computational resources and may lead to confusing errors.<sup>12</sup> Limit plane displacement lengthens or widens the original subelement to eliminate those gaps. Finally, the entry fields identified as "F3I limits" refer to a subordinate volume contained within the flowfield where the particular subelement lies. This information is used to speed up the discretization process by telling the code to check for a particular surface only within that subvolume instead of searching the entire flowfield.

Dimensions and locations for various facets of the UARS satellite have been obtained from engineering drawings provided by HALOE instrument managers, and a complete listing of the data entered for the baseline geometric representation is presented in Table 3. Code has been developed to alter subassemblies of the geometric UARS model by taking the baseline geometry file listed in Table 3, and rotating the required subelements about a given axis at a given point. The input files for cases studied are displayed in Table 4, and the output resembles Table 3, except that values for the affected subelements have been duly altered.

### **3.2.2 Outgassing Inputs**

Code has been developed to process information pertaining to individual outgassing surfaces for incorporation into the general DSMC run code. These input files include subelement-level information pertaining to the outgassing flux at a given reference temperature, and the molar composition of the outgassing flux. Table 5 is an example of typical outgassing information, and Table 6 is a reproduction of the input file for outgassing information used in this investigation. The values listed before each outgassing rate are species mole fractions for each of the six species modeled.

The preprocessor code contains enough flexibility to process information on whether or not an individual subelement is composed of several regions outgassing different species at different rates. This capability has been used to create vent sources on certain surfaces of the Instrument Module (IM) by superimposing vent locations, flux rates, and gas constituents on existing larger elements. An example is illustrated in the data fields associated with the first geometric element in Table 6. Since outgassing rates are strongly dependent on surface temperature, additional coding has been developed to assign a unique value to each satellite surface. A listing of subelement-level temperatures in °C is presented in Table 7.

### **3.2.3 Vent Plume Modeling**

In addition to outgassing information, a preprocessing routine for handling jet-like vent plumes from sonic orifices has been developed. Whereas effluents outgassed from surfaces and exiting most vents diffuse into the flowfield with modeled velocity distributions resembling drifting Maxwellian distributions at  $T_{\text{surface}}$ , "jet" sources represent relatively high mass flux rates exiting small orifices as choked, uniform flow at a supplied exit temperature  $T_{\text{exit}}$ . The data necessary to recreate such sources are shown in Table 8.

### **3.2.4 Global Resolution**

Finally, Table 9 lists inputs used by the DSMC code in order to initialize the overall simulation. Some of the input variables are simply switches used to tailor the code to the problem at hand with respect to where high grid resolution is needed, sizing maximum lengths for Fortran arrays, information required for setting reasonable estimates for DSMC simulation parameters, flow direction with respect to the body, and the like.<sup>12</sup>

## **4.0 APPLICATION TO UARS/HALOE CONTAMINATION**

### **4.1 UARS/HALOE DESCRIPTION**

UARS was placed in orbit in September 1991 to probe Earth's upper atmosphere and characterize global atmospheric changes which are thought to be taking place. It operates at a roughly circular 600km altitude orbit with a 96-minute period ( $\tau$ ). Depicted in Fig. 1, UARS is about 10.3m long, 5.9m high, 3.2m wide, and its solar panel (SP) measures 13.3m by 3.3m.

Several instruments have been mounted on the Instrument Module (IM), including HALOE, (an occultation viewing radiometer that requires part per million signal precision and characterization<sup>1</sup>), the Cryogenic Limb Array Etalon Spectrometer (CLAES), and the Nadir and Zenith Energetic Particle Spectrometers (NEPS and ZEPS). The High Gain Antenna (HGA) receives signals from UARS mission controllers, and the Solar/Stellar Positioning Platform (SSPP) assists in navigating the satellite. The Multi-mission Modular Spacecraft (MMS) is used to periodically boost or maneuver the satellite in accordance with mission guidelines.

UARS is designed to always keep the side with HALOE and the SP facing the Sun when it is over the horizon, but HALOE only takes measurements during sunrise and sunset, which occur once every period. At other times, whether the Sun is above or below the horizon, HALOE is stowed facing away from the freestream direction and the bulk of the satellite. Even though HALOE's stowed position has been chosen to minimize contamination from surface outgassing, it will periodically have substantial viewfactors from the continuously-rotating solar panel.

### **4.2 PARALLEL CODE SCHEME**

As described in Section 3.1, the flowfield has been separated into two domains in order to increase grid resolution near the satellite and to create a large outer domain for computing return flux. Figure 2 shows a schematic representation of the computing arrangement. A different processor computes the solution in each domain independently, and Parallel Virtual Machine software from Oak Ridge National Laboratories has been implemented to allow the processors to communicate data between one another.<sup>14</sup>

The potential utility of this parallel routine software has been demonstrated even though an outer domain was not considered necessary for the scope of this particular investigation. Although the effect of return flux on HALOE is deemed insignificant, this feature could be useful in other contamination studies (at lower altitudes, for instance), where the far-field effect could play a more significant role. In this investigation, the inner domain takes on the shape of a right parallelepiped with dimensions slightly larger than the maximum

dimensions of UARS, and the outer domain is a cube. During a given timestep  $\Delta t$ , particles reaching or passing through the interface boundary separating the domains are moved to the boundary, and information required by the other processor for these entering particles is stored in a buffer. Data include particle position and velocity information, remaining fraction of  $\Delta t$ , individual species codes, and individual tag parameters. The buffer file is transmitted as a message to the other processor once each timestep.

It is reasoned advantageous to size the domains using the following equation:

$$\frac{FNUM_i}{FNUM_o} = \frac{\Delta t_i}{\Delta t_o} = \frac{V_i}{V_o} \propto \left(\frac{l_i}{l_o}\right)^3. \quad (1)$$

Concentrating on the first equality in Eq. (1), the need to clone or remove particles at the interfaces to ensure correct transmitted species flux levels is obviated. The second equality is an attempt to achieve roughly equal numbers of particles in each domain, a desirable feature which could result in roughly equal processor loadings under certain circumstances. One compromise inherent in Eq. (1) requires finding suitable timesteps for the different domains, such that when adequate temporal resolution in the inner domain is obtained, particles do not travel too quickly through the outer domain. Of course, shorter timesteps translate into longer run times.

#### **4.3 SPECIES WEIGHTING FACTORS**

Due to the large variation in species concentrations within a contaminant cloud, "species weighting factors" (*SWF*) have been implemented to artificially enhance minor species concentrations. Important species, such as the organic volatiles most likely to deposit and remain on critical surfaces, are usually present in trace amounts, and statistical sample sizes concerning these molecules would therefore be inadequate without the use of these weighting factors. The DSMC code has been modified by artificially increasing the outgassing flux of trace species by a species weighting factor, which in effect enables one to specify species-dependent values of *FNUM* to obtain reasonable numbers of each representative simulated species within the flowfield for better statistical property measurement. The only aspects of the simulation affected by this artifice are collision rates and quantities associated with flowfield sampling. These aspects may be accounted for by reducing bimolecular collision probabilities and cumulative species sampling summations by the same factors within the code.

The conditions under which *SWF*'s may be applied should be considered carefully, since mean free path lengths of trace species may be artificially increased when intermolecular collisions become important. Such an approximation is not considered a problem for the simulated UARS/HALOE environment.

## **5.0 COMPUTATIONAL CONDITIONS**

This section describes details concerning the application of the tools mentioned above to the analysis of the UARS/HALOE contamination environment. First is a description of the geometric configurations that were considered to provide realistic worst-case estimates for deposits at the HALOE aperture, followed by assumed freestream and outgassing conditions.

### **5.1 GEOMETRIC CONSIDERATIONS**

#### **5.1.1 Configurations**

For the set of assumptions associated with this approach, a realistic, conservative estimate for the cumulative level of contaminants deposited at the HALOE aperture must recognize that certain instruments rotate with respect to the rest of UARS over time. The solar panel (SP) continuously tracks the Sun, and the Solar/Stellar Positioning Platform (SSPP) undergoes limited movement as it alternately tracks the Sun and certain stars. HALOE faces the Sun during sunrise and sunset every 96-minute orbital period. Otherwise, it is stowed facing away from the freestream direction with severely restricted views of the rest of the satellite.<sup>3</sup> Three different configurations have been chosen, representing a realistic worst case set of orientations. Two of these represent the beginning and end of the HALOE data collection period considered most deleterious with respect to contamination, and one represents the instrument in its stowed position after this data collection period.

Since the direct flux of outgassed molecules intercepted by a target surface is strongly dependent on the solid angle  $\Omega$  subtended by the originating surfaces within the target's line of sight (viewfactor), cases have been chosen where HALOE collects data facing the  $-X$ -direction (toward the Multi-mission Modular Spacecraft (MMS)). In this orientation, viewfactors subtended by the SP and the bulk of the satellite are maximized. In addition, since both the SP and HALOE track the Sun during HALOE data collection periods, the SP presents a large frontal area to the oncoming freestream, which could potentially contribute to increased overall number flux levels at the HALOE aperture. Movement of the SSPP has been ignored.

The angle between the HALOE aperture normal and the UARS body axis during data collection periods is equal to  $\beta$ , the angle between the Earth-Sun line and the plane of the satellite orbit.<sup>3</sup> Angle  $\beta$  also plays a role in outgassing, since satellite surface temperatures are directly proportional to local surface inclination with respect to the Sun. For this particular orbit ( $0^\circ \leq \beta \leq 80^\circ$ ), temperatures of influential surfaces are generally maximized when  $\beta = 80^\circ$ . One important exception is that trends for the SP surface temperatures run counter to the other objects. Due to the glancing angle it makes with the Sun at  $\beta = 80^\circ$ , SP surface

temperatures, and hence its outgassing rates, are minimized there. Conversely, SP surface temperatures are maximized when  $\beta = 0^\circ$ . The large SP surface area and its orientation with respect to HALOE make it a formidable influence on the latter's contamination environment. Another influential factor is that although the temperatures of the many influential outgassing surfaces are minimized at  $\beta = 0^\circ$ , their viewfactors are maximized with respect to HALOE for this orientation.

The three sets of geometric orientations studied in this investigation are listed below in expected descending order of severity. Angle  $\alpha$  represents azimuth angle with respect to the UARS  $X$  axis, and  $\theta$  represents elevation. Case 1 assumed  $\alpha = -180^\circ$  and  $\theta = 6^\circ$  (end of sunrise data collection period); Case 2 assumed  $\alpha = -180^\circ$  and  $\theta = -23.6^\circ$  (beginning of sunrise data collection period); and Case 3 assumed  $\alpha = 45^\circ$  and  $\theta = -25^\circ$  (stow position immediately prior to  $\beta = 0^\circ$  sunset data collection period). Views of the geometric configurations for these cases are depicted in Fig. 1. Note that the SP location in Fig. 1c lies behind the HALOE aperture plane. The visual absence of that large, relatively high-temperature, outgassing object nearby should have a significant impact on the Case 2 contamination environment.

During each orbit at  $\beta = 0^\circ$ , HALOE collects data for a maximum total of 15 minutes (7.5 min. during each sunrise and sunset), and is stowed during the remainder of that period. Assuming that only the volatile species accumulate on critical optical surfaces, the average mass flux rate  $\bar{\phi}$  per orbit per species  $j$  may be estimated by

$$\bar{\phi}_{j,\text{sunrise}} = \frac{\dot{\phi}_j|_{\theta=6^\circ} + \dot{\phi}_j|_{\theta=-23.6^\circ}}{2}, \quad (2)$$

$$\begin{aligned} \bar{\phi}_{j,\text{orbit}} = & \left( \frac{\tau_{\text{sunrise}}}{\tau_{\text{orbit}}} \right) \bar{\phi}_{j,\text{sunrise}} + \left( \frac{\tau_{\text{sunset}}}{\tau_{\text{orbit}}} \right) \bar{\phi}_{j,\text{sunset}} \\ & + \left( \frac{\tau_{\text{stow}}}{\tau_{\text{orbit}}} \right) \dot{\phi}_{j,\text{stow}}. \end{aligned} \quad (3)$$

In Eq. (2), linear behavior of  $\dot{\phi}_j$  is assumed between the two cases, and in Eq. (3) for conservative estimates,  $\bar{\phi}_{j,\text{sunset}} = \bar{\phi}_{j,\text{sunrise}}$ , even though satellite IM-area viewfactors are lower for sunset viewing periods.

The probability that a contaminant molecule adheres to a critical surface is determined by its "sticking coefficient," a probabilistic parameter dependent on the combined effects of individual contaminant/surface material pairing, energy differences between contaminant molecules and the surface, and photopolymerization,<sup>15</sup> among other things. Multiplying Eq. (3) by the number of orbits in the 35-month nominal HALOE lifespan and the area of the HALOE aperture, an upper bound for the total mass accumulated for each species may be calculated, assuming a sticking coefficient of unity. Neglecting the effects of highly-reactive  $O$  atomic flux on removing these deposits, such an assumption may be valid during data collection periods due to photopolymerization of volatile compounds on optical surfaces, but may considerably overestimate the mass accumulated while HALOE is stowed facing away from the Sun. Assuming values for the mass and volume

associated with each species, one can make a crude estimate for the depth of deposits at the aperture for each species. The total thickness becomes the summation of the contributions from each species.

### **5.1.2 DSMC Resolution**

Figure 3 illustrates representative cross-sections of the inner domain cell network used for the present study after grid adaptation. Figure 3b shows the extent of the solar panel along with the rest of the vehicle. The body geometry is discretized and stored at the FCM level. Each element is characterized by a wetted surface area and a set of normal direction cosines. Figure 4 shows an XY-planar slice through the discretized geometry using a diagnosis utility developed for use with the DSMC code. In Fig. 4, pixels representing the surface are displayed along with outward direction cosines. Additionally, information on different levels of subcells surrounding the geometry can be represented. To simulate the UARS geometry, about 85,000 pixels have been used (pixel dimension  $\approx 5.0\text{cm}$ ), and the inner domain computational grid is composed of 35,000 cells. All outgassing and venting particles enter the flowfield from positions adjacent to the center of the pixel face closest to the outward normal of the outgassing pixel, about 0.2 percent the distance represented by a pixel length scale inside the flowfield volume. This has been done to eliminate position round-off error. These particles are given velocity components sampled from a drifting Maxwellian at the local outgassing surface temperature.

## **5.2 FREESTREAM PARAMETERS**

Assumed ambient conditions at the satellite operating altitude of 600km consisted of 100 percent atomic oxygen (O) at a nominal number density  $n_\infty$  of  $6 \times 10^{12}$  molecules/ $\text{m}^3$ .<sup>16</sup> At this altitude, the density may vary from this standard in either direction by roughly an order of magnitude due to solar activity. In addition, solar activity can cause appreciable helium concentrations to develop at this altitude. For conservative calculations, assuming 100 percent O maximizes its presence, and since O is highly corrosive to certain satellite materials, and may actually reduce the cumulative level of deposits on critical optical surfaces, instrument managers may be interested in its interactions with the satellite. Of course, ambient collision rates are affected by number density and species constituency,<sup>17</sup> however, using a single species to represent the freestream simplifies the simulation process, and it happens that UARS is operating in a period of low solar activity. These reasons may make the assumed level for  $n_\infty$  somewhat conservative. The assumed satellite orbital velocity  $V_\infty$  is 7500 m/sec.

### **5.3 OUTGASSING SPECIES, FLUX RATES, & TEMPERATURES**

#### **5.3.1 Outgassing Species**

In preliminary calculations,<sup>6</sup> two fictitious outgassing species were fabricated for demonstration purposes. One, with a gram molecular weight (*GMW*) of 200, was emitted from all outgassing surfaces. The other, with *GMW* = 100, was emitted only from the Instrument Module (IM) vent, located above the CLAES experiment.<sup>6</sup> The *GMW*'s are similar to those used in standard industry contamination codes, and are associated with heavy, volatile, organic compounds.<sup>5</sup>

Further investigation into likely types of outgassing materials covering UARS focused on four different items. These were: Mylar, used in the Multi-Layered Insulation (MLI) covering most of the satellite; Chemglaze Z306, a black paint covering portions of some instruments (as well as the interior of HALOE); S/13G/LO-V10, a white paint covering portions of some instruments as well as the back side of the SP; and adhesives possibly used to affix components to the front of the SP. A report investigating the types and mass fractions of volatile components outgassing from these materials at different temperatures identified compounds such as alkanes, alcohols, organic acids, and aldehydes.<sup>18</sup> Many components remained unidentified; however, taking the highest mass-fraction species identified for the materials listed above, a fictitious molecule with *GMW* close to each calculated average has been generated. Moreover, a fictitious species associated with venting from internally-carried components has been created. The *GMW* assumed for this material is 100, following standard contamination procedures.<sup>5</sup> Values describing each of these species and their outgassing rates are listed in Table 10.

Collision cross-sections for these species ratioed to that for monatomic oxygen have been assumed to scale with the 2/3 power of the associated mass ratio (see Table 10).<sup>17</sup> The mean viscosity-temperature power-law exponent  $\omega$  is assumed to be 0.75, a value associated with *O*, and no chemistry has been considered. This information is contained within the input gas species file used by the DSMC code, which is presented in Table 11. Due to lack of information, it is not clear how well the collision dynamics of heavy, long-chain, polyatomic organic molecules are modeled by these assumptions, but since temperatures are moderate and density levels are extremely low, collision rates are assumed to be negligible.

All surfaces reflected particles diffusely, although evidence suggests incomplete momentum and energy accommodation better represent certain surfaces exposed to the vacuum of space for extended periods.<sup>19</sup> Such behavior could affect the statistics of true fluxes encountered at the instrument aperture.

#### **5.3.2 Mass Flux Rates**

Measured mass flux rates associated with materials covering the instruments and subassemblies have been

obtained from Ref. 3, which lists data taken from a month-long bakeout test performed at NASA Goddard Space Flight Center on the completed UARS satellite at 100 °C. In that report, rates were assumed for units lacking measured data. It was noted that the rate associated with MLI covering the satellite bus varied from a high initial level to a lower, constant level by the end of the test. In this study the lower, constant value was assumed, since the HALOE aperture remained closed for the first month in orbit as a precautionary measure against the initial, transient levels of MLI outgassing. Unfortunately, no information was given on the relative location of instruments measuring these rates with respect to the satellite, and some subassemblies feature surfaces sporting more than one type of covering. Since only one rate was listed per unit, such information had to be supplemented through judicious interpretation of photographs depicting various UARS subcomponents to determine what surfaces were covered with which material. These photographs were supplied by HALOE instrument managers and personnel at Goddard Space Flight Center. The mass flux rates for surfaces and coatings deduced from Ref. 3 are presented in Table 10.

In addition to outgassing surfaces, other gas-emitting sources have been modeled. The CLAES experiment is cryogenically cooled by gases contained in two separate reservoirs.<sup>20-22</sup> One reservoir contains *Ne*, the other *CO*<sub>2</sub>. After cooling the instrument, these gases are expelled through vents. The *CO*<sub>2</sub> vent is located at the exit of a 1 in-diameter tube intersecting the CLAES shield plate, with direction cosines for the exit plane normal as (-.49, .64, .59) in the *X*, *Y*, *Z* coordinate system indicated in Fig. 1. The *Ne* vent is located at the end of a short, 2 in-diameter tube at the +*Z*-most section of the CLAES smaller cylinder, directed downward. The flow from these vent exits is assumed to be choked at an estimated temperature of  $T_{\text{exit}} = 207\text{K}$ .<sup>22</sup> Mass flow rates for the *CO*<sub>2</sub> and *Ne* vents have been estimated at 3.65 and 8.39mg/sec, respectively. In this study, these sources have been modeled using the jet-like vent plume routines for sonic orifices mentioned above. Calculated outgassing rates for the CLAES vents are listed in Table 10.

Other vents, such as the IM vent, MLI blanket vents, and those associated with the MMS, released effluents at much lower flux rates, and have been modeled as regular surface-temperature dependent outgassing surfaces. Assumed *GMW*'s and outgassing rates associated with these vents are listed in Table 10.

### 5.3.3 Temperature Variation

Mass flux rates given in Ref. 3 for the bakeout test have been adjusted to reflect levels associated with realistic operating temperatures through use of the following empirical relationship, formulated to characterize generic mass flux behavior of polymeric materials on Skylab<sup>4,5</sup> (*t* in °C):

$$\frac{\dot{\phi}_j(t)}{\dot{\phi}_j(t = 100\text{ }^{\circ}\text{C})} = \exp\left(\frac{t - 100}{29}\right). \quad (4)$$

This formula has been used to adjust all volatile organic compound outgassing rates. Although actual material outgassing rates probably deviate from Eq. (4), this formula is the only one available for use in

this investigation. Surface temperatures associated with various components have been estimated using data contained within Ref. 3, with one exception. UARS instrument managers provided solar panel operating temperatures which were measured in orbit. For  $\beta = 0^\circ$ , SP temperatures oscillate on orbit between  $-60^\circ\text{C}$  and  $30^\circ\text{C}$ . The maximum SP temperature has been assumed for all cases, and values for other subassembly surfaces are listed in Table 7.

#### **5.3.4 Species Weighting Factors**

Upon commencement of the first DSMC computations, problems were encountered obtaining volatile fluxes at the HALOE aperture, because the outgassing rates associated with those species created flowfield number density levels orders of magnitude lower than those associated with the freestream and the CLAES vent species.<sup>7</sup> In a single timestep, about 3300 simulated monatomic oxygen molecules would enter the upstream boundary (area  $\cong 110\text{m}^2$ ), 30 simulated volatile, organic molecules of all types outgassed from the satellite (surface area  $\cong 230\text{m}^2$ ), and 200,000 particles exited the CLAES vents (total vent exit area  $= 2.5 \times 10^{-3}\text{m}^2$ ). The number flux of volatiles in the inner domain is therefore about two billionths of that for the CLAES vent species. Thus, by adjusting computational resources to adequately simulate the dominant  $\text{CO}_2$  and  $\text{Ne}$  environment, keeping the computational size of the simulation large enough to simulate  $\sim 10^6$  particles, the simulation would completely lose track of the volatile species whose development was the motivation for engaging in this investigation.

The solution adopted has been to implement the species weighting factors discussed in Section 4.3. First, a simulation was run without the contributions of the CLAES vents in order to assess the ratio of volatile, organic species number density levels to the freestream. Another simulation included CLAES vent contributions in order to determine those density levels relative to those from the freestream as well. With information on the relative species number density levels, simulated fluxes of the various species have been altered using arbitrary *SWF*'s in order to obtain roughly equal orders of magnitude for numbers of each simulated species in the computational volume. The weighting factors used for  $\text{O}$ ,  $\text{Ne}$ ,  $\text{CO}_2$ , and the volatile, organic species with  $\text{GMW} = 100, 150, \text{ and } 200$  are 40, 1, 1,  $10^3$ ,  $10^4$ , and  $5 \times 10^3$ , respectively.

#### **5.4 CODE SETUP**

The methodology adopted for this study is to initially run the code for each set of conditions in a free molecule (collisionless) mode. Due to the large size of the satellite and the low thermal velocity of the heavy outgassing molecules, the approach to steady state is slow ( $N_{ss} \cong 10^4 \Delta t$ , where  $\Delta t \approx 7\mu\text{sec}$ ). Figure 5 shows the number of particles in the inner and outer domains versus number of elapsed timesteps. Depending on

the type of problem being studied, the region where the curves flatten out may mark the onset of steady state. (While this rule-of-thumb may usually be adequate for measuring surface quantities, it is no panacea. For example, wakes behind bodies evolve over a long period of time without perceptible change in overall density levels.) Since exploratory calculations<sup>6,7</sup> demonstrated that the global level of collisions was very low, the simulation is initially run in free molecule mode to reach an approximate steady state more quickly than if intermolecular collisions were allowed. After grid adaptation, each adapted cell contains roughly the same number of molecules (about 10 for the inner domain), as shown in Fig. 6. The code is then run with intermolecular collisions until a new steady state is reached. Subsequently, molecules incident on the HALOE aperture are counted, sampled, and written to a data file.

For the inner domain, high spatial resolution is necessary, since UARS is very complex and quite large ( $\sim 10m$ ), and the HALOE aperture is only 22.9cm (9 in) in diameter. At the CCM level, the inner domain is composed of  $74 \times 46 \times 104$  equal subdivisions of 15.1cm on a side. Each FCM subcell consisted of pixels having lengths three times smaller than the CCM level, resulting in a surface resolution of 5.0cm. Since overall density levels are lower in the outer domain, the physical domain could be simulated with much coarser resolution. The outer domain is a cube measuring 21.2m on a side, composed of  $70 \times 70 \times 70$  subcells at the CCM level, with each FCM subcell having resolution equal to the CCM level.

## **6.0 RESULTS AND DISCUSSION**

The wealth of information obtainable within a DSMC simulation will clearly be demonstrated in this section, as surface flux information is obtained along with flowfield behavior within the three-dimensional solution volume. First species number density contour maps will be presented, describing concentration levels surrounding the satellite, followed by results characterizing the fluxes incident on the HALOE aperture. The latter includes statistics concerning prior collisions, velocity distribution functions, and mass flux rates associated with simulated molecules impinging upon the aperture. This last item is manipulated to obtain a cumulative contamination deposit level. Finally, this cumulative level is compared to that of Ref. 3, and some code performance measurements are presented.

### **6.1 SPECIES NUMBER DENSITY**

Figures 7-15 depict number density contour maps for each of the six gaseous species in the entire simulated flowfield surrounding UARS, ratioed to the freestream ambient number density,  $n_{O,\infty}$  using a  $\log_{10}$  scale. This information is presented in two planes that capture information concerning the majority of the flowfield physics in the three-dimensional volume. One plane runs longitudinally, parallel to the main body axis, while

the other runs normal to it and the freestream direction.

For the first set of figures concerning Case 1 (Figs. 7-12), a longitudinal solution plane has been chosen that runs through the vehicle coincident with its main body axis ( $X$ -axis), while the transverse solution plane coincides with the streamwise location of the center of the CLAES  $Ne$  vent in order to capture a cross-section of the plume emanating from it. These planes have been picked to present the overall physical environment. For the remainder of these number density maps, planes have been chosen that better reflect the environment in the vicinity of the HALOE instrument.

The black outline surrounding UARS denotes the boundary separating inner and outer domains. While contributions of each species are presented separately, they co-exist simultaneously within the simulation.

#### 6.1.1 Case 1

In Figs. 7a and 7b, contours for freestream species monatomic oxygen are presented for Case 1. In Fig. 7a, an expected buildup of  $O$  is observed on UARS windward side components. However, in initial DSMC calculations omitting the CLAES vents,<sup>6</sup> and in subsequent calculations prior to grid adaptation, when intermolecular collisions have been disallowed, the maximum density level peaked at about 25 times the freestream level on the cylindrical face of the MMS.<sup>6</sup> After grid adaptation and allowing intermolecular collisions to occur, the maximum density ratio there becomes roughly 50 times the freestream level. It seems apparent that this density level increase is due to interaction of the freestream with the gases emitted from the CLAES vents. Even though the global level of intermolecular collisions is low (about 130 collisions per timestep over 740,000 simulated molecules), the CLAES vent plumes create an effectively larger frontal area for UARS with respect to the freestream and scatter  $O$  out of the streamwise direction. An advantage of presenting these maps with a logarithmic scale is that the diminished levels of  $O$  in the wake of the vehicle are clearly evident. Figure 7b depicts the same set of contours viewed from the opposite side of the domain. The large, dark parallelogram jutting out from behind the transverse plane is the SP, canted  $6^\circ$  upward for this case.

In Figs. 8 and 9, number density contour maps are depicted for CLAES  $Ne$  and  $CO_2$  vent gases. In Fig. 8a, the plume developing from the  $Ne$  vent exit is clearly captured. In the transverse plane, one can observe a sizable amount of upward scattering although the vent is pointed directly downward. This is likely the result of diffuse surface scattering from surfaces of the CLAES experiment, due to its proximity to the  $Ne$  vent. Figure 8b reveals that very little of the  $Ne$  plume extends into the  $-Z$  regions. In Figs. 9a and 9b, the plume associated with the  $CO_2$  vent is also clearly defined, although its axis is directed at oblique angles to both the streamwise and transverse planes.

In Figs. 10-12, number density contour maps are presented for the outgassing species. In Figs. 10a and 10b,

the entire vehicle is surrounded by outgassing of species with  $GMW = 100$ . The streamwise plane contour map above UARS is dominated by outgassing from the IM vent (located just above CLAES on the  $+Z$  side of the satellite bus and angled  $45^\circ$  upward), although much of the concentration extending in front of the satellite is due to outgassing of adhesive material from the cell side of the SP (see Fig. 10b). The minor contribution to the flowfield from surfaces outgassing Chemglaze Z306 is shown in Figs. 11a and 11b ( $GMW = 150$ ). These clouds originate chiefly from surfaces located on NEPS and ZEPS, although the interior of HALOE outgasses this material through its aperture. In Figs. 12a and 12b,  $GMW = 200$  concentrations are presented. In the streamwise plane, the highest density levels are found near the HGA dish, although most of the outgassed material originates from the back side of the SP (Fig. 12b).

Results for this identical case are shown using two other planes that better depict the HALOE environment. The HALOE instrument is located in the center of each figure. In Fig. 13a, a buildup of  $O$  is clearly seen in front of HALOE and its mount. One also notices that the highest levels are found before the SP as it plows through the rarefied atmosphere. In Fig. 13b, even though the vast majority of  $Ne$  is directed downward on UARS' other side, there is a slight presence of that species in the vicinity of HALOE through a combination of surface and intermolecular collisions. As for  $CO_2$ , in comparing streamwise plane results for Fig. 13c with Fig. 9b, where the former is displaced approximately  $1m$  closer to HALOE than the latter in Fig. 9b, density levels for that species have abated by roughly an order of magnitude. No  $CO_2$  flux was detected at the HALOE aperture.

Comparing streamwise planes from Fig. 13d with Fig. 10b for the  $GMW = 100$  material, it becomes clear that the influence of the IM vent is greatly diminished over that  $1m$  separation distance, and the local flowfield is dominated by the influence of the SP. In Fig. 13e, the contribution of the  $GMW = 150$  material is globally quite minor, yet there is a relatively high concentration of it at the HALOE aperture, thanks to its own contribution. Finally, the concentrations of  $GMW = 200$  material at the aperture are shown in Fig. 13f to be about an order of magnitude higher than for the previous figure, which is a consequence of the high concentrations of this material from the back side of the solar panel and the  $-Z$  side of the Instrument Module.

### **6.1.2 Case 2**

Planes chosen to represent the Case 2 flowfield solution (Figs. 14a-14f) are identical to those depicted in the last subsection, emphasizing the HALOE environment. The number density contour maps for this case are similar to those presented in the preceeding two paragraphs. Besides the obvious repositioning of the SP and the HALOE instrument ( $-23^\circ$  inclination versus  $6^\circ$  above), the most striking difference is in the map for the  $GMW = 200$  material (Fig. 14f vs. Fig. 13f). The difference in SP inclination accounts for a dramatic

decrease of this material in the vicinity of HALOE.

### **6.1.3 Case 3**

The general features presented in Figs. 15a through 15f are similar to the other two cases. Although the SP front face and HALOE no longer face the freestream, the SP rear face now opposes it. In Fig. 15a, the solar panel still impedes the motion of freestream  $O$ , but the position of the transverse planar solution cut reveals the wake behind it. In Fig. 15b,  $Ne$  is still present around HALOE, but HALOE's orientation  $25^\circ$  away from the body axis toward  $-Z$  effectively shields its aperture from this gas. No  $Ne$  or  $CO_2$  was detected at the aperture for this case (Figs. 15b and 15c).

Because the SP is roughly aligned with the  $+X$  direction, the  $GMW = 100$  contour density map in Fig. 15d shows a striking difference from the analogous Case 1 solution depicted in Fig. 13d above, where it is roughly aligned in the opposite direction. There is a reversal of which portions of the flowfield are densely and sparsely populated with this material. Even though HALOE is stowed, its viewfactor of the SP approaches that for Case 1 ( $\Omega_{SP}|_{Case\ 3} = 0.412$  steradians versus  $\Omega_{SP}|_{Case\ 1} = 0.527$  steradians). It will be shown shortly that in this configuration, there is still a surprisingly significant level of contaminant flux at the instrument aperture, mostly due to the SP. Fig. 15e shows the contribution from  $GMW = 150$  material for this case, with local concentration maxima emanating from the HALOE aperture, NEPS, and ZEPS. Finally, in Fig. 15f, number density contours for the  $GMW = 200$  material are presented, where once again, a reversal in high and low concentrations of this material are evident compared to Case 1 results in Fig. 13f.

## **6.2 CAPTURED MOLECULES—PRIOR COLLISIONS**

There are a variety of statistics one can glean from simulated molecules striking the HALOE aperture. Two sets of information are presented in this section and the next. First, for each case, the history of each impinging simulated molecule is presented with respect to number of prior collisions it has suffered before reaching the aperture. Second, histograms are generated, representing the  $X$ ,  $Y$ , and  $Z$  velocity probability distribution functions (PDF) for these same particles.

### **6.2.1 Case 1**

In Figs. 16a-16c, plots are presented depicting the number of surface collisions prior to reaching the aperture for each species in each case. For Case 1, depicted in Fig. 16a, nearly 90 percent of  $O$  atoms reach the aperture directly from the freestream with no prior surface collisions. In contrast, all  $Ne$  atoms suffer at least two surface collisions before reaching this location. Outgassing molecules with  $GMW = 100$  and 150 tend to encounter multiple surfaces before arrival, while most  $GMW = 200$  material deposits directly from the back side of the SP and the  $-Z$  side of the IM.

### **6.2.2 Case 2**

In Fig. 16b, Case 2 collision history statistics for *O* are similar to those for Case 1. However, *Ne* atoms collected encountered at least five prior surface collisions before impinging on HALOE. This could be because the solar panel lies behind it in this run, and in its visual absence (zero viewfactor from the HALOE perspective), many other surfaces are required to facilitate the presence of neon. Again, outgassing molecules tend to encounter multiple reflections before arriving at the aperture, except for the  $GMW = 200$  material. This material tends to collect from direct viewing of the  $-Z$  side of the IM.

### **6.2.3 Case 3**

Figure 16c shows that no *O* atoms directly encounter the aperture; most reflect once off the SP instead. Also, due to HALOE instrument orientation, no *Ne* is detected at all.  $GMW = 100$  and 150 materials also tend to reflect once off the SP before impinging, but as in Case 1,  $GMW = 200$  material emitted from the back side of the SP tends to arrive directly.

These figures do not reveal all information pertinent to *O*, whose distributions contain a rather long tail of multiply-reflected particles. The highest number recorded is 114 prior surface collisions for Case 1.

## **6.3 CAPTURED MOLECULES-**

### **VELOCITY PROBABILITY DISTRIBUTION FUNCTIONS**

#### **6.3.1 Case 1**

Figure 17 depicts Case 1 histograms representing the *X*, *Y*, and *Z* PDF for particles striking the aperture. Only *Ne* contributes any return flux; all other species have been deposited as the result of direct flux. Beginning with the *X*, or streamwise direction in Fig. 17a, notice that  $PDF(V_x)$  for *O* is bimodal. One mode, a full Maxwellian distribution centered at  $V_x = V_s$ , represents molecules having suffered no previous surface collisions. The other mode, corresponding to a drifting Maxwellian distribution near  $V_x = 0$ , represents molecules having previously collided with the satellite at least once. Figure 17b shows PDF behavior for  $V_x$  near the origin for better detail. In this figure, the volatile outgassing species have a streamwise PDF corresponding to drifting Maxwellian distributions whose shapes differ from one another due to individual  $GMW$ 's. These distributions have been checked and compare favorably with theoretical calculations, but for clarity's sake the theoretical functions for  $PDF(V_x)$  have been omitted from the figure. However, the *Ne* distribution does not conform to any simple theoretical model because the majority of *Ne* samples had experienced intermolecular collisions. In Figs. 17c and 17d, probability density functions are presented for the *Y* and *Z*, or transverse, directions. The *O* distributions behave as expected, as they are dominated by contributions from the freestream mode, and compare quite well with theory. Due to the complicated

nature of the geometric setup, no comparisons between these histograms and theoretical PDF's have been attempted in these directions.

### **6.3.2 Case 2**

Figure 18 depicts Case 2 velocity PDF histograms. The  $X$  direction plot (Fig. 18a), generally appears similar to that for Case 1. However, the origin detail displayed in Fig. 18b shows that some portion of the flux has  $V_x < 0$ . Figs. 18c and 18d show that although  $O$  behaves as in Case 1, other species PDF's tend to be narrower and more peaked than in the previous case. This may be because overall viewfactors for HALOE are lower than Case 1, and impinging molecules come from a smaller, more select group of surfaces.

### **6.3.3 Case 3**

In Case 3, there is no contribution from directly-impinging, freestream  $O$  atoms, so the distinct, bell-shaped Maxwellian mode associated with that species for Figs. 17a and 18a is not present in Fig. 19a. Although the mass flux associated with  $O$  still dominates the HALOE aperture environment, it is nearly two orders of magnitude lower than for the first two cases. The contribution from  $GMW = 150$  molecules come entirely from the aperture itself, where emitted molecules reflect off the SP back towards HALOE. In Figs. 19b and 19c, most of the  $O$  flux has  $V_y < 0$  and  $V_z > 0$ , indicating that it is constituted mostly from simulated atoms scattered downward and toward UARS from the SP, since that is the only assembly occupying  $-Z$  space relative to HALOE.

## **6.4 MASS FLUX RATES**

Individual species mass flux rates impinging on the HALOE aperture are presented in Table 12. Accuracy of these results rests heavily on the reliability of values for surface outgassing flux rates at the bakeout temperature, the use of Eq. (4) to adjust those rates for surface temperature, and the relative orientation and proximity of HALOE to the contributing surfaces. The rate for  $O$  has been subdivided into those atoms coming directly from the freestream and those having suffered prior surface collisions. Since a substantial portion of impinging  $Ne$  is attributed to return flux, while the rest reaches HALOE through surface collisions alone, two entries have been listed for  $Ne$  as well. Notice that fluxes from the outgassing species are orders of magnitude less than the others. Without using  $SWF$ 's, much longer run times would be required to achieve a reasonable sample sizes—possibly by a factor of many thousand.

Tables 13a-13c relate the relative contributions of different surfaces to the mass flux rates presented in Table 12. The SP is the chief progenitor of the HALOE contamination environment for all three cases. This is because it apparently attains the highest temperatures of any surface expected on the satellite for  $\beta = 0^\circ$  (see Table 7), it is large, and it is located relatively near the HALOE aperture. The  $-Z$  side of the IM

(second largest contributor), also represents a large outgassing surface near HALOE, but its contributions are diminished because its outgassing rates are lower than those of the SP, and its surface normal does not oppose the HALOE aperture.

Flux rates for Case 2 are significantly less than Case 1 due to reduced viewfactors of the main contributing outgassing surfaces. Included in Tables 13a-13c are viewfactors ([solid angle  $\Omega$ ] = steradians out of  $2\pi$ ) of the SP and the  $-Z$  side of the IM experienced by the HALOE aperture. Ironically, Case 3 demonstrates that while a stowed HALOE instrument is exposed to very little direct flux from the bulk of UARS, it is sometimes prone to relatively high viewfactors of the continuously-rotating SP, periodically enhancing the pernicious contamination environment surrounding HALOE.

Also enhancing this environment is a contribution from the Chemglaze-painted surfaces within its interior, whose effluents are allowed to escape out through the aperture. Some of these molecules strike other surfaces and return to the HALOE aperture, and are counted along with the other contaminants.

## **6.5 CUMULATIVE DEPOSIT LEVELS**

Eqs. (2) and (3) may be used to estimate an upper-bound cumulative total level of deposits at the HALOE aperture. Assuming that only volatile, organic molecules accumulate (with a sticking coefficient of unity), and each occupies the space of a cube of length  $l$ , where  $l$  equals the particular species diameter listed in Table 10, a deposit depth of  $\approx 3550\text{\AA}$  is estimated. If standard contamination procedures are followed, and  $l = 10\text{\AA}$  is assumed regardless of species diameter,<sup>3</sup> that estimate increases to  $\approx 13,350\text{\AA}$ . If the contribution HALOE receives while stowed is disregarded (sticking coefficient of zero), these estimates fall to  $\approx 650\text{\AA}$  and  $\approx 2650\text{\AA}$ , respectively.

Tables 14 and 15 show the species-level contributions from each run to the final, averaged estimates quoted above. It is interesting to observe how *GMW* factors into the second estimate described, which is a standard procedure in the contamination community.<sup>3</sup> A greater number of lighter *GMW* species molecules are required for a mass flux equal to that of a heavier *GMW* species. Since the deposit depth of contaminant molecules only depends on the number that accumulate, it becomes important to accurately assess the *GMW*'s of the accumulated molecules. Also, the true sticking coefficient is not known, and can be much less than unity under certain conditions (small gas/surface temperature differences, absence of direct sunlight, etc.).<sup>15</sup> Finally, the effects of scrubbing from the high monatomic oxygen flux on reducing the level of accumulants is not clear.

The effect of this predicted cumulative buildup on instrument performance is not clear. At this time, UARS has been in orbit for over two years, and the instrument has shown negligible loss in performance.

HALOE instrument managers have provided figures quantifying performance degradation in terms of signal strength attenuation for different species concentration measurements over the first year of operation. Signal voltages obtained over the first two months of operation were used to compute a standard expected signal voltage strength per channel, with instrument temperature corrections. Subsequent voltage strengths were measured and compared to the standard. Figures 20a and 20b show signal loss correlations for *HF* and *HCl* channel measurements, respectively. For initial standard voltages of  $\approx 3.3$  volts and  $\approx 3.45$  volts, after one year's operation, *HF* and *HCl* signal strengths have apparently been attenuated by 0.02 volts and 0.004 volts, respectively. This level of voltage attenuation is indicative of measurements made for the other channels used by HALOE as well. This may suggest that the concentrations of contaminants in the vicinity of the HALOE instrument have been overestimated in this as well as in previous studies, or that the effects of contamination from the types of outgassing materials carried on board UARS are relatively benign. Perhaps better understanding of volatile *GMW*'s, outgassing rates, temperature dependence on outgassing rates, gas/surface sticking coefficients, the cleansing effects of atomic oxygen, and light attenuation and scattering due to outgassing contaminants will come from the current examination of samples carried aboard the Long Duration Exposure Facility (LDEF).<sup>23</sup>

## **6.6 COMPARISON WITH PREVIOUS ANALYSES**

It is difficult to make detailed comparisons with the results described in Ref. 3 for a number of reasons. First, in Ref. 3, the orientations of the SP and HALOE were decoupled. The SP cellside surface was pointed downward at HALOE, minimizing the distance between the two objects. Meanwhile, HALOE was allowed to assume various orientations associated with data collection periods as well as possible stow positions. In reality, HALOE would be stowed pointing away from the SP when its cell side faces downward. Second, the earlier contamination analyses<sup>3</sup> assumed a constant solar array surface temperature of 100 °C. This investigation benefitted from on-orbit data measured directly on the SP which indicate that  $\beta = 0^\circ$  surface temperatures are cyclic with each orbit over a range of -60 °C to 30 °C. For the 30 °C value used in this study, Eq. (4) predicts that the SP would outgas only 9 percent of the value expected at 100 °C. Third, the earlier analyses assumed only one outgassing species (*GMW* = 100) to relate cumulative depth to mass fluxes. Obscuring detailed comparisons further, the earlier analyses could not take into account the fact that after the Goddard bakeout test, MLI blankets covering the instrument module surface on the  $-Z$  side had themselves been covered with panels of S/13G/LO-V10 (which outgasses at mass flux rates one to two orders of magnitude higher than MLI—see Table 10). This had the impact of increasing assumed flux levels from those surfaces to HALOE. Finally, the geometry used in Ref. 3 was somewhat less detailed than in the

present study. Taking these differences into consideration, it seems that the results of this investigation tend to confirm those contained within Ref. 3 nevertheless.

### 6.7 CODE PERFORMANCE

The DSMC code is run simultaneously on two Sun SPARC 2 workstations with 64MBytes memory (RAM) each. Statistics concerning memory requirements, number of particles, weighting factor  $FNUM$ , timestep  $\Delta t$ , and overall computational volumes for the cases studied are listed in Table 16.

Regarding values for CPU time spent processing each region, it should be noted that  $FNUM$  and  $\Delta t$  could have been adjusted to create better load balancing between the inner and outer domain processors. This was not a major goal of the study, however.

Computational performance for simulations using particle methods is often measured in terms of average CPU time taken to process the state of an average particle per timestep. Using this metric, levels of approximately 29  $\mu\text{sec}/\text{particle}/\text{timestep}$  and 44  $\mu\text{sec}/\text{particle}/\text{timestep}$  have been obtained in the outer and inner domains, respectively, with the difference chiefly due to handling outgassing surfaces in the latter. This is a fairly exotic application for DSMC however, and it may be difficult to compare this performance estimate to other results in a straightforward, detailed manner.

### 7.0 CONCLUDING REMARKS

This report describes the development and application of a DSMC code to study contamination problems on satellites and estimate the effect of outgassing on sensitive instruments. Discussion is included on the development of a number of specially-developed preprocessor routines to incorporate detailed information regarding geometry, outgassing rates and temperature data, different types of outgassing sources, and the use of species weighting factors to enhance the statistical representation of important trace species. In estimating the amount of volatile organic molecular deposits collected at the HALOE aperture, special attention has been given to accurately account for outgassing species characteristics, surface temperatures, and geometric orientation of UARS subassemblies deemed critical to this endeavor. Using the best information available, and neglecting the scouring effects of monatomic oxygen, an upper bound on the cumulative contaminant deposition level at the HALOE aperture has been estimated at 13,350Å. If there is negligible tendency for volatile species to accumulate while HALOE is stored, this value falls to 2650Å. Notwithstanding consideration of important differences in geometric orientation, outgassing species weights and flux rates, and other specific influential input data, it appears that these results tend to confirm the earlier work described in Ref. 3.

Although the model for outgassing contained in DSMC has often been compared to other methods,<sup>9,10,24</sup> it could be instructive to make direct comparisons between results obtained using the DSMC method described in this report for a simple geometry over different ambient conditions with results from industry-standard codes and experimental data when they become available. Also, this study would benefit from better characterization of outgassing materials in terms of average molecular weights, mass flux rates, temperature dependence on mass flux rates, etc.

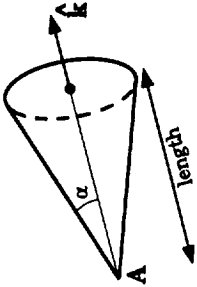
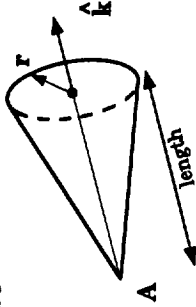
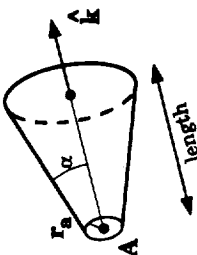
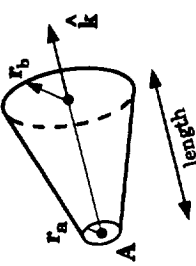
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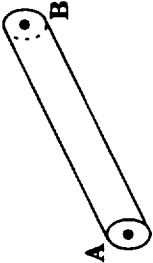
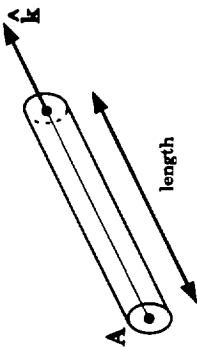
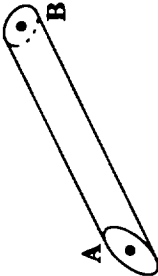
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Table 1: Library of Geometric Primitives (5 pgs.)

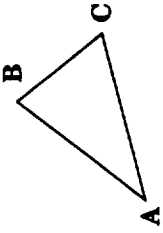
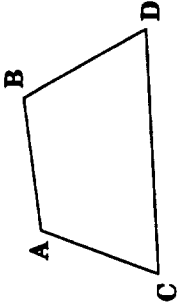
Geometry Definition for X Program:  
Cones

| Name  | Definition    | Variables                                                                            | Shape                                                                               |
|-------|---------------|--------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| ConeA | straight cone | half angle $\alpha$<br>apex <b>A</b><br>dir. cosine<br>length                        |    |
| ConeB | straight cone | apex <b>A</b><br>dir. cosine<br>length<br>exit radius                                |    |
| ConeC | frustum       | half angle $\alpha$<br>point <b>A</b><br>length<br>dir. cosine<br>radius at <b>A</b> |   |
| ConeD | frustum       | point <b>A</b><br>length<br>dir. cosine<br>radius at <b>A</b><br>radius at <b>B</b>  |  |

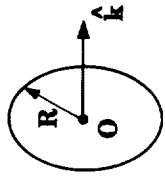
# Geometry Definition for X Program: Cylinders

| Name      | Definition        | Variables                                                      | Shape                                                                              |
|-----------|-------------------|----------------------------------------------------------------|------------------------------------------------------------------------------------|
| CylinderA | straight cylinder | point A<br>point B<br>radius                                   |   |
| CylinderB | straight cylinder | point A<br>radius<br>dir. cosine<br>length                     |   |
| CylinderC | skewed cylinder   | point A<br>point B<br>radius<br>dir. cosine A<br>dir. cosine B |  |

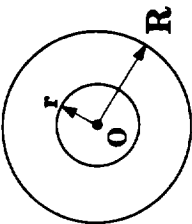
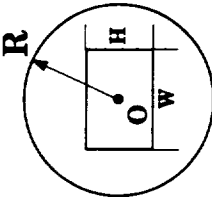
## Geometry Definition for X Program: Plates

| Name   | Definition                                             | Variables                                | Shape                                                                             |
|--------|--------------------------------------------------------|------------------------------------------|-----------------------------------------------------------------------------------|
| PlateA | triangular plate                                       | point A<br>point B<br>point C            |  |
| PlateB | four-sided plate<br>(note order of<br>successive pts.) | point A<br>point B<br>point C<br>point D |  |

## Disk

|      |               |                                        |                                                                                     |
|------|---------------|----------------------------------------|-------------------------------------------------------------------------------------|
| Disk | circular disk | centerpoint<br>dir. cosine<br>radius R |  |
|------|---------------|----------------------------------------|-------------------------------------------------------------------------------------|

# Geometry Definition for X Program: Rings

| Name  | Definition                                            | Variables                                                                                            | Shape                                                                              |
|-------|-------------------------------------------------------|------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
| RingA | concentric<br>circular ring                           | centerpoint<br>inner radius <b>r</b><br>outer radius <b>R</b><br>dir. cosine                         |   |
| RingB | circular ring<br>with centered<br>rectangular<br>hole | centerpoint<br>radius <b>R</b><br>dir. cosine<br>half height <b>H</b> / 2<br>half width <b>W</b> / 2 |  |

# Geometry Definition for X Program: Spheres

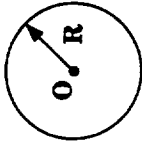
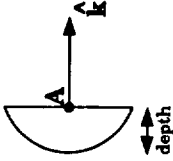
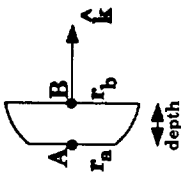
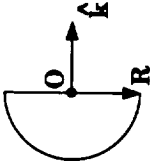
| Name    | Definition                                                         | Variables                                                                          | Shape                                                                               |
|---------|--------------------------------------------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| SphereA | complete sphere                                                    | centerpoint<br>radius <b>R</b>                                                     |    |
| SphereC | portion of sphere                                                  | point <b>A</b><br>depth<br>dir. cosine                                             |    |
| SphereD | spherical section<br>( <b>A</b> & <b>B</b> same side<br>as center) | point <b>A</b><br>depth<br>dir. cosine<br>radius at <b>A</b><br>radius at <b>B</b> |  |
| SphereE | hemispherical cap                                                  | centerpoint<br>dir. cosine<br>radius <b>R</b>                                      |  |

Table 2: Geometry Input Data Spreadsheet

| Data                         |      |       |      |       |     |  | Description                               |
|------------------------------|------|-------|------|-------|-----|--|-------------------------------------------|
| 27                           | 347  |       |      |       |     |  | no. of data planes, quadrics              |
| 0.0254                       |      |       |      |       |     |  | scale                                     |
| 100.                         | 1.   | -20.  |      |       |     |  | origin of axis                            |
| -80.                         | 327. | -100. | 110. | -515. | 90. |  | parallelepiped around body                |
| 100.                         | 1.   | -20.  |      |       |     |  | center of gravity                         |
| 10000.                       | 300. |       |      |       |     |  | reference area and length                 |
| 'Main block top plate ABCD1' |      |       |      |       |     |  | Quadric 1                                 |
| 1                            |      |       |      |       |     |  | component to which this quadric belongs   |
| PlateB                       |      |       |      |       |     |  |                                           |
| 1                            |      |       |      |       |     |  | flow is outward, inward, or on both sides |
| 3.                           | 48.1 | -42.5 |      |       |     |  | pointA                                    |
| 218.                         | 48.1 | -42.5 |      |       |     |  | pointB                                    |
| 3.                           | 48.1 | 2.1   |      |       |     |  | pointC                                    |
| 218.                         | 48.1 | 2.1   |      |       |     |  | pointD                                    |
| 100.                         | 50.  | -20.  |      |       |     |  | exterior point                            |
| 0.                           | 0.   | 0.    | 0.   |       |     |  | displacement of limit planes (in pixels)  |
|                              |      |       |      |       |     |  |                                           |
| . . . .                      |      |       |      |       |     |  |                                           |
| 'CLAES small cylinder'       |      |       |      |       |     |  | Quadric 15                                |
| 3                            |      |       |      |       |     |  | component to which this quadric belongs   |
| CylinderA                    |      |       |      |       |     |  |                                           |
| 1                            |      |       |      |       |     |  | flow is outward, inward, or on both sides |
| 64.5                         | 2.7  | 30.6  |      |       |     |  | pointA                                    |
| 97.1                         | 2.7  | 30.6  |      |       |     |  | pointB                                    |
| 20.0                         |      |       |      |       |     |  | radius                                    |
| 0.                           | 0.   |       |      |       |     |  | displacement of limit planes (in pixels)  |
| 0.                           | 65.  | -30.  | 30.  | 0.    | 60. |  | F3I limits                                |
| 'CLAES Ring'                 |      |       |      |       |     |  | Plane 1                                   |
| 3                            |      |       |      |       |     |  | component to which this quadric belongs   |
| RingA                        |      |       |      |       |     |  |                                           |
| 64.5                         | 2.7  | 30.6  |      |       |     |  | pointA                                    |
| 1.                           | 0.   | 0.    |      |       |     |  | direction cosine perpendicular to plane   |
| 20.0                         |      |       |      |       |     |  | radius A                                  |
| 25.9                         |      |       |      |       |     |  | radius B                                  |
| 'CLAES small cap'            |      |       |      |       |     |  | Quadric 16                                |
| 3                            |      |       |      |       |     |  | component to which this quadric belongs   |
| SphereE                      |      |       |      |       |     |  |                                           |
| 1                            |      |       |      |       |     |  | flow is outward, inward, or on both sides |
| 97.1                         | 2.7  | 30.6  |      |       |     |  | pointA                                    |
| -1.                          | 0.   | 0.    |      |       |     |  | direction cosine perpendicular to plane   |
| 20.0                         |      |       |      |       |     |  | radius                                    |
| 0.5                          |      |       |      |       |     |  | displacement of limit plane (in pixels)   |
| 64.                          | 118. | -20.  | 25.  | 0.    | 55. |  | F3I limits                                |



|                                |                                 |       |       |                            |                               |                 |    |                               |  |  |  |
|--------------------------------|---------------------------------|-------|-------|----------------------------|-------------------------------|-----------------|----|-------------------------------|--|--|--|
| 'CLAES big cap'                |                                 |       |       | 0.                         | 0.                            | 0.              | 0. | limit plane disp. (in pixels) |  |  |  |
| 3                              | Quadic 13                       |       |       | Quadic 19                  |                               |                 |    |                               |  |  |  |
| SphereE                        |                                 |       |       | Component no.              |                               |                 |    |                               |  |  |  |
| 1                              | flow on ext., int. or both      |       |       | flow on ext., int. or both |                               |                 |    |                               |  |  |  |
|                                | pointA                          | 30.0  | 2.7   | 30.6                       | pointA:                       | actual point C3 |    |                               |  |  |  |
|                                | dircos                          | 1.    | 0.    | 0.                         | pointB:                       | actual point D3 |    |                               |  |  |  |
|                                | radius                          | 25.9  |       |                            | pointC:                       | actual point E3 |    |                               |  |  |  |
| 0.5                            | limit plane disp. (in pixels)   |       |       |                            | pointD:                       | actual point F3 |    |                               |  |  |  |
| 0.                             | 30.0                            | -30.0 | 30.0  | 0.0                        | Exterior point                |                 |    |                               |  |  |  |
|                                | 60.0 F3I limits                 |       |       |                            | limit plane disp. (in pixels) |                 |    |                               |  |  |  |
| 'CLAES fat cylindrical part'   |                                 |       |       | Quadic 20                  |                               |                 |    |                               |  |  |  |
| 3                              | Quadic 14                       |       |       | Component no.              |                               |                 |    |                               |  |  |  |
| CylinderA                      |                                 |       |       | flow on ext., int. or both |                               |                 |    |                               |  |  |  |
| 1                              | flow on ext., int. or both      |       |       | pointA: actual point E3    |                               |                 |    |                               |  |  |  |
|                                | pointA                          | 30.0  | 2.7   | 30.6                       | pointB:                       | actual point F3 |    |                               |  |  |  |
|                                | pointB                          | 64.5  | 2.7   | 30.6                       | pointC:                       | actual point G3 |    |                               |  |  |  |
|                                | radius                          | 25.9  |       |                            | pointD:                       | actual point H3 |    |                               |  |  |  |
| 0.                             | 0.                              |       |       |                            | Exterior point                |                 |    |                               |  |  |  |
| 0.                             | 65.0                            | -30.0 | 30.0  | 0.0                        | limit plane disp. (in pixels) |                 |    |                               |  |  |  |
|                                | 60.0 F3I limits                 |       |       |                            | Quadic 21                     |                 |    |                               |  |  |  |
| 'CLAES small cylindrical part' |                                 |       |       | Component no.              |                               |                 |    |                               |  |  |  |
| 3                              | Quadic 15                       |       |       | flow on ext., int. or both |                               |                 |    |                               |  |  |  |
| CylinderA                      |                                 |       |       | pointA: actual point G3    |                               |                 |    |                               |  |  |  |
| 1                              | flow on ext., int. or both      |       |       | pointB: actual point H3    |                               |                 |    |                               |  |  |  |
|                                | pointA                          | 64.5  | 2.7   | 30.6                       | pointC:                       | actual point I3 |    |                               |  |  |  |
|                                | pointB                          | 97.1  | 2.7   | 30.6                       | pointD:                       | actual point J3 |    |                               |  |  |  |
|                                | radius                          | 20.0  |       |                            | Exterior point                |                 |    |                               |  |  |  |
| 0.                             | 0.                              |       |       |                            | limit plane disp. (in pixels) |                 |    |                               |  |  |  |
| 64.                            | 118.0                           | -20.0 | 30.0  | 0.                         | Quadic 22                     |                 |    |                               |  |  |  |
| 'CLAES Ring'                   |                                 |       |       | Component no.              |                               |                 |    |                               |  |  |  |
| 3                              | Plane 1                         |       |       | flow on ext., int. or both |                               |                 |    |                               |  |  |  |
| RingA                          |                                 |       |       | pointA: actual point G3    |                               |                 |    |                               |  |  |  |
| 1                              | flow on ext., int. or both      |       |       | pointB: actual point H3    |                               |                 |    |                               |  |  |  |
|                                | pointA                          | 64.5  | 2.7   | 30.6                       | pointC:                       | actual point I3 |    |                               |  |  |  |
|                                | direction cosine normal to disk | 1.    | 0.    | 0.                         | pointD:                       | actual point J3 |    |                               |  |  |  |
|                                | radius1                         | 20.0  |       |                            | Exterior point                |                 |    |                               |  |  |  |
|                                | radius2                         | 25.9  |       |                            | limit plane disp. (in pixels) |                 |    |                               |  |  |  |
| 'CLAES small cap'              |                                 |       |       | Quadic 23                  |                               |                 |    |                               |  |  |  |
| 3                              | Quadic 16                       |       |       | Component no.              |                               |                 |    |                               |  |  |  |
| SphereE                        |                                 |       |       | flow on ext., int. or both |                               |                 |    |                               |  |  |  |
| 1                              | flow on ext., int. or both      |       |       | pointA: actual point I3    |                               |                 |    |                               |  |  |  |
|                                | pointA                          | 97.1  | 2.7   | 30.6                       | pointB:                       | actual point J3 |    |                               |  |  |  |
|                                | dircos                          | -1.   | 0.    | 0.                         | pointC:                       | actual point K3 |    |                               |  |  |  |
|                                | radius                          | 20.0  |       |                            | pointD:                       | actual point L3 |    |                               |  |  |  |
| 0.5                            | limit plane disp. (in pixels)   |       |       |                            | Exterior point                |                 |    |                               |  |  |  |
| 64.                            | 118.0                           | -20.  | 25.0  | 0.                         | 55.                           | F3I limits      |    |                               |  |  |  |
| 'CLAES shield plate'           |                                 |       |       | Quadic 24                  |                               |                 |    |                               |  |  |  |
| 3                              | Quadic 17                       |       |       | Component no.              |                               |                 |    |                               |  |  |  |
| PlateB                         |                                 |       |       | flow on ext., int. or both |                               |                 |    |                               |  |  |  |
| 0                              | flow on ext., int. or both      |       |       | pointA: actual point K3    |                               |                 |    |                               |  |  |  |
|                                | pointA:                         | 7.8   | 33.1  | 2.1                        | pointB:                       | actual point L3 |    |                               |  |  |  |
|                                | pointB:                         | 127.8 | 33.1  | 2.1                        | pointC:                       | actual point M3 |    |                               |  |  |  |
|                                | pointD:                         | 7.8   | 33.1  | 37.0                       | pointD:                       | actual point N3 |    |                               |  |  |  |
|                                | pointC:                         | 127.8 | 33.1  | 37.0                       | Exterior point                |                 |    |                               |  |  |  |
|                                | Exterior point                  | 100.  | 50.   | -20.                       | limit plane disp. (in pixels) |                 |    |                               |  |  |  |
|                                | limit plane disp. (in pixels)   | 0.    | 0.    | 0.                         | Quadic 25                     |                 |    |                               |  |  |  |
| 'Battery package ABCD3'        |                                 |       |       | Component no.              |                               |                 |    |                               |  |  |  |
| 4                              | Quadic 18                       |       |       | flow on ext., int. or both |                               |                 |    |                               |  |  |  |
| PlateB                         |                                 |       |       | pointA: actual point M3    |                               |                 |    |                               |  |  |  |
| 1                              | flow on ext., int. or both      |       |       | pointB: actual point N3    |                               |                 |    |                               |  |  |  |
|                                | pointA:                         | -58.3 | -28.0 | 0.                         | pointC:                       | actual point O3 |    |                               |  |  |  |
|                                | pointB:                         | -3.   | -28.0 | 0.                         | pointD:                       | actual point P3 |    |                               |  |  |  |
|                                | pointC:                         | -58.3 | -39.2 | 21.5                       | Exterior point                |                 |    |                               |  |  |  |
|                                | pointD:                         | -3.   | -39.2 | 21.5                       | limit plane disp. (in pixels) |                 |    |                               |  |  |  |
|                                | Exterior point                  | -50.  | -45.  | 10.                        | Quadic 25                     |                 |    |                               |  |  |  |



|   |  |  |  |                               |                                   |               |       |                               |
|---|--|--|--|-------------------------------|-----------------------------------|---------------|-------|-------------------------------|
| 0 |  |  |  | flow on ext., int. or both    | 100.                              | -90.          | -10.  | Exterior point                |
|   |  |  |  | pointA: actual point C4       | 0.                                | 0.            | 0.    | limit plane disp. (in pixels) |
|   |  |  |  | pointB: actual point D4       | 'Thin box under main block ABCD6' |               |       |                               |
|   |  |  |  | pointC: actual point E4       | 8                                 | Component no. |       |                               |
|   |  |  |  | Exterior point                | Quadric 44                        |               |       |                               |
|   |  |  |  | limit plane disp. (in pixels) | 1                                 | Component no. |       |                               |
|   |  |  |  | Quadric 38                    | 49.3                              | -30.2         | -25.5 | flow on ext., int. or both    |
|   |  |  |  | Component no.                 | 49.3                              | -30.2         | -42.5 | pointA: actual point A6       |
|   |  |  |  | flow on ext., int. or both    | 49.3                              | -38.7         | -25.5 | pointB: actual point B6       |
|   |  |  |  | pointA: actual point B4       | 49.3                              | -38.7         | -42.5 | pointC: actual point C6       |
|   |  |  |  | pointB: actual point C4       | 49.3                              | -38.7         | -42.5 | pointD: actual point D6       |
|   |  |  |  | pointC: actual point E4       | 0.                                | -35.          | -20.  | Exterior point                |
|   |  |  |  | Exterior point                | 0.                                | 0.            | 0.    | limit plane disp. (in pixels) |
|   |  |  |  | limit plane disp. (in pixels) | Quadric 45                        |               |       |                               |
|   |  |  |  | Quadric 39                    | 8                                 | Component no. |       |                               |
|   |  |  |  | Component no.                 | Quadric 46                        |               |       |                               |
|   |  |  |  | flow on ext., int. or both    | 1                                 | Component no. |       |                               |
|   |  |  |  | pointA: actual point A5       | 49.3                              | -38.7         | 2.1   | flow on ext., int. or both    |
|   |  |  |  | pointB: actual point B5       | 49.3                              | -38.7         | -42.5 | pointA: actual point C6       |
|   |  |  |  | pointC: actual point C5       | 176.3                             | -38.7         | 2.1   | pointB: actual point D6       |
|   |  |  |  | pointD: actual point D5       | 176.3                             | -38.7         | -42.5 | pointC: actual point G6       |
|   |  |  |  | Exterior point                | 100.                              | -50.          | -20.  | pointD: actual point H6       |
|   |  |  |  | limit plane disp. (in pixels) | 0.                                | 0.            | 0.    | Exterior point                |
|   |  |  |  | Quadric 40                    | limit plane disp. (in pixels)     |               |       |                               |
|   |  |  |  | Component no.                 | Quadric 46                        |               |       |                               |
|   |  |  |  | flow on ext., int. or both    | 8                                 | Component no. |       |                               |
|   |  |  |  | pointA: actual point B5       | Quadric 47                        |               |       |                               |
|   |  |  |  | pointB: actual point F5       | 1                                 | Component no. |       |                               |
|   |  |  |  | pointC: actual point D5       | 49.3                              | -38.7         | -42.5 | flow on ext., int. or both    |
|   |  |  |  | pointD: actual point H5       | 176.3                             | -30.2         | -42.5 | pointA: actual point E6       |
|   |  |  |  | Exterior point                | 49.3                              | -30.2         | -42.5 | pointB: actual point A6       |
|   |  |  |  | limit plane disp. (in pixels) | 176.3                             | -38.7         | 2.1   | pointC: actual point G6       |
|   |  |  |  | Quadric 41                    | 49.3                              | -38.7         | 2.1   | pointD: actual point C6       |
|   |  |  |  | Component no.                 | 100.                              | -35.          | 10.   | Exterior point                |
|   |  |  |  | flow on ext., int. or both    | 0.                                | 0.            | 0.    | limit plane disp. (in pixels) |
|   |  |  |  | pointA: actual point F5       | Quadric 48                        |               |       |                               |
|   |  |  |  | pointB: actual point E5       | 9                                 | Component no. |       |                               |
|   |  |  |  | pointC: actual point H5       | Quadric 49                        |               |       |                               |
|   |  |  |  | pointD: actual point G5       | 1                                 | Component no. |       |                               |
|   |  |  |  | Exterior point                | 176.3                             | -30.2         | 2.1   | flow on ext., int. or both    |
|   |  |  |  | limit plane disp. (in pixels) | 49.3                              | -30.2         | 2.1   | pointA: actual point A7       |
|   |  |  |  | Quadric 42                    | 176.3                             | -38.7         | 2.1   | pointB: actual point E7       |
|   |  |  |  | Component no.                 | 176.3                             | -51.0         | 2.1   | pointC: actual point C7       |
|   |  |  |  | flow on ext., int. or both    | 218.0                             | -51.0         | 2.1   | pointD: actual point G7       |
|   |  |  |  | pointA: actual point E5       | 200.                              | -35.          | 10.   | Exterior point                |
|   |  |  |  | pointB: actual point A5       | 0.                                | 0.            | 0.    | limit plane disp. (in pixels) |
|   |  |  |  | pointC: actual point G5       | Quadric 49                        |               |       |                               |
|   |  |  |  | pointD: actual point C5       | 9                                 | Component no. |       |                               |
|   |  |  |  | Exterior point                | Quadric 49                        |               |       |                               |
|   |  |  |  | limit plane disp. (in pixels) | 1                                 | Component no. |       |                               |
|   |  |  |  | Quadric 43                    | 176.3                             | -30.2         | 2.1   | flow on ext., int. or both    |
|   |  |  |  | Component no.                 | 218.0                             | -30.2         | 2.1   | pointA: actual point E7       |
|   |  |  |  | flow on ext., int. or both    | 218.0                             | -30.2         | -42.5 | pointB: actual point F7       |
|   |  |  |  | pointA: actual point J5       | 218.0                             | -51.0         | 2.1   | pointC: actual point G7       |
|   |  |  |  | pointB: actual point L5       | 218.0                             | -51.0         | -42.5 | pointD: actual point H7       |
|   |  |  |  | pointC: actual point I5       | 250.                              | -35.          | -20.  | Exterior point                |
|   |  |  |  | pointD: actual point K5       | 0.                                | 0.            | 0.    | limit plane disp. (in pixels) |

|                              |                               |                   |                   |                            |                               |
|------------------------------|-------------------------------|-------------------|-------------------|----------------------------|-------------------------------|
| 'Box under main block BFDH7' |                               | Quadrac 50        |                   | flow on ext., int. or both |                               |
| 9                            | Component no.                 | 1                 | 123.3 -38.7 6.1   | pointA: actual point A8    | pointB: actual point A8       |
| 1                            | 176.3 -30.2 -42.5             | 104.7 -38.7 6.1   | 123.3 -61.4 6.1   | pointC: actual point E8    | pointD: actual point G8       |
| 218.0 -30.2 -42.5            | pointB: actual point B7       | 110.7 -61.4 6.1   | 110.7 -50. 10.    | Exterior point             | limit plane disp. (in pixels) |
| 176.3 -51.0 -42.5            | pointC: actual point D7       | 0. 0. 0.          |                   |                            |                               |
| 218.0 -51.0 -42.5            | pointD: actual point H7       |                   |                   |                            |                               |
| 250. -35. -50.               | Exterior point                |                   |                   |                            |                               |
| 0. 0. 0.                     | limit plane disp. (in pixels) |                   |                   |                            |                               |
| 'Box under main block IJCD7' |                               | Quadrac 51        |                   | flow on ext., int. or both |                               |
| 9                            | Component no.                 | 1                 | 123.3 -38.7 6.1   | pointA: actual point A8    | pointB: actual point E8       |
| 1                            | 176.3 -38.7 2.1               | 104.7 -38.7 6.1   | 123.3 -61.4 6.1   | pointC: actual point J8    | pointD: actual point I8       |
| 176.3 -38.7 -42.5            | pointB: actual point I7       | 110.7 -61.4 6.1   | 110.7 -30. 4.     | Exterior point             | limit plane disp. (in pixels) |
| 176.3 -51.0 2.1              | pointC: actual point C7       | 0. 0. 0.          |                   |                            |                               |
| 176.3 -51.0 -42.5            | pointD: actual point D7       |                   |                   |                            |                               |
| 150. -45. -20.               | Exterior point                |                   |                   |                            |                               |
| 0. 0. 0.                     | limit plane disp. (in pixels) |                   |                   |                            |                               |
| 'Box under main block CGDH7' |                               | Quadrac 52        |                   | flow on ext., int. or both |                               |
| 9                            | Component no.                 | 1                 | 123.3 -61.4 6.1   | pointA: actual point C8    | pointB: actual point D8       |
| 1                            | 176.3 -51.0 2.1               | 123.3 -61.4 -40.4 | 104.7 -61.4 6.1   | pointC: actual point G8    | pointD: actual point H8       |
| 176.3 -51.0 2.1              | pointC: actual point G7       | 104.7 -61.4 -40.4 | 110.7 -70. -20.   | Exterior point             | limit plane disp. (in pixels) |
| 176.3 -51.0 -42.5            | pointD: actual point D7       | 0. 0. 0.          |                   |                            |                               |
| 218.0 -51.0 -42.5            | pointH: actual point H7       |                   |                   |                            |                               |
| 200. -60. -20.               | Exterior point                |                   |                   |                            |                               |
| 0. 0. 0.                     | limit plane disp. (in pixels) |                   |                   |                            |                               |
| 'Box under main block CGDH7' |                               | Quadrac 53        |                   | flow on ext., int. or both |                               |
| 9                            | Component no.                 | 1                 | 123.3 -38.7 6.1   | pointA: actual point A8    | pointB: actual point B8       |
| 1                            | 176.3 -38.7 6.1               | 123.3 -38.7 -40.4 | 123.3 -61.4 6.1   | pointC: actual point C8    | pointD: actual point D8       |
| 123.3 -38.7 -40.4            | pointB: actual point B8       | 123.3 -61.4 6.1   | 104.7 -61.4 -40.4 | Exterior point             | limit plane disp. (in pixels) |
| 123.3 -61.4 6.1              | pointC: actual point C8       | 104.7 -61.4 -40.4 | 110.7 -50. -20.   |                            |                               |
| 123.3 -61.4 -40.4            | pointD: actual point D8       | 0. 0. 0.          |                   |                            |                               |
| 150. -50. -20.               | Exterior point                |                   |                   |                            |                               |
| 0. 0. 0.                     | limit plane disp. (in pixels) |                   |                   |                            |                               |
| 'Box under main block BFDH8' |                               | Quadrac 54        |                   | flow on ext., int. or both |                               |
| 9                            | Component no.                 | 1                 | 123.3 -38.7 -40.4 | pointA: actual point B8    | pointB: actual point F8       |
| 1                            | 176.3 -38.7 -40.4             | 104.7 -38.7 -40.4 | 123.3 -61.4 -40.4 | pointC: actual point D8    | pointD: actual point H8       |
| 123.3 -38.7 -40.4            | pointB: actual point B8       | 123.3 -61.4 -40.4 | 104.7 -61.4 -40.4 | Exterior point             | limit plane disp. (in pixels) |
| 123.3 -61.4 -40.4            | pointC: actual point D8       | 104.7 -61.4 -40.4 | 110.7 -50. -50.   |                            |                               |
| 104.7 -61.4 -40.4            | pointD: actual point H8       | 0. 0. 0.          |                   |                            |                               |
| 110. -50. -50.               | Exterior point                |                   |                   |                            |                               |
| 0. 0. 0.                     | limit plane disp. (in pixels) |                   |                   |                            |                               |
| 'Box under main block HGFH8' |                               | Quadrac 55        |                   | flow on ext., int. or both |                               |
| 9                            | Component no.                 | 1                 | 123.3 -61.4 -40.4 | pointA: actual point H8    | pointB: actual point G8       |
| 1                            | 176.3 -61.4 -40.4             | 104.7 -61.4 6.1   | 104.7 -38.7 -40.4 | pointC: actual point F8    | pointD: actual point E8       |
| 123.3 -61.4 -40.4            | pointB: actual point H8       | 104.7 -61.4 6.1   | 104.7 -38.7 6.1   | Exterior point             | limit plane disp. (in pixels) |
| 123.3 -61.4 -40.4            | pointC: actual point F8       | 104.7 -38.7 6.1   | 100. -50. -20.    |                            |                               |
| 104.7 -38.7 6.1              | pointD: actual point E8       | 0. 0. 0.          |                   |                            |                               |
| 100. -50. -20.               | Exterior point                |                   |                   |                            |                               |
| 0. 0. 0.                     | limit plane disp. (in pixels) |                   |                   |                            |                               |
| 'Box under main block AECG8' |                               | Quadrac 56        |                   | flow on ext., int. or both |                               |
| 9                            | Component no.                 | 1                 | 123.3 -61.4 -40.4 | pointA: actual point A8    | pointB: actual point B8       |
| 1                            | 176.3 -61.4 -40.4             | 104.7 -61.4 6.1   | 104.7 -38.7 -40.4 | pointC: actual point C8    | pointD: actual point D8       |
| 123.3 -61.4 -40.4            | pointB: actual point A8       | 104.7 -61.4 6.1   | 104.7 -38.7 -40.4 | Exterior point             | limit plane disp. (in pixels) |
| 123.3 -61.4 -40.4            | pointC: actual point C8       | 104.7 -38.7 -40.4 | 110.7 -50. -20.   |                            |                               |
| 104.7 -38.7 -40.4            | pointD: actual point D8       | 0. 0. 0.          |                   |                            |                               |
| 110. -50. -20.               | Exterior point                |                   |                   |                            |                               |
| 0. 0. 0.                     | limit plane disp. (in pixels) |                   |                   |                            |                               |





|                            |        |                               |     |      |                |                               |
|----------------------------|--------|-------------------------------|-----|------|----------------|-------------------------------|
| 0.                         | 0.     | limit plane disp. (in pixels) | 1.  | 0.   | 0.             | dircos                        |
| 100.                       | 150.   | F3I limits                    | 2.4 |      |                | radius                        |
| 'solar panel support J12'  | 80.    |                               | 0.  |      |                | limit plane disp. (in pixels) |
| 13                         |        | Component no.                 | 70. | 200. | -5. 120. -100. | F3I limits                    |
| SphereE                    |        |                               |     |      |                | Quadric 97                    |
| 1                          |        | flow on ext., int. or both    |     |      |                | Component no.                 |
| 136.1                      | 56.3   | pointA                        |     |      |                | flow on ext., int. or both    |
| 0.                         | 0.     | dircos                        |     |      |                | pointA                        |
| 3.5                        | 1.     | radius                        |     |      |                | dircos                        |
| 0.                         |        | limit plane disp. (in pixels) |     |      |                | radius                        |
| 100.                       | 150.   | F3I limits                    |     |      |                | limit plane disp. (in pixels) |
| 'solar panel support JK12' | 0.     |                               |     |      |                | F3I limits                    |
| 13                         |        | Component no.                 |     |      |                | Quadric 98                    |
| CylinderA                  |        |                               |     |      |                | Component no.                 |
| 1                          |        | flow on ext., int. or both    |     |      |                | flow on ext., int. or both    |
| 136.1                      | 56.3   | pointA                        |     |      |                | pointA                        |
| 136.1                      | 105.79 | pointB                        |     |      |                | pointB                        |
| 2.4                        | -55.5  | radius                        |     |      |                | radius                        |
| 0.                         | 0.     | limit plane disp. (in pixels) |     |      |                | limit plane disp. (in pixels) |
| 80.                        | 185.   | F3I limits                    |     |      |                | F3I limits                    |
| 'solar panel support JL12' | 0.     |                               |     |      |                | Quadric 99                    |
| 13                         |        | Component no.                 |     |      |                | Component no.                 |
| CylinderA                  |        |                               |     |      |                | flow on ext., int. or both    |
| 1                          |        | flow on ext., int. or both    |     |      |                | pointA                        |
| 136.1                      | 56.3   | pointA                        |     |      |                | radiusA                       |
| 106.28                     | 105.79 | pointB                        |     |      |                | radiusB                       |
| 1.4                        | -55.5  | radius                        |     |      |                | length                        |
| 0.                         | 0.     | limit plane disp. (in pixels) |     |      |                | dircos                        |
| 70.                        | 200.   | F3I limits                    |     |      |                | limit plane disp. (in pixels) |
| 'solar panel support JM12' | 0.     |                               |     |      |                | F3I limits                    |
| 13                         |        | Component no.                 |     |      |                | Quadric 100                   |
| CylinderA                  |        |                               |     |      |                | Component no.                 |
| 1                          |        | flow on ext., int. or both    |     |      |                | flow on ext., int. or both    |
| 136.1                      | 56.3   | pointA                        |     |      |                | pointA                        |
| 165.92                     | 105.79 | pointB                        |     |      |                | radiusA                       |
| 1.4                        | -55.5  | radius                        |     |      |                | radiusB                       |
| 0.                         | 0.     | limit plane disp. (in pixels) |     |      |                | length                        |
| 70.                        | 200.   | F3I limits                    |     |      |                | dircos                        |
| 'solar panel support JN12' | 0.     |                               |     |      |                | limit plane disp. (in pixels) |
| 13                         |        | Component no.                 |     |      |                | F3I limits                    |
| CylinderA                  |        |                               |     |      |                | Quadric 101                   |
| 1                          |        | flow on ext., int. or both    |     |      |                | Component no.                 |
| 136.1                      | 56.3   | pointA                        |     |      |                | flow on ext., int. or both    |
| 165.92                     | 105.79 | pointB                        |     |      |                | pointA: actual point F13      |
| 1.4                        | -55.5  | radius                        |     |      |                | pointB: actual point G13      |
| 0.                         | 0.     | limit plane disp. (in pixels) |     |      |                | pointC: actual point J13      |
| 70.                        | 200.   | F3I limits                    |     |      |                | pointD: actual point K13      |
| 'solar panel, NOPQ12'      | 0.     |                               |     |      |                | Exterior point                |
| 13                         |        | Component no.                 |     |      |                | limit plane disp. (in pixels) |
| PlateB                     |        |                               |     |      |                | Quadric 102                   |
| 0                          |        | flow on ext., int. or both    |     |      |                | Component no.                 |
| 200.5                      | 105.79 | pointA: actual point N12      |     |      |                | flow on ext., int. or both    |
| 71.7                       | 105.79 | pointB: actual point Q12      |     |      |                | pointA: actual point H13      |
| 200.5                      | -34.55 | pointC: actual point P12      |     |      |                | pointB: actual point I13      |
| 71.7                       | -34.55 | pointD: actual point Q12      |     |      |                | pointC: actual point L13      |
| 150.                       | 100.   | Exterior point                |     |      |                | pointD: actual point M13      |
| 0.                         | 0.     | limit plane disp. (in pixels) |     |      |                | Exterior point                |
| 'solar panel support RS12' | 0.     |                               |     |      |                | limit plane disp. (in pixels) |
| 13                         |        | Component no.                 |     |      |                | Quadric 103                   |
| CylinderA                  |        |                               |     |      |                | Component no.                 |
| 1                          |        | flow on ext., int. or both    |     |      |                | flow on ext., int. or both    |
| 106.28                     | 105.79 | pointA                        |     |      |                | pointA: actual point H13      |
| 165.92                     | 105.79 | pointB                        |     |      |                | pointB: actual point I13      |
| 2.4                        | -70.63 | radius                        |     |      |                | pointC: actual point L13      |
| 0.                         | 0.     | limit plane disp. (in pixels) |     |      |                | pointD: actual point M13      |
| 70.                        | 200.   | F3I limits                    |     |      |                | Exterior point                |
| 'solar panel support R12'  | 0.     |                               |     |      |                | limit plane disp. (in pixels) |
| 13                         |        | Component no.                 |     |      |                | Quadric 104                   |
| SphereE                    |        |                               |     |      |                | Component no.                 |
| 1                          |        | flow on ext., int. or both    |     |      |                | flow on ext., int. or both    |
| 106.28                     | 105.79 | pointA                        |     |      |                | pointA: actual point F13      |
|                            | -70.63 |                               |     |      |                | pointB: actual point G13      |
|                            |        |                               |     |      |                | pointC: actual point H13      |
|                            |        |                               |     |      |                | pointD: actual point I13      |
|                            |        |                               |     |      |                | Exterior point                |
|                            |        |                               |     |      |                | limit plane disp. (in pixels) |







|                           |                  |                               |  |                             |                               |               |  |
|---------------------------|------------------|-------------------------------|--|-----------------------------|-------------------------------|---------------|--|
| 'ISAMS box KLMN15'        |                  | Quadric 137                   |  | 'HGA antenna C16'           |                               | Plane 10      |  |
| 16                        | PlateB           | Component no.                 |  | 17                          | Disk                          | Component no. |  |
| 1                         | 19.8 -76.2 11.6  | flow on ext., int. or both    |  |                             | pointA                        |               |  |
|                           | 44.8 -76.2 11.6  | pointA: actual point K15      |  | 278.7 40.4 2.7              | dircos                        |               |  |
|                           | 19.8 -76.2 -25.5 | pointB: actual point L15      |  | -1. 0. 0.                   | radius                        |               |  |
|                           | 44.8 -76.2 -25.5 | pointC: actual point M15      |  | 4.6                         |                               |               |  |
| 50.                       | -100. 0.         | pointD: actual point N15      |  |                             |                               |               |  |
| 0.                        | 0. 0. 0.         | Exterior point                |  |                             |                               |               |  |
| 0.                        | 0. 0. 0.         | limit plane disp. (in pixels) |  |                             |                               |               |  |
| 'ISAMS box IJPR15'        |                  | Quadric 138                   |  | 'HGA antenna D16'           |                               | Quadric 143   |  |
| 16                        | PlateB           | Component no.                 |  | 17                          | SphereE                       | Component no. |  |
| 1                         | 57.3 -38.7 11.6  | flow on ext., int. or both    |  |                             | pointA                        |               |  |
|                           | 57.3 -38.7 -25.5 | pointA: actual point I15      |  | 301.5 40.4 2.7              | dircos                        |               |  |
|                           | 57.3 -61.2 11.6  | pointB: actual point J15      |  | -1. 0. 0.                   | radius                        |               |  |
|                           | 57.3 -61.2 -25.5 | pointC: actual point P15      |  | 4.6                         |                               |               |  |
| 100.                      | -100. 0.         | pointD: actual point R15      |  | 250. 350. 0. 60. 0. 20.     | limit plane disp. (in pixels) |               |  |
| 0.                        | 0. 0. 0.         | Exterior point                |  |                             | F3I limits                    |               |  |
| 0.                        | 0. 0. 0.         | limit plane disp. (in pixels) |  |                             |                               |               |  |
| 'ISAMS box DHIJ15'        |                  | Quadric 139                   |  | 'HGA antenna E16'           |                               | Quadric 144   |  |
| 16                        | PlateB           | Component no.                 |  | 17                          | CylinderA                     | Component no. |  |
| 1                         | 49.3 -38.7 11.6  | flow on ext., int. or both    |  |                             | pointA                        |               |  |
|                           | 49.3 -38.7 2.1   | pointA: actual point D15      |  | 301.5 40.4 2.7              | pointB                        |               |  |
|                           | 57.3 -38.7 11.6  | pointB: actual point H15      |  | 301.5 60.4 2.7              | radius                        |               |  |
|                           | 57.3 -38.7 2.1   | pointC: actual point I15      |  | 2.5                         |                               |               |  |
| 100.                      | 0. 0. 0.         | pointD: actual point J15      |  | 250. 350. 0. 100. 0. 20.    | limit plane disp. (in pixels) |               |  |
| 0.                        | 0. 0. 1.         | Exterior point                |  |                             | F3I limits                    |               |  |
| 0.                        | 0. 0. 0.         | limit plane disp. (in pixels) |  |                             |                               |               |  |
| 'HGA antenna AB16'        |                  | Quadric 140                   |  | 'HGA antenna E16'           |                               | Quadric 145   |  |
| 17                        | CylinderA        | Component no.                 |  | 17                          | SphereC                       | Component no. |  |
| 1                         | 279.7 40.4 -3.7  | flow on ext., int. or both    |  |                             | pointA                        |               |  |
|                           | 279.7 40.4 -18.7 | pointA                        |  | 301.5 71.4 2.7              | dircos                        |               |  |
| 2.8                       | 0. 0.            | pointB                        |  | 0. 1. 0.                    | depth                         |               |  |
| 0.                        | 0. 0.            | radius                        |  | 11. 25.5                    | radius                        |               |  |
| 250. 300. 0. 60. -30. 20. |                  | limit plane disp. (in pixels) |  | 250. 400. 0. 100. -50. 50.  | limit plane disp. (in pixels) |               |  |
|                           |                  | F3I limits                    |  |                             | F3I limits                    |               |  |
| 'HGA antenna A16'         |                  | Quadric 141                   |  | 'CLAES lower mount, ABC17'  |                               | Quadric 146   |  |
| 17                        | SphereE          | Component no.                 |  | 18                          | PlateA                        | Component no. |  |
| 1                         | 279.7 40.4 -3.7  | flow on ext., int. or both    |  |                             | pointA                        |               |  |
| 0.                        | 0. 0. -1.        | pointA                        |  | 102.4 -29.2 2.1             | pointA: actual point A17      |               |  |
| 2.8                       | 0. 0. -1.        | dircos                        |  | 41.9 -29.2 2.1              | pointB: actual point B17      |               |  |
| 0.                        | 0. 0. -1.        | radius                        |  | 63.2 -26.2 33.4             | pointC: actual point C17      |               |  |
| 250. 300. 0. 60. -30. 20. |                  | limit plane disp. (in pixels) |  | 100. -35. 50.               | Exterior point                |               |  |
|                           |                  | F3I limits                    |  | 0. 0. 0. 0.                 | limit plane disp. (in pixels) |               |  |
| 'HGA antenna B16'         |                  | Plane 9                       |  | 'CLAES lower mount, DEF17'  |                               | Quadric 147   |  |
| 17                        | Disk             | Component no.                 |  | 18                          | PlateA                        | Component no. |  |
| 1                         | 279.7 40.4 -18.7 | flow on ext., int. or both    |  |                             | pointA                        |               |  |
| 0.                        | 0. 0. -1.        | pointA                        |  | 102.4 -26.2 2.1             | pointA: actual point D17      |               |  |
| 2.8                       | 0. 0. -1.        | dircos                        |  | 41.9 -26.2 2.1              | pointB: actual point E17      |               |  |
| 0.                        | 0. 0. -1.        | radius                        |  | 63.2 -23.2 33.4             | pointC: actual point F17      |               |  |
| 250. 300. 0. 60. -30. 20. |                  | limit plane disp. (in pixels) |  | 100. -20. 50.               | Exterior point                |               |  |
|                           |                  | F3I limits                    |  | 0. 0. 0. 0.                 | limit plane disp. (in pixels) |               |  |
| 'HGA antenna CD16'        |                  | Quadric 142                   |  | 'CLAES lower mount, ACDF17' |                               | Quadric 148   |  |
| 17                        | CylinderA        | Component no.                 |  | 18                          | PlateB                        | Component no. |  |
| 1                         | 278.7 40.4 2.7   | flow on ext., int. or both    |  |                             | pointA                        |               |  |
|                           | 301.5 40.4 2.7   | pointA                        |  | 102.4 -29.2 2.1             | pointA: actual point A17      |               |  |
| 4.6                       | 0. 0.            | pointB                        |  | 63.2 -26.2 33.4             | pointB: actual point C17      |               |  |
| 0.                        | 0. 0.            | radius                        |  | 102.4 -26.2 2.1             | pointC: actual point D17      |               |  |
| 250. 350. 0. 60. 0. 20.   |                  | limit plane disp. (in pixels) |  | 63.2 -23.2 33.4             | pointD: actual point F17      |               |  |
|                           |                  | F3I limits                    |  | 100. -30. 50.               | Exterior point                |               |  |
|                           |                  |                               |  | 0. 0. 0. 0.                 | limit plane disp. (in pixels) |               |  |



|                                                                                                                                     |    |                              |                                                                                                                                                                   |                   |                                                                                       |                                                                                                                                     |    |                              |                                                                                                                                                                                               |                   |                                                                                                                                    |                                            |                              |                                                                                                                                                                   |                   |                                                                                                           |                                            |                              |                                                                                                                                                                                               |                   |                                                                                                           |                                              |                              |                                                                                                                                                                                               |                   |                                                                                                           |                                              |                              |                                                                                                                                                                                               |                   |                                                                                                          |                                              |                              |                                                                                                                                                                                               |                   |                                                                                                           |                                              |                              |                                                                                                                                            |                   |                                                                              |                                                                                                                                                                                               |                   |                                                                                                           |                                              |                              |                                                                                                                                                                                               |                   |                                                                                       |                                                                                                                                     |    |                              |                                                                                                                                                                                               |                   |                                                                                                           |                                              |                              |                                                                                                                                                                                               |                   |                                                                                                           |                                              |                              |                                                                                                                                                                                               |                   |                                                                                                          |                                              |                              |                                                                                                                                                                                               |                   |                                                                                                           |                                              |                              |                                                                                                                                            |                   |                                                                              |                                                                          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| pointB: actual point J18<br>pointC: actual point K18<br>pointD: actual point L18<br>Exterior point<br>limit plane disp. (in pixels) | 0. | Quadric 162<br>Component no. | flow on ext., int. or both<br>pointA: actual point F18<br>pointB: actual point G18<br>pointC: actual point H18<br>Exterior point<br>limit plane disp. (in pixels) | 19<br>PlateB<br>1 | 173.4 -31.9 46.4<br>119.7 -45.0 46.4<br>179.7 -45.0 46.4<br>200. -40. 80.<br>0. 0. 0. | pointB: actual point J18<br>pointC: actual point K18<br>pointD: actual point L18<br>Exterior point<br>limit plane disp. (in pixels) | 0. | Quadric 169<br>Component no. | flow on ext., int. or both<br>pointA: actual point H18<br>pointB: actual point J18<br>pointC: actual point N18<br>pointD: actual point L18<br>Exterior point<br>limit plane disp. (in pixels) | 19<br>PlateB<br>1 | 'WINDII base, HJNL18'<br>157.9 -22.8 27.3<br>173.4 -31.9 46.4<br>162.0 -36.4 21.8<br>179.7 -45.0 46.4<br>200. 100. 50.<br>2. 2. 2. | 'WINDII base, IGRM18'<br>19<br>PlateB<br>1 | Quadric 163<br>Component no. | flow on ext., int. or both<br>pointA: actual point G18<br>pointB: actual point E18<br>pointC: actual point M18<br>Exterior point<br>limit plane disp. (in pixels) | 19<br>PlateB<br>1 | 124.9 -31.9 46.4<br>140.4 -22.8 27.3<br>119.7 -45.0 46.4<br>136.0 -36.4 21.8<br>100. 100. 50.<br>2. 2. 2. | 'WINDII base, IGRM18'<br>19<br>PlateB<br>1 | Quadric 164<br>Component no. | flow on ext., int. or both<br>pointA: actual point C18<br>pointB: actual point D18<br>pointC: actual point E18<br>pointD: actual point F18<br>Exterior point<br>limit plane disp. (in pixels) | 19<br>PlateB<br>1 | 269.8 -34.6 36.4<br>247.1 -34.6 36.4<br>263.9 -34.6 16.8<br>253.0 -34.6 16.8<br>250. -50. 50.<br>0. 0. 0. | 'PEM-AXIS base, ABCD19'<br>20<br>PlateB<br>1 | Quadric 165<br>Component no. | flow on ext., int. or both<br>pointA: actual point M18<br>pointB: actual point N18<br>pointC: actual point Q18<br>pointD: actual point O18<br>Exterior point<br>limit plane disp. (in pixels) | 19<br>PlateB<br>1 | 269.8 -34.6 36.4<br>247.1 -34.6 36.4<br>263.9 -34.6 16.8<br>253.0 -34.6 16.8<br>250. -50. 50.<br>0. 0. 0. | 'PEM-AXIS base, EFGH19'<br>20<br>PlateB<br>1 | Quadric 166<br>Component no. | flow on ext., int. or both<br>pointA: actual point M18<br>pointB: actual point N18<br>pointC: actual point K18<br>pointD: actual point L18<br>Exterior point<br>limit plane disp. (in pixels) | 19<br>PlateB<br>1 | 269.8 -32.3 36.4<br>247.1 -32.3 36.4<br>263.9 -32.3 16.8<br>253.0 -32.3 16.8<br>250. 50. 50.<br>0. 0. 0. | 'PEM-AXIS base, AECC19'<br>20<br>PlateB<br>1 | Quadric 167<br>Component no. | flow on ext., int. or both<br>pointA: actual point G18<br>pointB: actual point H18<br>pointC: actual point I18<br>pointD: actual point J18<br>Exterior point<br>limit plane disp. (in pixels) | 19<br>PlateB<br>1 | 269.8 -34.6 36.4<br>269.8 -32.3 36.4<br>263.9 -34.6 16.8<br>263.9 -32.3 16.8<br>300. -30. 20.<br>0. 0. 0. | 'PEM-AXIS base, BFDD19'<br>20<br>PlateB<br>1 | Quadric 168<br>Component no. | flow on ext., int. or both<br>pointA: actual point B19<br>pointB: actual point F19<br>pointC: actual point D19<br>pointD: actual point H19 | 19<br>PlateB<br>1 | 247.1 -34.6 36.4<br>247.1 -32.3 36.4<br>253.0 -34.6 16.8<br>253.0 -32.3 16.8 | flow on ext., int. or both<br>pointA: actual point A19<br>pointB: actual point E19<br>pointC: actual point C19<br>pointD: actual point G19<br>Exterior point<br>limit plane disp. (in pixels) | 19<br>PlateB<br>1 | 269.8 -34.6 36.4<br>269.8 -32.3 36.4<br>263.9 -34.6 16.8<br>263.9 -32.3 16.8<br>300. -30. 20.<br>0. 0. 0. | 'PEM-AXIS base, BFDD19'<br>20<br>PlateB<br>1 | Quadric 169<br>Component no. | flow on ext., int. or both<br>pointA: actual point H18<br>pointB: actual point J18<br>pointC: actual point N18<br>pointD: actual point L18<br>Exterior point<br>limit plane disp. (in pixels) | 19<br>PlateB<br>1 | 173.4 -31.9 46.4<br>119.7 -45.0 46.4<br>179.7 -45.0 46.4<br>200. -40. 80.<br>0. 0. 0. | pointB: actual point J18<br>pointC: actual point K18<br>pointD: actual point L18<br>Exterior point<br>limit plane disp. (in pixels) | 0. | Quadric 170<br>Component no. | flow on ext., int. or both<br>pointA: actual point I18<br>pointB: actual point G18<br>pointC: actual point K18<br>pointD: actual point M18<br>Exterior point<br>limit plane disp. (in pixels) | 19<br>PlateB<br>1 | 124.9 -31.9 46.4<br>140.4 -22.8 27.3<br>119.7 -45.0 46.4<br>136.0 -36.4 21.8<br>100. 100. 50.<br>2. 2. 2. | 'PEM-AXIS base, ABCD19'<br>20<br>PlateB<br>1 | Quadric 171<br>Component no. | flow on ext., int. or both<br>pointA: actual point A19<br>pointB: actual point B19<br>pointC: actual point C19<br>pointD: actual point D19<br>Exterior point<br>limit plane disp. (in pixels) | 19<br>PlateB<br>1 | 269.8 -34.6 36.4<br>247.1 -34.6 36.4<br>263.9 -34.6 16.8<br>253.0 -34.6 16.8<br>250. -50. 50.<br>0. 0. 0. | 'PEM-AXIS base, EFGH19'<br>20<br>PlateB<br>1 | Quadric 172<br>Component no. | flow on ext., int. or both<br>pointA: actual point E19<br>pointB: actual point F19<br>pointC: actual point G19<br>pointD: actual point H19<br>Exterior point<br>limit plane disp. (in pixels) | 19<br>PlateB<br>1 | 269.8 -32.3 36.4<br>247.1 -32.3 36.4<br>263.9 -32.3 16.8<br>253.0 -32.3 16.8<br>250. 50. 50.<br>0. 0. 0. | 'PEM-AXIS base, AECC19'<br>20<br>PlateB<br>1 | Quadric 173<br>Component no. | flow on ext., int. or both<br>pointA: actual point A19<br>pointB: actual point E19<br>pointC: actual point C19<br>pointD: actual point G19<br>Exterior point<br>limit plane disp. (in pixels) | 19<br>PlateB<br>1 | 269.8 -34.6 36.4<br>269.8 -32.3 36.4<br>263.9 -34.6 16.8<br>263.9 -32.3 16.8<br>300. -30. 20.<br>0. 0. 0. | 'PEM-AXIS base, BFDD19'<br>20<br>PlateB<br>1 | Quadric 174<br>Component no. | flow on ext., int. or both<br>pointA: actual point B19<br>pointB: actual point F19<br>pointC: actual point D19<br>pointD: actual point H19 | 19<br>PlateB<br>1 | 247.1 -34.6 36.4<br>247.1 -32.3 36.4<br>253.0 -34.6 16.8<br>253.0 -32.3 16.8 | flow on ext., int. or both<br>pointA: actual point A19<br>pointB: actual point E19<br>pointC: actual point C19<br>pointD: actual point G19<br>Exterior point |
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|-------------------------|-------|-------|-------|----|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 200.                    | -30.  | 20.   | 0.    | 0. | 0.  | Exterior point<br>limit plane disp. (in pixels)                                                                                                                                               |
| 0.                      | 0.    | 0.    | 0.    | 0. | 0.  |                                                                                                                                                                                               |
| 'PEM-AXIS base, CDGH19' |       |       |       |    |     |                                                                                                                                                                                               |
| 20                      |       |       |       |    |     | Component no.                                                                                                                                                                                 |
| PlateB                  |       |       |       |    |     |                                                                                                                                                                                               |
| 1                       | 263.9 | -34.6 | 16.8  |    |     | flow on ext., int. or both<br>pointA: actual point C19<br>pointB: actual point D19<br>pointC: actual point G19<br>pointD: actual point H19<br>Exterior point<br>limit plane disp. (in pixels) |
| 253.0                   | -34.6 | 16.8  |       |    |     |                                                                                                                                                                                               |
| 263.9                   | -32.3 | 16.8  |       |    |     |                                                                                                                                                                                               |
| 253.0                   | -32.3 | 16.8  |       |    |     |                                                                                                                                                                                               |
| 250.                    | -30.  | 0.    |       |    |     |                                                                                                                                                                                               |
| 0.                      | 0.    | 0.    |       |    |     |                                                                                                                                                                                               |
| 'PEM-AXIS base, AEBF19' |       |       |       |    |     |                                                                                                                                                                                               |
| 20                      |       |       |       |    |     | Component no.                                                                                                                                                                                 |
| PlateB                  |       |       |       |    |     |                                                                                                                                                                                               |
| 1                       | 269.8 | -34.6 | 36.4  |    |     | flow on ext., int. or both<br>pointA: actual point A19<br>pointB: actual point E19<br>pointC: actual point B19<br>pointD: actual point F19<br>Exterior point<br>limit plane disp. (in pixels) |
| 269.8                   | -32.3 | 36.4  |       |    |     |                                                                                                                                                                                               |
| 247.1                   | -34.6 | 36.4  |       |    |     |                                                                                                                                                                                               |
| 247.1                   | -32.3 | 36.4  |       |    |     |                                                                                                                                                                                               |
| 250.                    | -30.  | 50.   |       |    |     |                                                                                                                                                                                               |
| 0.                      | 0.    | 0.    |       |    |     |                                                                                                                                                                                               |
| 'PEM-AXIS base, KLMN19' |       |       |       |    |     |                                                                                                                                                                                               |
| 20                      |       |       |       |    |     | Component no.                                                                                                                                                                                 |
| PlateB                  |       |       |       |    |     |                                                                                                                                                                                               |
| 1                       | 253.0 | -34.6 | 31.5  |    |     | flow on ext., int. or both<br>pointA: actual point K19<br>pointB: actual point L19<br>pointC: actual point M19<br>pointD: actual point N19<br>Exterior point<br>limit plane disp. (in pixels) |
| 263.9                   | -34.6 | 31.5  |       |    |     |                                                                                                                                                                                               |
| 253.0                   | -48.3 | 31.5  |       |    |     |                                                                                                                                                                                               |
| 263.9                   | -48.3 | 31.5  |       |    |     |                                                                                                                                                                                               |
| 260.                    | -40.  | 50.   |       |    |     |                                                                                                                                                                                               |
| 0.                      | 0.    | 0.    |       |    |     |                                                                                                                                                                                               |
| 'PEM-AXIS base, OPQR19' |       |       |       |    |     |                                                                                                                                                                                               |
| 20                      |       |       |       |    |     | Component no.                                                                                                                                                                                 |
| PlateB                  |       |       |       |    |     |                                                                                                                                                                                               |
| 1                       | 253.0 | -34.6 | 20.9  |    |     | flow on ext., int. or both<br>pointA: actual point O19<br>pointB: actual point P19<br>pointC: actual point Q19<br>pointD: actual point R19<br>Exterior point<br>limit plane disp. (in pixels) |
| 263.9                   | -34.6 | 20.9  |       |    |     |                                                                                                                                                                                               |
| 253.0                   | -48.3 | 20.9  |       |    |     |                                                                                                                                                                                               |
| 263.9                   | -48.3 | 20.9  |       |    |     |                                                                                                                                                                                               |
| 250.                    | -40.  | 0.    |       |    |     |                                                                                                                                                                                               |
| 0.                      | 0.    | 0.    |       |    |     |                                                                                                                                                                                               |
| 'PEM-AXIS base, KOMQ19' |       |       |       |    |     |                                                                                                                                                                                               |
| 20                      |       |       |       |    |     | Component no.                                                                                                                                                                                 |
| PlateB                  |       |       |       |    |     |                                                                                                                                                                                               |
| 1                       | 253.0 | -34.6 | 31.5  |    |     | flow on ext., int. or both<br>pointA: actual point K19<br>pointB: actual point L19<br>pointC: actual point M19<br>pointD: actual point Q19<br>Exterior point<br>limit plane disp. (in pixels) |
| 253.0                   | -34.6 | 31.5  |       |    |     |                                                                                                                                                                                               |
| 253.0                   | -48.3 | 31.5  |       |    |     |                                                                                                                                                                                               |
| 253.0                   | -48.3 | 31.5  |       |    |     |                                                                                                                                                                                               |
| 200.                    | -60.  | 30.   |       |    |     |                                                                                                                                                                                               |
| 0.                      | 0.    | 0.    |       |    |     |                                                                                                                                                                                               |
| 'PEM-AXIS base, LPNR19' |       |       |       |    |     |                                                                                                                                                                                               |
| 20                      |       |       |       |    |     | Component no.                                                                                                                                                                                 |
| PlateB                  |       |       |       |    |     |                                                                                                                                                                                               |
| 1                       | 263.9 | -34.6 | 31.5  |    |     | flow on ext., int. or both<br>pointA: actual point L19<br>pointB: actual point P19<br>pointC: actual point N19<br>pointD: actual point R19<br>Exterior point<br>limit plane disp. (in pixels) |
| 263.9                   | -34.6 | 31.5  |       |    |     |                                                                                                                                                                                               |
| 263.9                   | -48.3 | 31.5  |       |    |     |                                                                                                                                                                                               |
| 263.9                   | -48.3 | 31.5  |       |    |     |                                                                                                                                                                                               |
| 300.                    | -60.  | 30.   |       |    |     |                                                                                                                                                                                               |
| 0.                      | 0.    | 0.    |       |    |     |                                                                                                                                                                                               |
| 'PEM-AXIS base, MNQR19' |       |       |       |    |     |                                                                                                                                                                                               |
| 20                      |       |       |       |    |     | Component no.                                                                                                                                                                                 |
| PlateB                  |       |       |       |    |     |                                                                                                                                                                                               |
| 1                       | 253.0 | -48.3 | 31.5  |    |     | flow on ext., int. or both<br>pointA: actual point M19<br>pointB: actual point N19<br>pointC: actual point Q19<br>pointD: actual point R19<br>Exterior point<br>limit plane disp. (in pixels) |
| 263.9                   | -48.3 | 31.5  |       |    |     |                                                                                                                                                                                               |
| 253.0                   | -48.3 | 20.9  |       |    |     |                                                                                                                                                                                               |
| 263.9                   | -48.3 | 20.9  |       |    |     |                                                                                                                                                                                               |
| 250.                    | -60.  | 30.   |       |    |     |                                                                                                                                                                                               |
| 0.                      | 0.    | 0.    |       |    |     |                                                                                                                                                                                               |
| 'PEM-AXIS antenna JI19' |       |       |       |    |     |                                                                                                                                                                                               |
| 20                      |       |       |       |    |     | Component no.                                                                                                                                                                                 |
| ConeD                   |       |       |       |    |     |                                                                                                                                                                                               |
| 0                       | 258.3 | -44.4 | 38.8  |    |     | flow on ext., int. or both<br>pointA<br>radiusA<br>radiusB<br>Rlength<br>dircos<br>limit plane disp. (in pixels)<br>F3I limits                                                                |
| 0                       | 6.3   |       |       |    |     |                                                                                                                                                                                               |
| 12.3                    |       |       |       |    |     |                                                                                                                                                                                               |
| 15.2                    |       |       |       |    |     |                                                                                                                                                                                               |
| 0.                      | 0.5   | 0.866 |       |    |     |                                                                                                                                                                                               |
| 0.                      | 0.    |       |       |    |     |                                                                                                                                                                                               |
| 200.                    | 300.  | -80.  | 0.    | 0. | 80. |                                                                                                                                                                                               |
| 'PEM-AXIS antenna J19'  |       |       |       |    |     |                                                                                                                                                                                               |
| 20                      |       |       |       |    |     | Component no.                                                                                                                                                                                 |
| Disk                    |       |       |       |    |     |                                                                                                                                                                                               |
| 0                       | 258.3 | -44.4 | 38.8  |    |     | pointA<br>dircos<br>radius                                                                                                                                                                    |
| 0.                      | 0.5   | 0.866 |       |    |     |                                                                                                                                                                                               |
| 6.3                     |       |       |       |    |     |                                                                                                                                                                                               |
| 'PEM-AXIS base, ST19'   |       |       |       |    |     |                                                                                                                                                                                               |
| 20                      |       |       |       |    |     | Component no.                                                                                                                                                                                 |
| CylinderA               |       |       |       |    |     |                                                                                                                                                                                               |
| 1                       | 255.8 | 19.6  | 10.4  |    |     | flow on ext., int. or both<br>pointA<br>pointB<br>radius<br>limit plane disp. (in pixels)<br>F3I limits                                                                                       |
| 258.3                   | -33.0 | 26.6  |       |    |     |                                                                                                                                                                                               |
| 2.                      |       |       |       |    |     |                                                                                                                                                                                               |
| 0.                      | -0.5  |       |       |    |     |                                                                                                                                                                                               |
| 200.                    | 300.  | -50.  | 50.   | 0. | 50. |                                                                                                                                                                                               |
| 'PEM-ZEPS base, ABC20'  |       |       |       |    |     |                                                                                                                                                                                               |
| 21                      |       |       |       |    |     | Component no.                                                                                                                                                                                 |
| PlateA                  |       |       |       |    |     |                                                                                                                                                                                               |
| 1                       | 5.9   | 48.1  | -42.5 |    |     | flow on ext., int. or both<br>pointA: actual point A20<br>pointB: actual point B20<br>pointC: actual point C20<br>Exterior point<br>limit plane disp. (in pixels)                             |
| 28.7                    | 48.1  | -51.4 |       |    |     |                                                                                                                                                                                               |
| 42.8                    | 48.1  | -42.5 |       |    |     |                                                                                                                                                                                               |
| 30.                     | 100.  | -50.  |       |    |     |                                                                                                                                                                                               |
| 0.                      | 0.    | 0.    |       |    |     |                                                                                                                                                                                               |
| 'PEM-ZEPS base, ABD20'  |       |       |       |    |     |                                                                                                                                                                                               |
| 21                      |       |       |       |    |     | Component no.                                                                                                                                                                                 |
| PlateA                  |       |       |       |    |     |                                                                                                                                                                                               |
| 1                       | 5.9   | 48.1  | -42.5 |    |     | flow on ext., int. or both<br>pointA: actual point A20<br>pointB: actual point B20<br>pointC: actual point D20<br>Exterior point<br>limit plane disp. (in pixels)                             |
| 28.7                    | 48.1  | -51.4 |       |    |     |                                                                                                                                                                                               |
| 5.9                     | 36.4  | -42.5 |       |    |     |                                                                                                                                                                                               |
| 10.                     | 50.   | -100. |       |    |     |                                                                                                                                                                                               |
| 0.                      | 0.    | 0.    |       |    |     |                                                                                                                                                                                               |
| 'PEM-ZEPS base, BCE20'  |       |       |       |    |     |                                                                                                                                                                                               |
| 21                      |       |       |       |    |     | Component no.                                                                                                                                                                                 |
| PlateA                  |       |       |       |    |     |                                                                                                                                                                                               |
| 1                       | 28.7  | 48.1  | -51.4 |    |     | flow on ext., int. or both<br>pointA: actual point B20<br>pointB: actual point C20<br>pointC: actual point E20<br>Exterior point<br>limit plane disp. (in pixels)                             |
| 42.8                    | 48.1  | -42.5 |       |    |     |                                                                                                                                                                                               |
| 42.8                    | 36.4  | -42.5 |       |    |     |                                                                                                                                                                                               |
| 80.                     | 50.   | -100. |       |    |     |                                                                                                                                                                                               |
| 0.                      | 0.    | 0.    |       |    |     |                                                                                                                                                                                               |

|                               |                  |                               |
|-------------------------------|------------------|-------------------------------|
| 'PEM-ZEPS base, BDE20'        | 13.0 138.6 -43.7 | pointD: actual point N20      |
| 21                            | 0. 100. -50.     | Exterior point                |
| PlateA                        | 0. 0. 0.         | limit plane disp. (in pixels) |
| 1                             |                  |                               |
| flow on ext., int. or both    |                  |                               |
| pointA: actual point B20      |                  |                               |
| pointB: actual point D20      |                  |                               |
| pointC: actual point E20      |                  |                               |
| Exterior point                |                  |                               |
| limit plane disp. (in pixels) |                  |                               |
| 0.                            |                  |                               |
| Quadric 188                   |                  |                               |
| Component no.                 |                  |                               |
| flow on ext., int. or both    |                  |                               |
| pointA: actual point B20      |                  |                               |
| pointB: actual point D20      |                  |                               |
| pointC: actual point E20      |                  |                               |
| Exterior point                |                  |                               |
| limit plane disp. (in pixels) |                  |                               |
| 0.                            |                  |                               |
| Quadric 189                   |                  |                               |
| Component no.                 |                  |                               |
| flow on ext., int. or both    |                  |                               |
| pointA: actual point B20      |                  |                               |
| pointB: actual point D20      |                  |                               |
| pointC: actual point E20      |                  |                               |
| Exterior point                |                  |                               |
| limit plane disp. (in pixels) |                  |                               |
| 0.                            |                  |                               |
| Quadric 190                   |                  |                               |
| Component no.                 |                  |                               |
| flow on ext., int. or both    |                  |                               |
| pointA: actual point B20      |                  |                               |
| pointB: actual point D20      |                  |                               |
| pointC: actual point E20      |                  |                               |
| Exterior point                |                  |                               |
| limit plane disp. (in pixels) |                  |                               |
| 0.                            |                  |                               |
| Quadric 191                   |                  |                               |
| Component no.                 |                  |                               |
| flow on ext., int. or both    |                  |                               |
| pointA: actual point B20      |                  |                               |
| pointB: actual point D20      |                  |                               |
| pointC: actual point E20      |                  |                               |
| Exterior point                |                  |                               |
| limit plane disp. (in pixels) |                  |                               |
| 0.                            |                  |                               |
| Quadric 192                   |                  |                               |
| Component no.                 |                  |                               |
| flow on ext., int. or both    |                  |                               |
| pointA: actual point B20      |                  |                               |
| pointB: actual point D20      |                  |                               |
| pointC: actual point E20      |                  |                               |
| Exterior point                |                  |                               |
| limit plane disp. (in pixels) |                  |                               |
| 0.                            |                  |                               |
| Quadric 193                   |                  |                               |
| Component no.                 |                  |                               |
| flow on ext., int. or both    |                  |                               |
| pointA: actual point B20      |                  |                               |
| pointB: actual point D20      |                  |                               |
| pointC: actual point E20      |                  |                               |
| Exterior point                |                  |                               |
| limit plane disp. (in pixels) |                  |                               |
| 0.                            |                  |                               |
| Quadric 194                   |                  |                               |
| Component no.                 |                  |                               |
| flow on ext., int. or both    |                  |                               |
| pointA: actual point B20      |                  |                               |
| pointB: actual point D20      |                  |                               |
| pointC: actual point E20      |                  |                               |
| Exterior point                |                  |                               |
| limit plane disp. (in pixels) |                  |                               |
| 0.                            |                  |                               |
| Quadric 195                   |                  |                               |
| Component no.                 |                  |                               |
| flow on ext., int. or both    |                  |                               |
| pointA: actual point B20      |                  |                               |
| pointB: actual point D20      |                  |                               |
| pointC: actual point E20      |                  |                               |
| Exterior point                |                  |                               |
| limit plane disp. (in pixels) |                  |                               |
| 0.                            |                  |                               |
| Quadric 196                   |                  |                               |
| Component no.                 |                  |                               |
| flow on ext., int. or both    |                  |                               |
| pointA: actual point B20      |                  |                               |
| pointB: actual point D20      |                  |                               |
| pointC: actual point E20      |                  |                               |
| Exterior point                |                  |                               |
| limit plane disp. (in pixels) |                  |                               |
| 0.                            |                  |                               |
| Quadric 197                   |                  |                               |
| Component no.                 |                  |                               |
| flow on ext., int. or both    |                  |                               |
| pointA: actual point B20      |                  |                               |
| pointB: actual point D20      |                  |                               |
| pointC: actual point E20      |                  |                               |
| Exterior point                |                  |                               |
| limit plane disp. (in pixels) |                  |                               |
| 0.                            |                  |                               |
| Quadric 198                   |                  |                               |
| Component no.                 |                  |                               |
| flow on ext., int. or both    |                  |                               |
| pointA: actual point B20      |                  |                               |
| pointB: actual point D20      |                  |                               |
| pointC: actual point E20      |                  |                               |
| Exterior point                |                  |                               |
| limit plane disp. (in pixels) |                  |                               |
| 0.                            |                  |                               |
| Quadric 199                   |                  |                               |
| Component no.                 |                  |                               |
| flow on ext., int. or both    |                  |                               |
| pointA: actual point B20      |                  |                               |
| pointB: actual point D20      |                  |                               |
| pointC: actual point E20      |                  |                               |
| Exterior point                |                  |                               |
| limit plane disp. (in pixels) |                  |                               |
| 0.                            |                  |                               |



|                      |                               |                            |  |                 |  |                 |  |                               |  |
|----------------------|-------------------------------|----------------------------|--|-----------------|--|-----------------|--|-------------------------------|--|
| 'MLS LHS box AEGG22' |                               | Quadric 211                |  | 1               |  | 169.3 29.1 9.5  |  | flow on ext., int. or both    |  |
| 22                   | PlateB                        | Component no.              |  | 22              |  | 172.7 29.1 9.5  |  | pointA: actual point Q22      |  |
| 1                    | 150.4 44.1 35.3               | flow on ext., int. or both |  | 1               |  | 169.3 29.1 2.1  |  | pointB: actual point K22      |  |
| 150.4 44.1 21.4      | pointA: actual point A22      |                            |  | 172.7 29.1 2.1  |  | 172.7 29.1 2.1  |  | pointC: actual point Q22      |  |
| 150.4 3.2 35.3       | pointB: actual point E22      |                            |  | 100. 50. 0.     |  | 0. 0. 0.        |  | pointD: actual point M22      |  |
| 150.4 3.2 21.4       | pointC: actual point G22      |                            |  | 0. 0. 0.        |  | 0. 0. 0.        |  | Exterior point                |  |
| 100. -10. 40.        | pointD: actual point G22      |                            |  |                 |  |                 |  | limit plane disp. (in pixels) |  |
| 0. 0. 0.             | Exterior point                |                            |  |                 |  |                 |  |                               |  |
| 0. 0. 0.             | limit plane disp. (in pixels) |                            |  |                 |  |                 |  |                               |  |
| 'MLS LHS box EFLJ22' |                               | Quadric 212                |  | 1               |  | 169.3 3.2 9.5   |  | flow on ext., int. or both    |  |
| 22                   | PlateB                        | Component no.              |  | 22              |  | 172.7 3.2 9.5   |  | pointA: actual point R22      |  |
| 1                    | 150.4 44.1 21.4               | flow on ext., int. or both |  | 1               |  | 169.3 3.2 2.1   |  | pointB: actual point L22      |  |
| 172.7 44.1 21.4      | pointA: actual point E22      |                            |  | 172.7 3.2 2.1   |  | 172.7 3.2 2.1   |  | pointC: actual point P22      |  |
| 150.4 29.1 21.4      | pointB: actual point F22      |                            |  | 100. -50. 0.    |  | 0. 0. 0.        |  | pointD: actual point N22      |  |
| 150.4 29.1 21.4      | pointC: actual point I22      |                            |  | 0. 0. 0.        |  | 0. 0. 0.        |  | Exterior point                |  |
| 172.7 29.1 21.4      | pointD: actual point J22      |                            |  |                 |  |                 |  | limit plane disp. (in pixels) |  |
| 200. 50. 0.          | Exterior point                |                            |  |                 |  |                 |  |                               |  |
| 0. 0. 0.             | limit plane disp. (in pixels) |                            |  |                 |  |                 |  |                               |  |
| 'MLS LHS box IQJR22' |                               | Quadric 213                |  | 1               |  | 169.3 29.1 9.5  |  | flow on ext., int. or both    |  |
| 22                   | PlateB                        | Component no.              |  | 22              |  | 169.3 29.1 2.1  |  | pointA: actual point Q22      |  |
| 1                    | 150.4 29.1 21.4               | flow on ext., int. or both |  | 1               |  | 169.3 3.2 9.5   |  | pointB: actual point Q22      |  |
| 172.7 29.1 21.4      | pointA: actual point J22      |                            |  | 169.3 3.2 2.1   |  | 169.3 3.2 2.1   |  | pointC: actual point R22      |  |
| 169.3 29.1 9.5       | pointB: actual point J22      |                            |  | 100. -50. 0.    |  | 0. 0. 0.        |  | pointD: actual point P22      |  |
| 172.7 29.1 9.5       | pointC: actual point Q22      |                            |  | 0. 0. 0.        |  | 0. 0. 0.        |  | Exterior point                |  |
| 200. 50. 0.          | pointD: actual point K22      |                            |  |                 |  |                 |  | limit plane disp. (in pixels) |  |
| 0. 0. 0.             | Exterior point                |                            |  |                 |  |                 |  |                               |  |
| 0. 0. 0.             | limit plane disp. (in pixels) |                            |  |                 |  |                 |  |                               |  |
| 'MLS LHS box GHRL22' |                               | Quadric 214                |  | 1               |  | 185.0 15.9 26.9 |  | flow on ext., int. or both    |  |
| 22                   | PlateB                        | Component no.              |  | 22              |  | 217.3 15.9 34.8 |  | pointA: actual point B24      |  |
| 1                    | 150.4 3.2 21.4                | flow on ext., int. or both |  | 1               |  | 186.1 29.8 33.7 |  | pointB: actual point C24      |  |
| 172.7 3.2 21.4       | pointA: actual point G22      |                            |  | 216.3 29.8 41.0 |  | 216.3 29.8 41.0 |  | pointC: actual point D24      |  |
| 172.7 3.2 9.5        | pointB: actual point H22      |                            |  | 200. 50. 100.   |  | 0. 0. 0.        |  | pointD: actual point E24      |  |
| 169.3 3.2 9.5        | pointC: actual point R22      |                            |  | 0. 0. 0.        |  | 0. 0. 0.        |  | Exterior point                |  |
| 172.7 3.2 9.5        | pointD: actual point L22      |                            |  |                 |  |                 |  | limit plane disp. (in pixels) |  |
| 200. -50. 0.         | Exterior point                |                            |  |                 |  |                 |  |                               |  |
| 0. 0. 0.             | limit plane disp. (in pixels) |                            |  |                 |  |                 |  |                               |  |
| 'MLS LHS box JKHJ22' |                               | Quadric 215                |  | 1               |  | 186.1 29.8 33.7 |  | flow on ext., int. or both    |  |
| 22                   | PlateB                        | Component no.              |  | 22              |  | 216.3 29.8 41.0 |  | pointA: actual point D24      |  |
| 1                    | 172.7 29.1 21.4               | flow on ext., int. or both |  | 1               |  | 190.6 37.3 38.7 |  | pointB: actual point E24      |  |
| 172.7 29.1 9.5       | pointA: actual point J22      |                            |  | 210.7 37.3 44.0 |  | 210.7 37.3 44.0 |  | pointC: actual point H24      |  |
| 172.7 3.2 21.4       | pointB: actual point K22      |                            |  | 200. 50. 100.   |  | 0. 0. 0.        |  | pointD: actual point I24      |  |
| 172.7 3.2 9.5        | pointC: actual point H22      |                            |  | 0. 0. 0.        |  | 0. 0. 0.        |  | Exterior point                |  |
| 200. -50. 0.         | pointD: actual point L22      |                            |  |                 |  |                 |  | limit plane disp. (in pixels) |  |
| 0. 0. 0.             | Exterior point                |                            |  |                 |  |                 |  |                               |  |
| 0. 0. 0.             | limit plane disp. (in pixels) |                            |  |                 |  |                 |  |                               |  |
| 'MLS LHS box IQGR22' |                               | Quadric 216                |  | 1               |  | 190.6 37.3 38.7 |  | flow on ext., int. or both    |  |
| 22                   | PlateB                        | Component no.              |  | 22              |  | 210.7 37.3 44.0 |  | pointA: actual point H24      |  |
| 1                    | 150.4 29.1 21.4               | flow on ext., int. or both |  | 1               |  | 200.2 42.3 46.2 |  | pointB: actual point I24      |  |
| 169.3 29.1 9.5       | pointA: actual point I22      |                            |  | 200. 50. 100.   |  | 0. 0. 0.        |  | pointC: actual point L24      |  |
| 150.4 3.2 21.4       | pointB: actual point Q22      |                            |  | 0. 0. 0.        |  | 0. 0. 0.        |  | Exterior point                |  |
| 169.3 3.2 9.5        | pointC: actual point G22      |                            |  |                 |  |                 |  | limit plane disp. (in pixels) |  |
| 100. -50. 0.         | pointD: actual point R22      |                            |  |                 |  |                 |  |                               |  |
| 0. 0. 0.             | Exterior point                |                            |  |                 |  |                 |  |                               |  |
| 0. 0. 0.             | limit plane disp. (in pixels) |                            |  |                 |  |                 |  |                               |  |
| 'MLS LHS box QKOM22' |                               | Quadric 217                |  | 1               |  | 185.0 15.9 26.9 |  | flow on ext., int. or both    |  |
| 22                   | PlateB                        | Component no.              |  | 22              |  | 217.3 15.9 34.8 |  | pointA: actual point B24      |  |
| 1                    | 150.4 29.1 21.4               | flow on ext., int. or both |  | 1               |  | 186.1 5.5 23.2  |  | pointB: actual point C24      |  |
| 169.3 29.1 9.5       | pointA: actual point Q22      |                            |  |                 |  |                 |  | pointC: actual point F24      |  |
| 150.4 3.2 21.4       | pointB: actual point Q22      |                            |  |                 |  |                 |  |                               |  |
| 169.3 3.2 9.5        | pointC: actual point R22      |                            |  |                 |  |                 |  |                               |  |
| 100. -50. 0.         | pointD: actual point R22      |                            |  |                 |  |                 |  |                               |  |
| 0. 0. 0.             | Exterior point                |                            |  |                 |  |                 |  |                               |  |
| 0. 0. 0.             | limit plane disp. (in pixels) |                            |  |                 |  |                 |  |                               |  |



|               |      |       |                               |        |       |       |                               |
|---------------|------|-------|-------------------------------|--------|-------|-------|-------------------------------|
| 217.3         | 16.4 | 32.1  | pointB: actual point C24      | 100.   | 40.   | 40.   | Exterior point                |
| 216.3         | 5.5  | 30.5  | pointC: actual point G24      | 0.     | 0.    | 0.    | limit plane disp. (in pixels) |
| 216.3         | 5.7  | 27.8  | pointD: actual point G24      |        |       |       |                               |
| 250.          | 15.  | 40.   | Exterior point                |        |       |       |                               |
| 0.            | 0.   | 0.    | limit plane disp. (in pixels) |        |       |       |                               |
| Quadric 237   |      |       |                               |        |       |       |                               |
| Component no. |      |       |                               |        |       |       |                               |
| 22            |      |       |                               |        |       |       |                               |
| PlateB        |      |       |                               |        |       |       |                               |
| 1             |      |       | flow on ext., int. or both    |        |       |       |                               |
| 216.3         | 5.5  | 30.5  | pointA: actual point G24      | 189.5  | -6.1  | 20.9  | pointA: actual point J24      |
| 216.3         | 5.7  | 27.8  | pointB: actual point G24      | 189.5  | -6.3  | 18.2  | pointB: actual point J24      |
| 213.9         | -6.1 | 26.8  | pointC: actual point K24      | 201.6  | -16.8 | 21.1  | pointC: actual point M24      |
| 213.9         | -6.3 | 24.1  | pointD: actual point K24      | 201.6  | -17.3 | 18.4  | pointD: actual point M24      |
| 250.          | 0.   | 40.   | Exterior point                | 100.   | -20.  | 40.   | Exterior point                |
| 0.            | 0.   | 0.    | limit plane disp. (in pixels) | 0.     | 0.    | 0.    | limit plane disp. (in pixels) |
| Quadric 244   |      |       |                               |        |       |       |                               |
| Component no. |      |       |                               |        |       |       |                               |
| 22            |      |       |                               |        |       |       |                               |
| PlateB        |      |       |                               |        |       |       |                               |
| 1             |      |       | flow on ext., int. or both    |        |       |       |                               |
| 174.7         | 4.6  | 53.5  | pointA: actual point Q24      | 174.7  | 4.6   | 53.5  | pointA: actual point Q24      |
| 183.8         | 4.6  | 55.7  | pointB: actual point P24      | 183.8  | 4.6   | 55.7  | pointB: actual point P24      |
| 175.6         | 9.1  | 54.9  | pointC: actual point Q24      | 175.6  | 9.1   | 54.9  | pointC: actual point Q24      |
| 182.9         | 9.1  | 57.1  | pointD: actual point R24      | 182.9  | 9.1   | 57.1  | pointD: actual point R24      |
| 200.          | 0.   | 100.  | Exterior point                | 200.   | 0.    | 100.  | Exterior point                |
| 0.            | 0.   | 0.    | limit plane disp. (in pixels) | 0.     | 0.    | 0.    | limit plane disp. (in pixels) |
| Quadric 245   |      |       |                               |        |       |       |                               |
| Component no. |      |       |                               |        |       |       |                               |
| 22            |      |       |                               |        |       |       |                               |
| PlateA        |      |       |                               |        |       |       |                               |
| 1             |      |       | flow on ext., int. or both    |        |       |       |                               |
| 175.6         | 9.1  | 54.9  | pointA: actual point Q24      | 175.6  | 9.1   | 54.9  | pointA: actual point Q24      |
| 182.9         | 9.1  | 57.1  | pointB: actual point R24      | 182.9  | 9.1   | 57.1  | pointB: actual point R24      |
| 179.25        | 13.7 | 57.8  | pointC: actual point U24      | 179.25 | 13.7  | 57.8  | pointC: actual point U24      |
| 200.          | 0.   | 100.  | Exterior point                | 200.   | 0.    | 100.  | Exterior point                |
| 0.            | 0.   | 0.    | limit plane disp. (in pixels) | 0.     | 0.    | 0.    | limit plane disp. (in pixels) |
| Quadric 246   |      |       |                               |        |       |       |                               |
| Component no. |      |       |                               |        |       |       |                               |
| 22            |      |       |                               |        |       |       |                               |
| PlateB        |      |       |                               |        |       |       |                               |
| 1             |      |       | flow on ext., int. or both    |        |       |       |                               |
| 174.7         | 4.7  | 50.8  | pointA: actual point Q24      | 174.7  | 4.7   | 50.8  | pointA: actual point Q24      |
| 183.8         | 4.7  | 53.0  | pointB: actual point P24      | 183.8  | 4.7   | 53.0  | pointB: actual point P24      |
| 175.6         | 9.4  | 52.2  | pointC: actual point Q24      | 175.6  | 9.4   | 52.2  | pointC: actual point Q24      |
| 182.9         | 9.4  | 54.4  | pointD: actual point R24      | 182.9  | 9.4   | 54.4  | pointD: actual point R24      |
| 200.          | 0.   | -100. | Exterior point                | 200.   | 0.    | -100. | Exterior point                |
| 0.            | 0.   | 0.    | limit plane disp. (in pixels) | 0.     | 0.    | 0.    | limit plane disp. (in pixels) |
| Quadric 247   |      |       |                               |        |       |       |                               |
| Component no. |      |       |                               |        |       |       |                               |
| 22            |      |       |                               |        |       |       |                               |
| PlateA        |      |       |                               |        |       |       |                               |
| 1             |      |       | flow on ext., int. or both    |        |       |       |                               |
| 175.6         | 9.4  | 52.2  | pointA: actual point Q24      | 175.6  | 9.4   | 52.2  | pointA: actual point Q24      |
| 182.9         | 9.4  | 54.4  | pointB: actual point R24      | 182.9  | 9.4   | 54.4  | pointB: actual point R24      |
| 179.25        | 14.1 | 55.1  | pointC: actual point U24      | 179.25 | 14.1  | 55.1  | pointC: actual point U24      |
| 200.          | 0.   | -100. | Exterior point                | 200.   | 0.    | -100. | Exterior point                |
| 0.            | 0.   | 0.    | limit plane disp. (in pixels) | 0.     | 0.    | 0.    | limit plane disp. (in pixels) |
| Quadric 248   |      |       |                               |        |       |       |                               |
| Component no. |      |       |                               |        |       |       |                               |
| 22            |      |       |                               |        |       |       |                               |
| PlateB        |      |       |                               |        |       |       |                               |
| 1             |      |       | flow on ext., int. or both    |        |       |       |                               |
| 174.7         | 4.6  | 53.5  | pointA: actual point Q24      | 174.7  | 4.6   | 53.5  | pointA: actual point Q24      |
| 183.8         | 4.6  | 55.7  | pointB: actual point P24      | 183.8  | 4.6   | 55.7  | pointB: actual point P24      |
| 175.6         | 0.   | 52.1  | pointC: actual point S24      | 175.6  | 0.    | 52.1  | pointC: actual point S24      |
| 182.9         | 0.   | 54.3  | pointD: actual point T24      | 182.9  | 0.    | 54.3  | pointD: actual point T24      |
| 200.          | 0.   | 100.  | Exterior point                | 200.   | 0.    | 100.  | Exterior point                |
| 0.            | 0.   | 0.    | limit plane disp. (in pixels) | 0.     | 0.    | 0.    | limit plane disp. (in pixels) |
| Quadric 249   |      |       |                               |        |       |       |                               |
| Component no. |      |       |                               |        |       |       |                               |
| 22            |      |       |                               |        |       |       |                               |
| PlateB        |      |       |                               |        |       |       |                               |
| 1             |      |       | flow on ext., int. or both    |        |       |       |                               |
| 174.7         | 4.6  | 53.5  | pointA: actual point Q24      | 174.7  | 4.6   | 53.5  | pointA: actual point Q24      |
| 183.8         | 4.6  | 55.7  | pointB: actual point P24      | 183.8  | 4.6   | 55.7  | pointB: actual point P24      |
| 175.6         | 0.   | 52.1  | pointC: actual point S24      | 175.6  | 0.    | 52.1  | pointC: actual point S24      |
| 182.9         | 0.   | 54.3  | pointD: actual point T24      | 182.9  | 0.    | 54.3  | pointD: actual point T24      |
| 200.          | 0.   | 100.  | Exterior point                | 200.   | 0.    | 100.  | Exterior point                |
| 0.            | 0.   | 0.    | limit plane disp. (in pixels) | 0.     | 0.    | 0.    | limit plane disp. (in pixels) |
| Quadric 250   |      |       |                               |        |       |       |                               |
| Component no. |      |       |                               |        |       |       |                               |
| 22            |      |       |                               |        |       |       |                               |
| PlateB        |      |       |                               |        |       |       |                               |
| 1             |      |       | flow on ext., int. or both    |        |       |       |                               |
| 190.6         | 37.3 | 38.7  | pointA: actual point H24      | 190.6  | 37.3  | 38.7  | pointA: actual point H24      |
| 190.6         | 38.4 | 36.0  | pointB: actual point H24      | 190.6  | 38.4  | 36.0  | pointB: actual point H24      |
| 200.2         | 42.3 | 46.2  | pointC: actual point L24      | 200.2  | 42.3  | 46.2  | pointC: actual point L24      |
| 200.2         | 43.6 | 43.5  | pointD: actual point L24      | 200.2  | 43.6  | 43.5  | pointD: actual point L24      |







|                     |             |           |               |       |                               |       |                               |  |
|---------------------|-------------|-----------|---------------|-------|-------------------------------|-------|-------------------------------|--|
| 'HALOE mount BC27'  | Quadric 288 |           | Component no. |       | PlateB                        |       | flow on ext., int. or both    |  |
|                     | 26          | CylinderA | 1             |       | pointA: actual point J27      |       |                               |  |
|                     | 136.3       | -26.7     | -60.0         | 131.3 | -34.4                         | -53.2 | pointB: actual point K27      |  |
|                     | 136.3       | -28.7     | -60.0         | 131.3 | -34.4                         | -60.0 | pointC: actual point L27      |  |
|                     | 6.7         | 0.        |               | 131.3 | -40.6                         | -53.2 | pointD: actual point M27      |  |
|                     | 0.          | 0.        |               | 50.   | -50.                          | -50.  | Exterior point                |  |
|                     | 100.        | 150.      | -50.          | 0.    | 0.                            | 0.    | limit plane disp. (in pixels) |  |
|                     | F3I limits  |           | 0.            |       | limit plane disp. (in pixels) |       |                               |  |
|                     | Plane 19    |           | Component no. |       | PlateB                        |       |                               |  |
|                     | 26          |           | 1             |       | pointA: actual point F27      |       |                               |  |
| 'HALOE mount C27'   | Quadric 289 |           | Component no. |       | PlateB                        |       | flow on ext., int. or both    |  |
|                     | 136.3       | -28.7     | -60.0         | 141.3 | -34.4                         | -53.2 | pointB: actual point G27      |  |
|                     | 0.          | -1.       | 0.            | 141.3 | -34.4                         | -60.0 | pointC: actual point J27      |  |
|                     | 5.0         | 0.        |               | 131.3 | -34.4                         | -60.0 | pointD: actual point K27      |  |
|                     | 6.7         | 0.        |               | 150.  | 0.                            | -50.  | Exterior point                |  |
|                     | 100.        | 150.      | -50.          | 0.    | 0.                            | 0.    | limit plane disp. (in pixels) |  |
|                     | F3I limits  |           | 0.            |       | limit plane disp. (in pixels) |       |                               |  |
|                     | Plane 20    |           | Component no. |       | PlateB                        |       |                               |  |
|                     | 26          |           | 1             |       | pointA: actual point H27      |       |                               |  |
|                     | 136.3       | -33.3     | -60.0         | 141.3 | -40.6                         | -53.2 | pointB: actual point I27      |  |
| 'HALOE mount CD27'  | Quadric 290 |           | Component no. |       | PlateB                        |       | flow on ext., int. or both    |  |
|                     | 136.3       | -33.3     | -60.0         | 141.3 | -34.4                         | -53.2 | pointB: actual point N27      |  |
|                     | 0.          | 1.        | 0.            | 141.3 | -38.8                         | -49.4 | pointC: actual point N27      |  |
|                     | 4.6         | 0.        |               | 131.3 | -34.4                         | -53.2 | pointD: actual point R27      |  |
|                     | 5.0         | 0.        |               | 131.3 | -38.8                         | -49.4 | Exterior point                |  |
|                     | 100.        | 150.      | -50.          | 0.    | 0.                            | 0.    | limit plane disp. (in pixels) |  |
|                     | F3I limits  |           | 0.            |       | limit plane disp. (in pixels) |       |                               |  |
|                     | Plane 21    |           | Component no. |       | PlateB                        |       |                               |  |
|                     | 26          |           | 1             |       | pointA: actual point F27      |       |                               |  |
|                     | 136.3       | -33.3     | -60.0         | 141.3 | -34.4                         | -53.2 | pointB: actual point F27      |  |
| 'HALOE mount DE27'  | Quadric 291 |           | Component no. |       | PlateB                        |       | flow on ext., int. or both    |  |
|                     | 136.3       | -33.3     | -60.0         | 141.3 | -34.4                         | -53.2 | pointB: actual point F27      |  |
|                     | 0.          | -1.       | 0.            | 141.3 | -50.5                         | -49.4 | pointC: actual point F27      |  |
|                     | 5.0         | 0.        |               | 141.3 | -50.5                         | -53.2 | pointD: actual point Q27      |  |
|                     | 100.        | 150.      | -50.          | 0.    | 0.                            | 0.    | limit plane disp. (in pixels) |  |
|                     | F3I limits  |           | 0.            |       | limit plane disp. (in pixels) |       |                               |  |
|                     | Plane 22    |           | Component no. |       | PlateB                        |       |                               |  |
|                     | 26          |           | 1             |       | pointA: actual point F27      |       |                               |  |
|                     | 136.3       | -33.3     | -60.0         | 141.3 | -34.4                         | -53.2 | pointB: actual point F27      |  |
|                     | 0.          | -1.       | 0.            | 141.3 | -50.5                         | -49.4 | pointC: actual point F27      |  |
| 'HALOE mount FG127' | Quadric 292 |           | Component no. |       | PlateB                        |       | flow on ext., int. or both    |  |
|                     | 136.3       | -33.3     | -60.0         | 141.3 | -34.4                         | -53.2 | pointB: actual point F27      |  |
|                     | 0.          | -1.       | 0.            | 141.3 | -50.5                         | -49.4 | pointC: actual point F27      |  |
|                     | 5.0         | 0.        |               | 141.3 | -50.5                         | -53.2 | pointD: actual point U27      |  |
|                     | 100.        | 150.      | -50.          | 0.    | 0.                            | 0.    | limit plane disp. (in pixels) |  |
|                     | F3I limits  |           | 0.            |       | limit plane disp. (in pixels) |       |                               |  |
|                     | Plane 23    |           | Component no. |       | PlateB                        |       |                               |  |
|                     | 26          |           | 1             |       | pointA: actual point F27      |       |                               |  |
|                     | 136.3       | -33.3     | -60.0         | 141.3 | -34.4                         | -53.2 | pointB: actual point F27      |  |
|                     | 0.          | -1.       | 0.            | 141.3 | -50.5                         | -49.4 | pointC: actual point F27      |  |
| 'HALOE mount JKL27' | Quadric 293 |           | Component no. |       | PlateB                        |       | flow on ext., int. or both    |  |
|                     | 136.3       | -33.3     | -60.0         | 141.3 | -34.4                         | -53.2 | pointB: actual point F27      |  |
|                     | 0.          | -1.       | 0.            | 141.3 | -50.5                         | -49.4 | pointC: actual point F27      |  |
|                     | 5.0         | 0.        |               | 141.3 | -50.5                         | -53.2 | pointD: actual point U27      |  |
|                     | 100.        | 150.      | -50.          | 0.    | 0.                            | 0.    | limit plane disp. (in pixels) |  |
|                     | F3I limits  |           | 0.            |       | limit plane disp. (in pixels) |       |                               |  |
|                     | Plane 24    |           | Component no. |       | PlateB                        |       |                               |  |
|                     | 26          |           | 1             |       | pointA: actual point F27      |       |                               |  |
|                     | 136.3       | -33.3     | -60.0         | 141.3 | -34.4                         | -53.2 | pointB: actual point F27      |  |
|                     | 0.          | -1.       | 0.            | 141.3 | -50.5                         | -49.4 | pointC: actual point F27      |  |

|               |       |       |                               |       |       |       |                               |
|---------------|-------|-------|-------------------------------|-------|-------|-------|-------------------------------|
| 131.3         | -40.6 | -53.2 | pointB: actual point L27      | 147.6 | -55.4 | -56.3 | pointC: actual point I28      |
| 141.3         | -50.5 | -53.2 | pointC: actual point Q27      | 121.0 | -55.4 | -56.3 | pointD: actual point J28      |
| 131.3         | -50.5 | -53.2 | pointD: actual point U27      | 150.  | -50.  | 0.    | Exterior point                |
| 150.          | -50.  | -100. | limit plane disp. (in pixels) | 0.    | 0.    | 0.    | limit plane disp. (in pixels) |
| 0.            | 0.    | 0.    |                               |       |       |       |                               |
| Quadric 299   |       |       |                               |       |       |       |                               |
| Component no. |       |       |                               |       |       |       |                               |
| PlateB        |       |       |                               |       |       |       |                               |
| 1             |       |       | flow on ext., int. or both    |       |       |       |                               |
| 141.3         | -38.8 | -49.4 | pointA: actual point N27      | 121.0 | -52.7 | -66.7 | pointA: actual point B28      |
| 131.3         | -38.8 | -49.4 | pointB: actual point R27      | 121.0 | -55.4 | -66.7 | pointB: actual point D28      |
| 141.3         | -50.5 | -49.4 | pointC: actual point P27      | 121.0 | -52.7 | -56.3 | pointC: actual point H28      |
| 131.3         | -50.5 | -49.4 | pointD: actual point T27      | 121.0 | -55.4 | -56.3 | pointD: actual point J28      |
| 250.          | -50.  | 0.    | Exterior point                | 50.   | -50.  | -100. | Exterior point                |
| 0.            | 0.    | 0.    | limit plane disp. (in pixels) | 0.    | 0.    | 0.    | limit plane disp. (in pixels) |
| 0.            | 0.    | 0.    |                               |       |       |       |                               |
| Quadric 300   |       |       |                               |       |       |       |                               |
| Component no. |       |       |                               |       |       |       |                               |
| PlateB        |       |       |                               |       |       |       |                               |
| 1             |       |       | flow on ext., int. or both    |       |       |       |                               |
| 136.3         | -50.5 | -49.4 | pointA                        | 147.6 | -55.4 | -66.7 | pointA: actual point C28      |
| 136.3         | -50.5 | -56.3 | pointB                        | 121.0 | -55.4 | -66.7 | pointB: actual point D28      |
| 5.0           |       |       | radius                        | 145.0 | -61.8 | -66.7 | pointC: actual point E28      |
| 0.            | 0.    |       | limit plane disp. (in pixels) | 133.8 | -61.8 | -66.7 | pointD: actual point F28      |
| 100.          | 160.  | -80.  | F31 limits                    | 150.  | -50.  | -100. | Exterior point                |
| -80.          | -30.  |       |                               | 0.    | 0.    | 0.    | limit plane disp. (in pixels) |
| Quadric 301   |       |       |                               |       |       |       |                               |
| Component no. |       |       |                               |       |       |       |                               |
| PlateB        |       |       |                               |       |       |       |                               |
| 1             |       |       | flow on ext., int. or both    |       |       |       |                               |
| 136.3         | -50.5 | -49.4 | pointA                        | 147.6 | -55.4 | -56.3 | pointA: actual point I28      |
| 136.3         | -50.5 | -47.4 | pointB                        | 121.0 | -55.4 | -56.3 | pointB: actual point J28      |
| 1.1           | 0.    | -1.   | radius1                       | 145.0 | -61.8 | -56.3 | pointC: actual point K28      |
| 5.0           |       |       | radius2                       | 133.8 | -61.8 | -56.3 | pointD: actual point L28      |
| 0.            | 0.    |       | limit plane disp. (in pixels) | 150.  | -50.  | 0.    | Exterior point                |
| 100.          | 160.  | -80.  | F31 limits                    | 0.    | 0.    | 0.    | limit plane disp. (in pixels) |
| -80.          | -30.  |       |                               |       |       |       |                               |
| Quadric 302   |       |       |                               |       |       |       |                               |
| Component no. |       |       |                               |       |       |       |                               |
| PlateB        |       |       |                               |       |       |       |                               |
| 1             |       |       | flow on ext., int. or both    |       |       |       |                               |
| 147.6         | -52.7 | -66.7 | pointA: actual point A28      | 145.0 | -61.8 | -66.7 | pointA: actual point E28      |
| 121.0         | -52.7 | -66.7 | pointB: actual point B28      | 145.0 | -61.8 | -56.3 | pointB: actual point F28      |
| 147.6         | -55.4 | -66.7 | pointC: actual point C28      | 133.8 | -61.8 | -56.3 | pointC: actual point K28      |
| 121.0         | -55.4 | -66.7 | pointD: actual point D28      | 150.  | -100. | 0.    | pointD: actual point L28      |
| 150.          | -50.  | -100. | Exterior point                | 0.    | 0.    | 0.    | Exterior point                |
| 0.            | 0.    | 0.    | limit plane disp. (in pixels) | 0.    | 0.    | 0.    | limit plane disp. (in pixels) |
| 0.            | 0.    | 0.    |                               |       |       |       |                               |
| Quadric 303   |       |       |                               |       |       |       |                               |
| Component no. |       |       |                               |       |       |       |                               |
| PlateB        |       |       |                               |       |       |       |                               |
| 1             |       |       | flow on ext., int. or both    |       |       |       |                               |
| 147.6         | -52.7 | -56.3 | pointA: actual point G28      | 121.0 | -55.4 | -66.7 | pointA: actual point D28      |
| 121.0         | -52.7 | -56.3 | pointB: actual point H28      | 133.8 | -61.8 | -66.7 | pointB: actual point F28      |
| 0.            | 0.    | 0.    | limit plane disp. (in pixels) | 133.8 | -61.8 | -56.3 | pointC: actual point J28      |
| 0.            | 0.    | 0.    |                               | 50.   | -100. | 0.    | pointD: actual point L28      |
| 0.            | 0.    | 0.    |                               |       |       |       | Exterior point                |

[illegible]



|                                 |    |    |                               |   |                             |                                                                                                                                                                                               |
|---------------------------------|----|----|-------------------------------|---|-----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0.                              | 0. | 0. | limit plane disp. (in pixels) | 1 | 63.7 -73.2 -2.1             | flow on ext., int. or both<br>pointA: actual point H15<br>pointB: actual point G15<br>pointC: actual point K15<br>pointD: actual point L15<br>Exterior point<br>limit plane disp. (in pixels) |
| 'ISAMS box UVVZ15'              |    |    | Quadic 334                    |   | 79.6 -73.2 -2.1             |                                                                                                                                                                                               |
| 16                              |    |    | Component no.                 |   | 63.7 -83.5 -2.1             |                                                                                                                                                                                               |
| PlateB                          |    |    |                               |   | 79.6 -83.5 -2.1             |                                                                                                                                                                                               |
| 0                               |    |    |                               |   | 70. -80. 0.                 |                                                                                                                                                                                               |
| 44.8 -76.2 -21.7                |    |    | flow on ext., int. or both    |   | 0. 0. 0.                    |                                                                                                                                                                                               |
| 57.3 -76.2 -21.7                |    |    | pointA: actual point U15      |   |                             |                                                                                                                                                                                               |
| 57.3 -76.2 -21.7                |    |    | pointB: actual point V15      |   |                             |                                                                                                                                                                                               |
| 44.8 -91.2 -25.5                |    |    | pointC: actual point Y15      |   |                             |                                                                                                                                                                                               |
| 57.3 -91.2 -25.5                |    |    | pointD: actual point Z15      |   |                             |                                                                                                                                                                                               |
| 50. -80. -80.                   |    |    | Exterior point                |   |                             |                                                                                                                                                                                               |
| 0.                              | 0. | 0. | limit plane disp. (in pixels) |   |                             |                                                                                                                                                                                               |
| 'ISAMS box PRTV15'              |    |    | Quadic 335                    |   | 79.6 -73.2 -15.9            |                                                                                                                                                                                               |
| 16                              |    |    | Component no.                 |   | 79.6 -73.2 -2.1             |                                                                                                                                                                                               |
| PlateB                          |    |    |                               |   | 79.6 -83.5 -15.9            |                                                                                                                                                                                               |
| 1                               |    |    |                               |   | 79.6 -83.5 -2.1             |                                                                                                                                                                                               |
| 57.3 -61.2 11.6                 |    |    | flow on ext., int. or both    |   | 100. -80. -10.              |                                                                                                                                                                                               |
| 57.3 -61.2 -25.5                |    |    | pointA: actual point R15      |   | 0. 0. 0.                    |                                                                                                                                                                                               |
| 57.3 -76.2 7.8                  |    |    | pointB: actual point S15      |   |                             |                                                                                                                                                                                               |
| 57.3 -76.2 -21.7                |    |    | pointC: actual point T15      |   |                             |                                                                                                                                                                                               |
| 150. -70. 0.                    |    |    | pointD: actual point V15      |   |                             |                                                                                                                                                                                               |
| 0.                              | 0. | 0. | Exterior point                |   |                             |                                                                                                                                                                                               |
| 'ISAMS box SUTV15'              |    |    | limit plane disp. (in pixels) |   |                             |                                                                                                                                                                                               |
| 16                              |    |    | Quadic 336                    |   | 63.7 -73.2 -15.9            |                                                                                                                                                                                               |
| PlateB                          |    |    | Component no.                 |   | 63.7 -73.2 -2.1             |                                                                                                                                                                                               |
| 1                               |    |    |                               |   | 63.7 -83.5 -15.9            |                                                                                                                                                                                               |
| 44.8 -76.2 7.8                  |    |    | flow on ext., int. or both    |   | 63.7 -83.5 -2.1             |                                                                                                                                                                                               |
| 44.8 -76.2 -21.7                |    |    | pointA: actual point S15      |   | 50. -80. -10.               |                                                                                                                                                                                               |
| 57.3 -76.2 7.8                  |    |    | pointB: actual point U15      |   | 0. 0. 0.                    |                                                                                                                                                                                               |
| 57.3 -76.2 -21.7                |    |    | pointC: actual point T15      |   |                             |                                                                                                                                                                                               |
| 50. -150. 0.                    |    |    | pointD: actual point V15      |   |                             |                                                                                                                                                                                               |
| 0.                              | 0. | 0. | Exterior point                |   |                             |                                                                                                                                                                                               |
| 'ISAMS box OLS15'               |    |    | limit plane disp. (in pixels) |   |                             |                                                                                                                                                                                               |
| 16                              |    |    | Quadic 337                    |   | 97.5 46.0 14.0              |                                                                                                                                                                                               |
| PlateA                          |    |    | Component no.                 |   | 0. -0.8706 -0.4921          |                                                                                                                                                                                               |
| 1                               |    |    |                               |   | 11.4                        |                                                                                                                                                                                               |
| 44.8 -61.2 11.6                 |    |    | flow on ext., int. or both    |   |                             |                                                                                                                                                                                               |
| 44.8 -76.2 11.6                 |    |    | pointA: actual point Q15      |   |                             |                                                                                                                                                                                               |
| 44.8 -76.2 7.8                  |    |    | pointB: actual point L15      |   |                             |                                                                                                                                                                                               |
| 150. -80. 0.                    |    |    | pointC: actual point S15      |   |                             |                                                                                                                                                                                               |
| 0.                              | 0. | 0. | Exterior point                |   |                             |                                                                                                                                                                                               |
| 'ISAMS box QNU15'               |    |    | limit plane disp. (in pixels) |   |                             |                                                                                                                                                                                               |
| 16                              |    |    | Quadic 338                    |   | 0. 0.                       |                                                                                                                                                                                               |
| PlateA                          |    |    | Component no.                 |   | 50. 150. 30. 70. 0. 30.     |                                                                                                                                                                                               |
| 1                               |    |    |                               |   |                             |                                                                                                                                                                                               |
| 44.8 -61.2 -25.5                |    |    | flow on ext., int. or both    |   |                             |                                                                                                                                                                                               |
| 44.8 -76.2 -25.5                |    |    | pointA: actual point Q15      |   |                             |                                                                                                                                                                                               |
| 44.8 -76.2 -21.7                |    |    | pointB: actual point N15      |   |                             |                                                                                                                                                                                               |
| 150. -80. 0.                    |    |    | pointC: actual point U15      |   |                             |                                                                                                                                                                                               |
| 0.                              | 0. | 0. | Exterior point                |   |                             |                                                                                                                                                                                               |
| 'NEPS DCIJ15'                   |    |    | limit plane disp. (in pixels) |   |                             |                                                                                                                                                                                               |
| 7                               |    |    | Quadic 339                    |   | 258.3 -45.4 37.068          |                                                                                                                                                                                               |
| PlateB                          |    |    | Component no.                 |   | 0. -0.5 -0.866              |                                                                                                                                                                                               |
| 1                               |    |    |                               |   | 6.3                         |                                                                                                                                                                                               |
| 63.7 -73.2 -15.9                |    |    | flow on ext., int. or both    |   |                             |                                                                                                                                                                                               |
| 79.6 -73.2 -15.9                |    |    | pointA: actual point D15      |   |                             |                                                                                                                                                                                               |
| 63.7 -83.5 -15.9                |    |    | pointB: actual point C15      |   |                             |                                                                                                                                                                                               |
| 79.6 -83.5 -15.9                |    |    | pointC: actual point I15      |   |                             |                                                                                                                                                                                               |
| 70. -80. -50.                   |    |    | pointD: actual point J15      |   |                             |                                                                                                                                                                                               |
| 0.                              | 0. | 0. | Exterior point                |   |                             |                                                                                                                                                                                               |
| 'NEPS HGKL15'                   |    |    | limit plane disp. (in pixels) |   |                             |                                                                                                                                                                                               |
| 7                               |    |    | Quadic 340                    |   | 200. 300. -60. -30. 20. 50. |                                                                                                                                                                                               |
| PlateB                          |    |    | Component no.                 |   | 0.                          |                                                                                                                                                                                               |
| 1                               |    |    |                               |   |                             |                                                                                                                                                                                               |
| 63.7 -73.2 -15.9                |    |    | flow on ext., int. or both    |   |                             |                                                                                                                                                                                               |
| 79.6 -73.2 -15.9                |    |    | pointA: actual point D15      |   |                             |                                                                                                                                                                                               |
| 63.7 -83.5 -15.9                |    |    | pointB: actual point C15      |   |                             |                                                                                                                                                                                               |
| 79.6 -83.5 -15.9                |    |    | pointC: actual point I15      |   |                             |                                                                                                                                                                                               |
| 70. -80. -50.                   |    |    | pointD: actual point J15      |   |                             |                                                                                                                                                                                               |
| 0.                              | 0. | 0. | Exterior point                |   |                             |                                                                                                                                                                                               |
| 'NEPS DHIK15'                   |    |    | limit plane disp. (in pixels) |   |                             |                                                                                                                                                                                               |
| 7                               |    |    | Quadic 342                    |   | 63.7 -73.2 -15.9            |                                                                                                                                                                                               |
| PlateB                          |    |    | Component no.                 |   | 63.7 -73.2 -2.1             |                                                                                                                                                                                               |
| 1                               |    |    |                               |   | 63.7 -83.5 -15.9            |                                                                                                                                                                                               |
| 63.7 -73.2 -15.9                |    |    | flow on ext., int. or both    |   | 63.7 -83.5 -2.1             |                                                                                                                                                                                               |
| 63.7 -73.2 -2.1                 |    |    | pointA: actual point D15      |   | 50. -80. -10.               |                                                                                                                                                                                               |
| 63.7 -83.5 -15.9                |    |    | pointB: actual point H15      |   | 0. 0. 0.                    |                                                                                                                                                                                               |
| 63.7 -83.5 -2.1                 |    |    | pointC: actual point I15      |   |                             |                                                                                                                                                                                               |
| 50. -80. -10.                   |    |    | pointD: actual point K15      |   |                             |                                                                                                                                                                                               |
| 0.                              | 0. | 0. | Exterior point                |   |                             |                                                                                                                                                                                               |
| 'Plane 26 (back face)'          |    |    | limit plane disp. (in pixels) |   |                             |                                                                                                                                                                                               |
| Component no.                   |    |    | Quadic 343                    |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    | Component no.                 |   |                             |                                                                                                                                                                                               |
| direction cosine normal to disk |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| flow on ext., int. or both      |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointB                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| limit plane disp. (in pixels)   |    |    |                               |   |                             |                                                                                                                                                                                               |
| F3I limits                      |    |    |                               |   |                             |                                                                                                                                                                                               |
| Plane 27 (back face)            |    |    |                               |   |                             |                                                                                                                                                                                               |
| Component no.                   |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| dircos                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| flow on ext., int. or both      |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointB                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| limit plane disp. (in pixels)   |    |    |                               |   |                             |                                                                                                                                                                                               |
| F3I limits                      |    |    |                               |   |                             |                                                                                                                                                                                               |
| Plane 27 (back face)            |    |    |                               |   |                             |                                                                                                                                                                                               |
| Component no.                   |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| dircos                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| flow on ext., int. or both      |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointB                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| limit plane disp. (in pixels)   |    |    |                               |   |                             |                                                                                                                                                                                               |
| F3I limits                      |    |    |                               |   |                             |                                                                                                                                                                                               |
| Plane 27 (back face)            |    |    |                               |   |                             |                                                                                                                                                                                               |
| Component no.                   |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| dircos                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| flow on ext., int. or both      |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointB                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| limit plane disp. (in pixels)   |    |    |                               |   |                             |                                                                                                                                                                                               |
| F3I limits                      |    |    |                               |   |                             |                                                                                                                                                                                               |
| Plane 27 (back face)            |    |    |                               |   |                             |                                                                                                                                                                                               |
| Component no.                   |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| dircos                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| flow on ext., int. or both      |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointB                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| limit plane disp. (in pixels)   |    |    |                               |   |                             |                                                                                                                                                                                               |
| F3I limits                      |    |    |                               |   |                             |                                                                                                                                                                                               |
| Plane 27 (back face)            |    |    |                               |   |                             |                                                                                                                                                                                               |
| Component no.                   |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| dircos                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| flow on ext., int. or both      |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointB                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| limit plane disp. (in pixels)   |    |    |                               |   |                             |                                                                                                                                                                                               |
| F3I limits                      |    |    |                               |   |                             |                                                                                                                                                                                               |
| Plane 27 (back face)            |    |    |                               |   |                             |                                                                                                                                                                                               |
| Component no.                   |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| dircos                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| flow on ext., int. or both      |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointB                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| limit plane disp. (in pixels)   |    |    |                               |   |                             |                                                                                                                                                                                               |
| F3I limits                      |    |    |                               |   |                             |                                                                                                                                                                                               |
| Plane 27 (back face)            |    |    |                               |   |                             |                                                                                                                                                                                               |
| Component no.                   |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| dircos                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| flow on ext., int. or both      |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointB                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| limit plane disp. (in pixels)   |    |    |                               |   |                             |                                                                                                                                                                                               |
| F3I limits                      |    |    |                               |   |                             |                                                                                                                                                                                               |
| Plane 27 (back face)            |    |    |                               |   |                             |                                                                                                                                                                                               |
| Component no.                   |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| dircos                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| flow on ext., int. or both      |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointB                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| limit plane disp. (in pixels)   |    |    |                               |   |                             |                                                                                                                                                                                               |
| F3I limits                      |    |    |                               |   |                             |                                                                                                                                                                                               |
| Plane 27 (back face)            |    |    |                               |   |                             |                                                                                                                                                                                               |
| Component no.                   |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| dircos                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| flow on ext., int. or both      |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointB                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| limit plane disp. (in pixels)   |    |    |                               |   |                             |                                                                                                                                                                                               |
| F3I limits                      |    |    |                               |   |                             |                                                                                                                                                                                               |
| Plane 27 (back face)            |    |    |                               |   |                             |                                                                                                                                                                                               |
| Component no.                   |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| dircos                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| flow on ext., int. or both      |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointB                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| limit plane disp. (in pixels)   |    |    |                               |   |                             |                                                                                                                                                                                               |
| F3I limits                      |    |    |                               |   |                             |                                                                                                                                                                                               |
| Plane 27 (back face)            |    |    |                               |   |                             |                                                                                                                                                                                               |
| Component no.                   |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| dircos                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| flow on ext., int. or both      |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointB                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| limit plane disp. (in pixels)   |    |    |                               |   |                             |                                                                                                                                                                                               |
| F3I limits                      |    |    |                               |   |                             |                                                                                                                                                                                               |
| Plane 27 (back face)            |    |    |                               |   |                             |                                                                                                                                                                                               |
| Component no.                   |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| dircos                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| flow on ext., int. or both      |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointB                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| limit plane disp. (in pixels)   |    |    |                               |   |                             |                                                                                                                                                                                               |
| F3I limits                      |    |    |                               |   |                             |                                                                                                                                                                                               |
| Plane 27 (back face)            |    |    |                               |   |                             |                                                                                                                                                                                               |
| Component no.                   |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| dircos                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| flow on ext., int. or both      |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointB                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| limit plane disp. (in pixels)   |    |    |                               |   |                             |                                                                                                                                                                                               |
| F3I limits                      |    |    |                               |   |                             |                                                                                                                                                                                               |
| Plane 27 (back face)            |    |    |                               |   |                             |                                                                                                                                                                                               |
| Component no.                   |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| dircos                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| flow on ext., int. or both      |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointB                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| limit plane disp. (in pixels)   |    |    |                               |   |                             |                                                                                                                                                                                               |
| F3I limits                      |    |    |                               |   |                             |                                                                                                                                                                                               |
| Plane 27 (back face)            |    |    |                               |   |                             |                                                                                                                                                                                               |
| Component no.                   |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| dircos                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| flow on ext., int. or both      |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointB                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| limit plane disp. (in pixels)   |    |    |                               |   |                             |                                                                                                                                                                                               |
| F3I limits                      |    |    |                               |   |                             |                                                                                                                                                                                               |
| Plane 27 (back face)            |    |    |                               |   |                             |                                                                                                                                                                                               |
| Component no.                   |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| dircos                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| flow on ext., int. or both      |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointB                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| limit plane disp. (in pixels)   |    |    |                               |   |                             |                                                                                                                                                                                               |
| F3I limits                      |    |    |                               |   |                             |                                                                                                                                                                                               |
| Plane 27 (back face)            |    |    |                               |   |                             |                                                                                                                                                                                               |
| Component no.                   |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| dircos                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| flow on ext., int. or both      |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointB                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| limit plane disp. (in pixels)   |    |    |                               |   |                             |                                                                                                                                                                                               |
| F3I limits                      |    |    |                               |   |                             |                                                                                                                                                                                               |
| Plane 27 (back face)            |    |    |                               |   |                             |                                                                                                                                                                                               |
| Component no.                   |    |    |                               |   |                             |                                                                                                                                                                                               |
| pointA                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| dircos                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| radius                          |    |    |                               |   |                             |                                                                                                                                                                                               |
| flow on ext., int. or both      |    |    |                               |   |                             |                                                                                                                                                                                               |

|               |       |       |                               |       |                               |
|---------------|-------|-------|-------------------------------|-------|-------------------------------|
| 133.0         | -74.3 | -3.2  | pointB: actual point b13      | 0.5   | radius                        |
| 143.3         | -65.3 | -11.2 | pointC: actual point e13      |       |                               |
| 143.3         | -65.3 | -3.2  | pointD: actual point f13      |       |                               |
| 120.          | -40.  | -10.  | Exterior point                |       |                               |
| 0.            | 0.    | 0.    | limit plane disp. (in pixels) |       |                               |
| Quadric 346   |       |       |                               |       |                               |
| Component no. |       |       |                               |       |                               |
| 1             | 12.0  | 45.1  | 2.1                           | 2.1   | flow on ext., int. or both    |
| 1             | 60.0  | 45.1  | 2.1                           | 2.1   | pointA: actual point A31      |
| 141.3         | -34.4 | -60.0 | 12.0                          | 44.1  | pointB: actual point B31      |
| 141.3         | -40.6 | -60.0 | 60.0                          | 44.1  | pointC: actual point E31      |
| 131.3         | -34.4 | -60.0 | 40.                           | 70.   | pointD: actual point F31      |
| 131.3         | -40.6 | -60.0 | 0.                            | 0.    | Exterior point                |
| 135.          | -36.  | -90.  | 0.                            | 0.    | limit plane disp. (in pixels) |
| 0.            | 0.    | 0.    |                               |       |                               |
| Quadric 347   |       |       |                               |       |                               |
| Component no. |       |       |                               |       |                               |
| 1             | 12.0  | 43.1  | 2.1                           | 2.1   | flow on ext., int. or both    |
| 1             | 60.0  | 43.1  | 2.1                           | 2.1   | pointA: actual point C31      |
| 141.3         | -50.5 | -49.4 | 12.0                          | 44.1  | pointB: actual point D31      |
| 141.3         | -50.5 | -53.2 | 60.0                          | 44.1  | pointC: actual point E31      |
| 131.3         | -50.5 | -49.4 | 40.                           | -70.  | pointD: actual point F31      |
| 131.3         | -50.5 | -53.2 | 0.                            | 0.    | Exterior point                |
| 135.          | -70.  | -50.  | 0.                            | 0.    | limit plane disp. (in pixels) |
| 0.            | 0.    | 0.    |                               |       |                               |
| Quadric 348   |       |       |                               |       |                               |
| Component no. |       |       |                               |       |                               |
| 1             | 12.0  | 45.1  | 2.1                           | 2.1   | flow on ext., int. or both    |
| 1             | 60.0  | 45.1  | 2.1                           | 2.1   | pointA: actual point A31      |
| 71.0          | 2.7   | 53.0  | 12.0                          | 43.1  | pointB: actual point D31      |
| 0.            | 1.    | 0.    | 60.0                          | 44.1  | pointC: actual point F31      |
| 1.0           |       |       | 100.                          | 0.0   | Exterior point                |
| 60.           | 80.   | -10.  | 0.                            | 0.    | limit plane disp. (in pixels) |
| 40.           | 60.   |       |                               |       |                               |
| Quadric 349   |       |       |                               |       |                               |
| Component no. |       |       |                               |       |                               |
| 1             | 171.4 | 30.8  | -42.5                         | -42.5 | flow on ext., int. or both    |
| 1             | 60.0  | 43.1  | 2.1                           | 2.1   | pointA: actual point A4       |
| 71.0          | 1.7   | 53.0  | 136.3                         | -23.6 | pointB: actual point C4       |
| 0.            | -1.   | 0.    | 171.4                         | 30.8  | pointC: actual point F4       |
| 1.0           |       |       | 136.3                         | -23.6 | pointD: actual point G4       |
| 60.           | 80.   | -10.  | 136.                          | 0.    | Exterior point                |
| 40.           | 60.   |       | 0.                            | -50.  | limit plane disp. (in pixels) |
|               |       |       |                               |       |                               |
| Quadric 350   |       |       |                               |       |                               |
| Component no. |       |       |                               |       |                               |
| 1             | 12.0  | 45.1  | 2.1                           | 2.1   | flow on ext., int. or both    |
| 1             | 60.0  | 45.1  | 2.1                           | 2.1   | pointA: actual point A31      |
| 71.0          | 2.7   | 53.0  | 12.0                          | 43.1  | pointB: actual point D31      |
| 0.            | 1.    | 0.    | 60.0                          | 44.1  | pointC: actual point F31      |
| 1.0           |       |       | 100.                          | 0.0   | Exterior point                |
| 60.           | 80.   | -10.  | 0.                            | 0.    | limit plane disp. (in pixels) |
| 40.           | 60.   |       |                               |       |                               |
| Quadric 351   |       |       |                               |       |                               |
| Component no. |       |       |                               |       |                               |
| 1             | 12.0  | 43.1  | 2.1                           | 2.1   | flow on ext., int. or both    |
| 1             | 60.0  | 43.1  | 2.1                           | 2.1   | pointA: actual point C31      |
| 141.3         | -50.5 | -49.4 | 12.0                          | 44.1  | pointB: actual point E31      |
| 141.3         | -50.5 | -53.2 | 60.0                          | 44.1  | pointC: actual point F31      |
| 131.3         | -50.5 | -49.4 | 40.                           | -70.  | Exterior point                |
| 131.3         | -50.5 | -53.2 | 0.                            | 0.    | limit plane disp. (in pixels) |
| 135.          | -70.  | -50.  |                               |       |                               |
| 0.            | 0.    | 0.    |                               |       |                               |
| Quadric 352   |       |       |                               |       |                               |
| Component no. |       |       |                               |       |                               |
| 1             | 12.0  | 45.1  | 2.1                           | 2.1   | flow on ext., int. or both    |
| 1             | 60.0  | 45.1  | 2.1                           | 2.1   | pointA: actual point A31      |
| 71.0          | 2.7   | 53.0  | 12.0                          | 43.1  | pointB: actual point C31      |
| 0.            | 1.    | 0.    | 60.0                          | 44.1  | pointC: actual point E31      |
| 1.0           |       |       | 100.                          | 0.0   | Exterior point                |
| 60.           | 80.   | -10.  | 0.                            | 0.    | limit plane disp. (in pixels) |
| 40.           | 60.   |       |                               |       |                               |
| Quadric 353   |       |       |                               |       |                               |
| Component no. |       |       |                               |       |                               |
| 1             | 12.0  | 45.1  | 2.1                           | 2.1   | flow on ext., int. or both    |
| 1             | 60.0  | 45.1  | 2.1                           | 2.1   | pointA: actual point B31      |
| 71.0          | 1.7   | 53.0  | 12.0                          | 43.1  | pointB: actual point D31      |
| 0.            | 0.    | 0.    | 60.0                          | 44.1  | pointC: actual point F31      |
| 1.0           |       |       | 100.                          | 0.0   | Exterior point                |
| 60.           | 80.   | -10.  | 0.                            | 0.    | limit plane disp. (in pixels) |
| 40.           | 60.   |       |                               |       |                               |
| Quadric 354   |       |       |                               |       |                               |
| Component no. |       |       |                               |       |                               |
| 1             | 171.4 | 30.8  | -42.5                         | -42.5 | flow on ext., int. or both    |
| 1             | 60.0  | 43.1  | 2.1                           | 2.1   | pointA: actual point A4       |
| 71.0          | 1.7   | 53.0  | 136.3                         | -23.6 | pointB: actual point C4       |
| 0.            | -1.   | 0.    | 171.4                         | 30.8  | pointC: actual point F4       |
| 1.0           |       |       | 136.3                         | -23.6 | pointD: actual point G4       |
| 60.           | 80.   | -10.  | 136.                          | 0.    | Exterior point                |
| 40.           | 60.   |       | 0.                            | -50.  | limit plane disp. (in pixels) |
|               |       |       |                               |       |                               |
| Quadric 355   |       |       |                               |       |                               |
| Component no. |       |       |                               |       |                               |
| 1             | 12.0  | 43.1  | 2.1                           | 2.1   | flow on ext., int. or both    |
| 1             | 60.0  | 43.1  | 2.1                           | 2.1   | pointA: actual point C31      |
| 141.3         | -50.5 | -49.4 | 12.0                          | 44.1  | pointB: actual point E31      |
| 141.3         | -50.5 | -53.2 | 60.0                          | 44.1  | pointC: actual point F31      |
| 131.3         | -50.5 | -49.4 | 40.                           | -70.  | Exterior point                |
| 131.3         | -50.5 | -53.2 | 0.                            | 0.    | limit plane disp. (in pixels) |
| 135.          | -70.  | -50.  |                               |       |                               |
| 0.            | 0.    | 0.    |                               |       |                               |
| Quadric 356   |       |       |                               |       |                               |
| Component no. |       |       |                               |       |                               |
| 1             | 12.0  | 45.1  | 2.1                           | 2.1   | flow on ext., int. or both    |
| 1             | 60.0  | 45.1  | 2.1                           | 2.1   | pointA: actual point A31      |
| 71.0          | 2.7   | 53.0  | 12.0                          | 43.1  | pointB: actual point D31      |
| 0.            | 1.    | 0.    | 60.0                          | 44.1  | pointC: actual point F31      |
| 1.0           |       |       | 100.                          | 0.0   | Exterior point                |
| 60.           | 80.   | -10.  | 0.                            | 0.    | limit plane disp. (in pixels) |
| 40.           | 60.   |       |                               |       |                               |

Table 4: Input Data Listing—Subassembly Rotation Data

|                                                             |                                         |
|-------------------------------------------------------------|-----------------------------------------|
| Case 1 Rotation Data:                                       |                                         |
| HALOE rotation (theta = 6 deg)                              |                                         |
| 28                                                          | How many subelements? (List follows)    |
| 325 326 327 328 329 330 331 332 333 334 335 336 337 338     |                                         |
| 339 340 341 342 343 344 345 346 347 348 349 350 351 352     |                                         |
| 6.                                                          | Rot. angle from baseline geometry (deg) |
| 136.3 -50.5 -56.3                                           |                                         |
| z                                                           | Coords. of rotating origin              |
|                                                             | Axis of rotation                        |
| -----                                                       |                                         |
| solar panel rotation (theta = 6 deg)                        |                                         |
| 7                                                           | How many subelements? (List follows)    |
| 93 94 95 96 97 98 99                                        |                                         |
| -84.                                                        | Rot. angle from baseline geometry (deg) |
| 136.1 56.3 -55.5                                            |                                         |
| z                                                           | Coords. of rotating origin              |
|                                                             | Axis of rotation                        |
| -----                                                       |                                         |
| Case 2 Rotation Data:                                       |                                         |
| HALOE rotation (theta = -23.6 deg)                          |                                         |
| 28                                                          | How many subelements? (List follows)    |
| 325 326 327 328 329 330 331 332 333 334 335 336 337 338     |                                         |
| 339 340 341 342 343 344 345 346 347 348 349 350 351 352     |                                         |
| -23.6                                                       | Rot. angle from baseline geometry (deg) |
| 136.3 -50.5 -56.3                                           |                                         |
| z                                                           | Coords. of rotating origin              |
|                                                             | Axis of rotation                        |
| -----                                                       |                                         |
| solar panel rotation (theta = -23.6 deg)                    |                                         |
| 7                                                           | How many subelements? (List follows)    |
| 93 94 95 96 97 98 99                                        |                                         |
| -113.6                                                      | Rot. angle from baseline geometry (deg) |
| 136.1 56.3 -55.5                                            |                                         |
| z                                                           | Coords. of rotating origin              |
|                                                             | Axis of rotation                        |
| -----                                                       |                                         |
| Case 3 Rotation Data:                                       |                                         |
| HALOE rotation (theta = -25 deg)                            |                                         |
| 28                                                          | How many subelements? (List follows)    |
| 325 326 327 328 329 330 331 332 333 334 335 336 337 338     |                                         |
| 339 340 341 342 343 344 345 346 347 348 349 350 351 352     |                                         |
| -25.                                                        | Rot. angle from baseline geometry (deg) |
| 136.3 -50.5 -56.3                                           |                                         |
| z                                                           | Coords. of rotating origin              |
|                                                             | Axis of rotation                        |
| -----                                                       |                                         |
| HALOE rotation (alpha = 45 deg)                             |                                         |
| 43                                                          | How many subelements? (List follows)    |
| 312 313 314 315 316 317 318 319 320 321 322 323 324 325     |                                         |
| 326 327 328 329 330 331 332 333 334 335 336 337 338 339     |                                         |
| 340 341 342 343 344 345 346 347 348 349 350 351 352 373 374 |                                         |
| 135.                                                        | Rot. angle from baseline geometry (deg) |
| 136.3 -41.0 -60.0                                           |                                         |
| y                                                           | Coords. of rotating origin              |
|                                                             | Axis of rotation                        |
| -----                                                       |                                         |
| solar panel rotation (theta = 84 deg)                       |                                         |
| 7                                                           | How many subelements (List follows)     |
| 93 94 95 96 97 98 99                                        |                                         |
| 84.                                                         | Rot. angle from baseline geometry (deg) |
| 136.1 56.3 -55.5                                            |                                         |
| z                                                           | Coords. of rotating origin              |
|                                                             | Axis of rotation                        |

Table 5: Typical Elemental Outgassing Data

| Data                         |      |            |      | Description                                                                                                     |
|------------------------------|------|------------|------|-----------------------------------------------------------------------------------------------------------------|
| 'Main block top plate ABCD1' |      |            |      | Quadric 1                                                                                                       |
| 1                            |      |            |      | number of outgassing surfaces on object                                                                         |
| PlateB                       |      |            |      | shape of outgassing surface                                                                                     |
| 1                            | 0    |            |      | flow direction code, outgassing index,<br>(0 if entire surface has one rate, or no. of defining points)         |
| 0.                           | 1.   | 0.6264E+17 | 100. | mole fractions of outgassing species,<br>total outgassing flux [molecules/m <sup>2</sup> /sec], ref. temp. [°C] |
| 'Main block side Zmax CDGH1' |      |            |      | Quadric 2                                                                                                       |
| 2                            |      |            |      | number of outgassing surfaces on object                                                                         |
| PlateB                       |      |            |      | shape of outgassing surface #1, entire surface                                                                  |
| 1                            | 0    |            |      | flow direction code, outgassing index,<br>(0 if entire surface has one rate, or no. of defining points)         |
| 0.                           | 1.   | 0.6264E+17 | 100. | mole fractions of outgassing species,<br>total outgassing flux [molecules/m <sup>2</sup> /sec], ref. temp. [°C] |
| PlateB                       |      |            |      | shape of outgassing surface #2, vent above CLAES                                                                |
| 1                            | 4    |            |      | flow direction code, outgassing index,<br>(number of defining points)                                           |
| 1.                           | 0.   | 0.7649E+20 | 100. | mole fractions of outgassing species,<br>total outgassing flux [molecules/m <sup>2</sup> /sec], ref. temp. [°C] |
| 12.                          | 43.1 | 2.1        |      | pointA for vent                                                                                                 |
| 60.                          | 43.1 | 2.1        |      | pointB for vent                                                                                                 |
| 12.                          | 45.1 | 2.1        |      | pointC for vent                                                                                                 |
| 60.                          | 45.1 | 2.1        |      | pointD for vent                                                                                                 |

Table 6: Input Data Listing—Outgassing Information (19 pgs.)

|                                |                                                   |  |  |
|--------------------------------|---------------------------------------------------|--|--|
| 'Main block top plate ABCD0'   |                                                   |  |  |
| 3                              | Number of different outgassing surfaces on object |  |  |
| PlateB                         |                                                   |  |  |
| 1                              | 0                                                 |  |  |
| 0.                             | 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate          |  |  |
| (Number/m2/sec), ref temp(C)   |                                                   |  |  |
| 'Front small plate Xmax EFHG1' |                                                   |  |  |
| 1                              | Number of different outgassing surfaces on object |  |  |
| PlateB                         |                                                   |  |  |
| 1                              | 0                                                 |  |  |
| 0.                             | 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate          |  |  |
| (Number/m2/sec), ref temp(C)   |                                                   |  |  |
| 'Front small plate Ymin DHCG1' |                                                   |  |  |
| 1                              | Number of different outgassing surfaces on object |  |  |
| PlateB                         |                                                   |  |  |
| 1                              | 0                                                 |  |  |
| 0.                             | 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate          |  |  |
| (Number/m2/sec), ref temp(C)   |                                                   |  |  |
| 'Front small plate Ymax ABEE1' |                                                   |  |  |
| 1                              | Number of different outgassing surfaces on object |  |  |
| PlateB                         |                                                   |  |  |
| 1                              | 0                                                 |  |  |
| 0.                             | 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate          |  |  |
| (Number/m2/sec), ref temp(C)   |                                                   |  |  |
| 'Front small plate Zmin AEDH1' |                                                   |  |  |
| 1                              | Number of different outgassing surfaces on object |  |  |
| PlateB                         |                                                   |  |  |
| 1                              | 0                                                 |  |  |
| 0.                             | 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate          |  |  |
| (Number/m2/sec), ref temp(C)   |                                                   |  |  |
| 'Front small plate Zmax BFCG1' |                                                   |  |  |
| 1                              | Number of different outgassing surfaces on object |  |  |
| PlateB                         |                                                   |  |  |
| 1                              | 0                                                 |  |  |
| 0.                             | 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate          |  |  |
| (Number/m2/sec), ref temp(C)   |                                                   |  |  |
| 'CLAES big cap'                |                                                   |  |  |
| 1                              | Number of different outgassing surfaces on object |  |  |
| SphereE                        |                                                   |  |  |
| 1                              | 0                                                 |  |  |
| 0.                             | 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate          |  |  |
| (Number/m2/sec), ref temp(C)   |                                                   |  |  |
| 'CLAES fat cylindrical part'   |                                                   |  |  |
| 1                              | Number of different outgassing surfaces on object |  |  |
| CylinderA                      |                                                   |  |  |
| 1                              | 0                                                 |  |  |
| 0.                             | 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate          |  |  |
| (Number/m2/sec), ref temp(C)   |                                                   |  |  |
| 'CLAES small cylindrical part' |                                                   |  |  |
| 1                              | Number of different outgassing surfaces on object |  |  |
| CylinderA                      |                                                   |  |  |
| 1                              | 0                                                 |  |  |
| 0.                             | 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate          |  |  |
| (Number/m2/sec), ref temp(C)   |                                                   |  |  |
| 'CLAES Ring'                   |                                                   |  |  |
| 1                              | Number of different outgassing surfaces on object |  |  |
| RingA                          |                                                   |  |  |
| 1                              | 0                                                 |  |  |
| 0.                             | 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate          |  |  |
| (Number/m2/sec), ref temp(C)   |                                                   |  |  |
| 'CLAES small cap'              |                                                   |  |  |
| 1                              |                                                   |  |  |

|                                |                                                   |        |  |
|--------------------------------|---------------------------------------------------|--------|--|
| 'Main block top plate ABCD0'   |                                                   |        |  |
| 3                              | Number of different outgassing surfaces on object |        |  |
| PlateB                         |                                                   |        |  |
| 1                              | 0                                                 |        |  |
| 0.                             | 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate          |        |  |
| (Number/m2/sec), ref temp(C)   |                                                   |        |  |
| 'Front small plate Xmax EFHG1' |                                                   |        |  |
| 1                              | Number of different outgassing surfaces on object |        |  |
| PlateB                         |                                                   |        |  |
| 1                              | 4                                                 |        |  |
| 0.                             | 0. 0. 1. 0. 0. 7.35E+17 100. outgas rate          |        |  |
| (Number/m2/sec), ref temp(C)   |                                                   |        |  |
| 4.0                            | 48.1 -42.25                                       | pointA |  |
| 4.0                            | 48.1 -42.5                                        | pointB |  |
| 14.0                           | 48.1 -42.25                                       | pointC |  |
| 14.0                           | 48.1 -42.5                                        | pointD |  |
| 'Main block side Zmax DCHG0'   |                                                   |        |  |
| 1                              | Number of different outgassing surfaces on object |        |  |
| PlateB                         |                                                   |        |  |
| 1                              | 0                                                 |        |  |
| 0.                             | 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate          |        |  |
| (Number/m2/sec), ref temp(C)   |                                                   |        |  |
| 'Main block side Zmin ABEE0'   |                                                   |        |  |
| 1                              | Number of different outgassing surfaces on object |        |  |
| PlateB                         |                                                   |        |  |
| 1                              | 0                                                 |        |  |
| 0.                             | 0. 0. 0. 1. 1.62E+15 100. outgas rate             |        |  |
| (Number/m2/sec), ref temp(C)   |                                                   |        |  |
| 'Main block bottom EFHJ0'      |                                                   |        |  |
| 1                              | Number of different outgassing surfaces on object |        |  |
| PlateB                         |                                                   |        |  |
| 1                              | 0                                                 |        |  |
| 0.                             | 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate          |        |  |
| (Number/m2/sec), ref temp(C)   |                                                   |        |  |
| 'Main block Xmin ADEH0'        |                                                   |        |  |
| 1                              | Number of different outgassing surfaces on object |        |  |
| PlateB                         |                                                   |        |  |
| 1                              | 0                                                 |        |  |
| 0.                             | 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate          |        |  |
| (Number/m2/sec), ref temp(C)   |                                                   |        |  |
| 'Main block Xmax BCFG0'        |                                                   |        |  |
| 2                              | Number of different outgassing surfaces on object |        |  |
| PlateB                         |                                                   |        |  |
| 1                              | 0                                                 |        |  |
| 0.                             | 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate          |        |  |
| (Number/m2/sec), ref temp(C)   |                                                   |        |  |
| 'Main block Ymin ABCD1'        |                                                   |        |  |
| 1                              | Number of different outgassing surfaces on object |        |  |
| PlateB                         |                                                   |        |  |
| 1                              | 4                                                 |        |  |
| 0.                             | 0. 0. 1. 0. 0. 7.35E+17 100. outgas rate          |        |  |
| (Number/m2/sec), ref temp(C)   |                                                   |        |  |
| 218.0                          | 43.1 -42.25                                       | pointA |  |
| 218.0                          | 43.1 -42.5                                        | pointB |  |
| 218.0                          | 33.1 -42.25                                       | pointC |  |
| 218.0                          | 33.1 -42.5                                        | pointD |  |
| 'Front small plate Xmin ABCD1' |                                                   |        |  |
| 1                              | Number of different outgassing surfaces on object |        |  |



```

'Battery package side BDHF3 higher X'
1
PlateA
0 0
Number of different outgassing surfaces on object
0. 0. 0. 1. 0. 0. 1.62E+15 100. outgas rate
(Number/m2/sec), ref temp(C)
0. 0. 0. 1. 0. 0. 1.62E+15 100. outgas rate
(Number/m2/sec), ref temp(C)

'NEPS ABCD5'
1
PlateB
0 0
Number of different outgassing surfaces on object
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'NEPS BFDH5'
1
PlateB
0 0
Number of different outgassing surfaces on object
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'NEPS FEHG5'
1
PlateB
0 0
Number of different outgassing surfaces on object
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'NEPS EAGC5'
1
PlateB
0 0
Number of different outgassing surfaces on object
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'NEPS JLIK5'
1
PlateB
0 0
Number of different outgassing surfaces on object
0. 0. 0. 1. 0. 0. 3.09E+15 100. outgas rate
(Number/m2/sec), ref temp(C)

'Thin box under main block ABCD6'
1
PlateB
0 0
Number of different outgassing surfaces on object
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'Thin box under main block CDGH6'
1
PlateB
0 0
Number of different outgassing surfaces on object
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'Thin box under main block DHBFG'
1
PlateB
0 0
Number of different outgassing surfaces on object
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'Thin box under main block EAGC6'
1
PlateB
0 0
Number of different outgassing surfaces on object
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'Battery package side BDHF3 higher X'
1
PlateB
0 0
Number of different outgassing surfaces on object
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'Battery package side HJNL3 higher X'
1
PlateB
0 0
Number of different outgassing surfaces on object
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'Battery package side NPBR3 higher X'
1
PlateB
0 0
Number of different outgassing surfaces on object
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'Battery package side AGM3 lower X'
1
PlateA
0 0
Number of different outgassing surfaces on object
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'Battery Cylindrical MMS'
1
CylinderB
0 0
Number of different outgassing surfaces on object
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'Battery MMS plane bottom'
1
Disk
0 0
Number of different outgassing surfaces on object
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE mount ABC4'
1
PlateA
0 0
Number of different outgassing surfaces on object
0. 0. 0. 1. 0. 0. 1.62E+15 100. outgas rate
(Number/m2/sec), ref temp(C)
0. 0. 0. 1. 0. 0. 1.62E+15 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE mount ACD4'
1
PlateA
0 0
Number of different outgassing surfaces on object
0. 0. 0. 1. 0. 0. 1.62E+15 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE mount CDE4'
1
PlateA
0 0
Number of different outgassing surfaces on object
0. 0. 0. 1. 0. 0. 1.62E+15 100. outgas rate
(Number/m2/sec), ref temp(C)
0. 0. 0. 1. 0. 0. 1.62E+15 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE mount BCE4'
1
PlateA
0 0
Number of different outgassing surfaces on object
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

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(Number/m2/sec), ref temp(C)
'Box under main block AECG7'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'Box under main block EFGH7'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'Box under main block BFDH7'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'Box under main block LCDH7'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'Box under main block CGDH7'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'HRDI interferometer ABCD8'
0
'HRDI interferometer BFDH8'
0
'HRDI interferometer HGFH8'
0
'HRDI interferometer ABCG8'
0
'HRDI interferometer AEJH8'
0
'HRDI interferometer CDGH8'
0
'cylindrical truss #1 at X = 0.'
1
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'cylindrical truss #2 at X = 0.'
1
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'cylindrical truss #3 at X = 0.'
1
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'cylindrical truss #4 at X = 0.'
1
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'cylindrical truss #5 at X = 0.'
1
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'cylindrical truss #6 at X = 0.'
1
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'Sphere junctn betwn trusses 1-2(X=0)'
0
'Sphere junctn betwn trusses 3-4(X=0)'
0
'Sphere junctn betwn trusses 5-6(X=0)'
0
'left-hand HGA-end box AFDI10'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'left-hand HGA-end box ABDE10'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'left-hand HGA-end box BCE10'
1
PlateA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'left/right-hand HGA-end box ABFG10'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'left/right-hand HGA-end box BCGH10'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

```

```

0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'left-hand HGA-end box CHEJ10'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'left/right-hand HGA-end box DELJ10'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'right-hand HGA-end box GHJK11'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'right-hand HGA-end box CEF11'
1
PlateA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'right-hand HGA-end box HIKL11'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'right-hand HGA-end box CIFL11'
0
Number of different outgassing surfaces on object

'right-hand HGA-end box EFKL11'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HGA-end nose box CIMN11'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HGA-end nose box MNFL11'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HGA-end nose box CHF11'
1
PlateA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HGA-end nose box INL11'
1
PlateA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'solar panel mount ABCD12'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'solar panel mount EFGH12'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'solar panel mount AECG12'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'solar panel mount BFDH12'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'solar panel mount ABEF12'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'solar panel support IJ12'
1
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'solar panel support J12'
1
SphereE
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'solar panel support JK12'
1
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'solar panel support JL12'
1
CylinderC
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

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```

1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'SSPP box BFDH14'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'SSPP box AEGG14'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'ISAMS box ABCD15'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'ISAMS box EFGH15'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'ISAMS box BFDH15'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'ISAMS box ABEF15'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'ISAMS box AKEH15'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'ISAMS box CDKL15'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'ISAMS box GHMN15'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'ISAMS box KLMN15'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'ISAMS box IJPR15'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'ISAMS box DHIJ15'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HGA antenna AB16'
1      Number of different outgassing surfaces on object
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HGA antenna A16'
1      Number of different outgassing surfaces on object
SphereE
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HGA antenna B16'
1      Number of different outgassing surfaces on object
Disk
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HGA antenna CD16'
1      Number of different outgassing surfaces on object
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HGA antenna C16'
1      Number of different outgassing surfaces on object
Disk
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HGA antenna D16'
1      Number of different outgassing surfaces on object
SphereE
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HGA antenna DE16'
1      Number of different outgassing surfaces on object
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

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'HCA antenna EJ6'
1      Number of different outgassing surfaces on object
SphereC
0 0
0. 0. 0. 0. 1. 1.62E+15 100. outgas rate
(Number/m2/sec), ref temp(C)
0. 0. 0. 0. 1. 1.62E+15 100. outgas rate
(Number/m2/sec), ref temp(C)

'CLAES lower mount, ABC17'
1      Number of different outgassing surfaces on object
PlateA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'CLAES lower mount, DEF17'
1      Number of different outgassing surfaces on object
PlateA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'CLAES lower mount, ACD17'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'CLAES lower mount, BCE17'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'CLAES upper mount, GHI17'
1      Number of different outgassing surfaces on object
PlateA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'CLAES upper mount, JKL17'
1      Number of different outgassing surfaces on object
PlateA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'CLAES upper mount, GJL17'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'CLAES upper mount, HIKL17'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'WINDII base, ABCD18'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 2.61E+13 100. outgas rate
(Number/m2/sec), ref temp(C)

'WINDII base, OPQR18'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 2.61E+13 100. outgas rate
(Number/m2/sec), ref temp(C)

'WINDII base, DBOPI8'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 2.61E+13 100. outgas rate
(Number/m2/sec), ref temp(C)

'WINDII base, ACRQ18'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 2.61E+13 100. outgas rate
(Number/m2/sec), ref temp(C)

'WINDII base, DFO18'
1      Number of different outgassing surfaces on object
PlateA
1 0
0. 0. 0. 1. 0. 0. 2.61E+13 100. outgas rate
(Number/m2/sec), ref temp(C)

'WINDII base, CEO18'
1      Number of different outgassing surfaces on object
PlateA
1 0
0. 0. 0. 1. 0. 0. 2.61E+13 100. outgas rate
(Number/m2/sec), ref temp(C)

'WINDII base, FNO18'
1      Number of different outgassing surfaces on object
PlateA
1 0
0. 0. 0. 1. 0. 0. 2.61E+13 100. outgas rate
(Number/m2/sec), ref temp(C)

'WINDII base, EMQ18'
1      Number of different outgassing surfaces on object
PlateA
1 0
0. 0. 0. 1. 0. 0. 2.61E+13 100. outgas rate
(Number/m2/sec), ref temp(C)

'WINDII base, HFN18'
1      Number of different outgassing surfaces on object
PlateA
1 0
0. 0. 0. 1. 0. 0. 2.61E+13 100. outgas rate
(Number/m2/sec), ref temp(C)

'WINDII base, GEM18'
1      Number of different outgassing surfaces on object
PlateA
1 0
0. 0. 0. 1. 0. 0. 2.61E+13 100. outgas rate
(Number/m2/sec), ref temp(C)

'WINDII base, CDEF18'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 2.61E+13 100. outgas rate
(Number/m2/sec), ref temp(C)

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PlateB
1 0
0. 0. 0. 1. 0. 0. 2.61E+13 100. outgas rate
(Number/m2/sec), ref temp(C)

'WINDII base, MNQ018'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 2.61E+13 100. outgas rate
(Number/m2/sec), ref temp(C)

'WINDII base, MNKL18'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 2.61E+13 100. outgas rate
(Number/m2/sec), ref temp(C)

'WINDII base, GH1J18'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 2.61E+13 100. outgas rate
(Number/m2/sec), ref temp(C)

'WINDII base, IJKL18'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 2.61E+13 100. outgas rate
(Number/m2/sec), ref temp(C)

'WINDII base, HJNL18'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 2.61E+13 100. outgas rate
(Number/m2/sec), ref temp(C)

'WINDII base, IGMW18'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 2.61E+13 100. outgas rate
(Number/m2/sec), ref temp(C)

'PEM-AXIS base, ABCD19'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'PEM-AXIS base, EFGH19'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'PEM-AXIS base, AECG19'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'PEM-AXIS base, BFDH19'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'PEM-AXIS base, CDGH19'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'PEM-AXIS base, AEBF19'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'PEM-AXIS base, KLMN19'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'PEM-AXIS base, OFQR19'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'PEM-AXIS base, KOMQ19'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'PEM-AXIS base, LPNR19'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'PEM-AXIS base, MNQR19'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'PEM-AXIS antenna JI19'
1
ConeD
0 0
0. 0. 0. 0. 0. 1. 0. 100. outgas rate
(Number/m2/sec), ref temp(C)

'PEM-AXIS antenna J19'
1
Disk
1 0
0. 0. 0. 0. 0. 1. 1.62E+15 100. outgas rate
(Number/m2/sec), ref temp(C)

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(Number/m2/sec), ref temp(C)

'PEM-AXIS base, ST19'
1      Number of different outgassing surfaces on object
CylinderA
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'PEM-ZEPS base, ABC20'
1      Number of different outgassing surfaces on object
PlateA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'PEM-ZEPS base, ABD20'
1      Number of different outgassing surfaces on object
PlateA
1 0
0. 0. 0. 1. 0. 0. 1.62E+15 100. outgas rate
(Number/m2/sec), ref temp(C)

'PEM-ZEPS base, BCE20'
1      Number of different outgassing surfaces on object
PlateA
1 0
0. 0. 0. 1. 0. 0. 1.62E+15 100. outgas rate
(Number/m2/sec), ref temp(C)

'PEM-ZEPS base, BDE20'
1      Number of different outgassing surfaces on object
PlateA
1 0
0. 0. 0. 1. 0. 0. 1.62E+15 100. outgas rate
(Number/m2/sec), ref temp(C)

'PEM-ZEPS base, Fc20'
1      Number of different outgassing surfaces on object
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'PEM-ZEPS base, G20'
1      Number of different outgassing surfaces on object
RingA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'PEM-ZEPS box HIJK20'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 0. 1. 0. 3.09E+15 100. outgas rate
(Number/m2/sec), ref temp(C)

'PEM-ZEPS box LMNO20'
0      Number of different outgassing surfaces on object

'PEM-ZEPS box JKN020'
0      Number of different outgassing surfaces on object

'PEM-ZEPS box HJLM20'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 0. 1. 0. 3.09E+15 100. outgas rate
(Number/m2/sec), ref temp(C)

'PEM-ZEPS box HILM20'
0      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 0. 1. 0. 3.09E+15 100. outgas rate
(Number/m2/sec), ref temp(C)

'PEM-ZEPS box IKMO20'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 0. 1. 0. 3.09E+15 100. outgas rate
(Number/m2/sec), ref temp(C)

'PEM-ZEPS shaft (approx.) FQ20'
0      Number of different outgassing surfaces on object

'MLS gizmo box ABCD21'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS gizmo box EFGH21'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS gizmo box EFAB21'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS gizmo box BFDE21'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS gizmo box AECG21'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS gizmo box CDGH21'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS box behind antenna IJKL21'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS box behind antenna JNLP21'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

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(Number/m2/sec), ref temp(C)

'MLS small antenna QRU24'
1
PlateA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS small antenna OPST24'
0
Number of different outgassing surfaces on object

'MLS small antenna STV24'
0
Number of different outgassing surfaces on object

'MLS small antenna OPST24'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS small antenna STV24'
1
PlateA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS small antenna PPR24'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS small antenna PPT24'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS small antenna RRU24'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS small antenna TTV24'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS small antenna OQQ24'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS small antenna OOS24'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

(Number/m2/sec), ref temp(C)

'MLS small antenna QQU24'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS small antenna SSV24'
1
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS antenna arm, RHS ABCD25'
1
PlateB
0 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS antenna arm, RHS EF25'
1
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS antenna arm, RHS E25'
1
Disk
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS antenna arm, RHS F25'
1
Disk
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS antenna arm, back GH25'
1
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS antenna arm, back IJ25'
1
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS antenna arm, back H25'
1
SphereE
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS antenna arm, back J25'
1
1
Number of different outgassing surfaces on object

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SphereE
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS antenna arm, back G25'
Number of different outgassing surfaces on object
SphereA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS antenna arm, back I25'
Number of different outgassing surfaces on object
SphereA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS antenna arm, back I25'
Number of different outgassing surfaces on object
SphereA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS antenna arm, between GK25'
Number of different outgassing surfaces on object
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS antenna arm, between IL25'
Number of different outgassing surfaces on object
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS antenna arm, side K25'
Number of different outgassing surfaces on object
SphereA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'MLS antenna arm, side L25'
Number of different outgassing surfaces on object
SphereA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HGA-side bracework AB23'
Number of different outgassing surfaces on object
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HGA-side bracework CB23'
Number of different outgassing surfaces on object
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HGA-side bracework EB23'
Number of different outgassing surfaces on object
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HGA-side bracework GB23'
Number of different outgassing surfaces on object
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HGA-side bracework IJ23'
Number of different outgassing surfaces on object
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HGA-side bracework KJ23'
Number of different outgassing surfaces on object
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HGA-side bracework MJ23'
Number of different outgassing surfaces on object
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HGA-side bracework OJ23'
Number of different outgassing surfaces on object
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HGA-side bracework QR23'
Number of different outgassing surfaces on object
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HGA-side bracework SR23'
Number of different outgassing surfaces on object
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'Sphere junctn B23'
Number of different outgassing surfaces on object
0

'Sphere junctn J23'
Number of different outgassing surfaces on object
0

'Sphere junctn R23'
Number of different outgassing surfaces on object
0

'Dish above CLAES'
Number of different outgassing surfaces on object
0

'Thrusters, AC26'
Number of different outgassing surfaces on object
1
ConeA
0 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
0. 0. 0. 0. 1. 0. 3.09E+15 100. outgas rate
(Number/m2/sec), ref temp(C)

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'Thrusters, BD26'
1      Number of different outgassing surfaces on object
ConeA
0 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
0. 0. 0. 0. 1. 0. 3.09E+15 100. outgas rate
(Number/m2/sec), ref temp(C)
'HALOE mount A27'
1      Number of different outgassing surfaces on object
Disk
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'HALOE mount AB27'
1      Number of different outgassing surfaces on object
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'HALOE mount B27'
1      Number of different outgassing surfaces on object
RingA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'HALOE mount BC27'
1      Number of different outgassing surfaces on object
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'HALOE mount C27'
1      Number of different outgassing surfaces on object
RingA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'HALOE mount CD27'
1      Number of different outgassing surfaces on object
ConeD
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'HALOE mount D27'
1      Number of different outgassing surfaces on object
RingA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'HALOE mount DE27'
1      Number of different outgassing surfaces on object
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'HALOE mount E27'
1      Number of different outgassing surfaces on object
Disk
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'HALOE mount FGH127'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'HALOE mount FGJK27'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'HALOE mount HILM27'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'HALOE mount FNJR27'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'HALOE mount NFPQ27'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'HALOE mount RJTU27'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'HALOE mount HLQU27'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'HALOE mount NRPT27'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
'HALOE mount VW27'
1      Number of different outgassing surfaces on object
CylinderA

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```

1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE mount V27'
1 Number of different outgassing surfaces on object
1 RingA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE mount VX27'
1 Number of different outgassing surfaces on object
1 CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE mount X27'
1 Number of different outgassing surfaces on object
1 Disk
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE box ABCD28'
1 Number of different outgassing surfaces on object
1 PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE box GHIJ28'
1 Number of different outgassing surfaces on object
1 PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE box BDHI28'
1 Number of different outgassing surfaces on object
1 PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE box CDEF28'
1 Number of different outgassing surfaces on object
1 PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE box IJKL28'
1 Number of different outgassing surfaces on object
1 PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE box CEIK28'
1 Number of different outgassing surfaces on object
1 PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE box EFKL28'
1 Number of different outgassing surfaces on object
0

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'HALOE box DFJL28'
0 Number of different outgassing surfaces on object

'HALOE box MNOP28'
1 Number of different outgassing surfaces on object
1 PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE box QRST28'
0 Number of different outgassing surfaces on object

'HALOE box QRUW28'
0 Number of different outgassing surfaces on object

'HALOE box STWX28'
1 Number of different outgassing surfaces on object
1 PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE box RVTX28'
0 Number of different outgassing surfaces on object

'HALOE box QUSW28'
0 Number of different outgassing surfaces on object

'HALOE box ABCD29'
1 Number of different outgassing surfaces on object
1 PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE box EFGH29'
1 Number of different outgassing surfaces on object
1 PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE box ABEF29'
1 Number of different outgassing surfaces on object
1 PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE box BDFH29'
1 Number of different outgassing surfaces on object
1 PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE box DHLW29'
1 Number of different outgassing surfaces on object
1 PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE cover IJ29'
1 Number of different outgassing surfaces on object
0

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```

ConeA
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE cover JK29'
1 Number of different outgassing surfaces on object
CylinderA
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE aperture K29'
1 Number of different outgassing surfaces on object
Disk
1 0
0. 0. 0. 0. 1. 0. 3.09E+15 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE sun-sensor NOPQ29'
0 Number of different outgassing surfaces on object

'HALOE sun-sensor NORS29'
1 Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE sun-sensor PQTU29'
1 Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE sun-sensor NRPT29'
1 Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE sun-sensor OSQU29'
1 Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'HALOE aperture cover L29'
0 Number of different outgassing surfaces on object

'SSPP support'
1 Number of different outgassing surfaces on object
CylinderA
1 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'ISAMS box DTOP15'
1 Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'ISAMS box HJQR15'
1 Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'ISAMS box HJQR15'
1 Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'ISAMS box OPST15'
0 Number of different outgassing surfaces on object

'ISAMS box QRU15'
0 Number of different outgassing surfaces on object

'ISAMS box STWX15'
1 Number of different outgassing surfaces on object
PlateB
0 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'ISAMS box UYV15'
1 Number of different outgassing surfaces on object
PlateB
0 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'ISAMS box SUTV15'
1 Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'ISAMS box OLS15'
1 Number of different outgassing surfaces on object
PlateA
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'ISAMS box QNU15'
1 Number of different outgassing surfaces on object
PlateA
1 0
0. 0. 0. 1. 0. 0. 4.17E+14 100. outgas rate
(Number/m2/sec), ref temp(C)

'NEPS DCIJ15'
1 Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 0. 1. 0. 3.09E+15 100. outgas rate
(Number/m2/sec), ref temp(C)

'NEPS HGKL15'
1 Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 0. 1. 0. 3.09E+15 100. outgas rate
(Number/m2/sec), ref temp(C)

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(Number/m2/sec), ref temp(C)

'NEPS CGJL15'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 0. 1. 0. 3.09E+15 100. outgas rate
(Number/m2/sec), ref temp(C)

'NEPS DHIK15'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 0. 1. 0. 3.09E+15 100. outgas rate
(Number/m2/sec), ref temp(C)

'Dish above CLAES'
0      Number of different outgassing surfaces on object

'Dish above CLAES'
0      Number of different outgassing surfaces on object

'PEM-AXIS antenna J19'
1      Number of different outgassing surfaces on object
Disk
1 0
0. 0. 0. 0. 0. 1. 1.62E+15 100. outgas rate
(Number/m2/sec), ref temp(C)

'PEM-AXIS antenna ?219'
1      Number of different outgassing surfaces on object
CylinderA
1 0
0. 0. 0. 0. 0. 1. 1.62E+15 100. outgas rate
(Number/m2/sec), ref temp(C)

'HRDI telescope box abef13'
0      Number of different outgassing surfaces on object

'HALOE mount GIKM27'
0      Number of different outgassing surfaces on object

'HALOE mount PQTU27'
0      Number of different outgassing surfaces on object

'CLAES Neon vent A30'
0      Number of different outgassing surfaces on object

'CLAES Neon vent AB30'
0      Number of different outgassing surfaces on object

'CLAES Neon vent B30'
0      Number of different outgassing surfaces on object

'CLAES CO2 vent CD30'
0      Number of different outgassing surfaces on object

'CLAES CO2 vent D30'
0      Number of different outgassing surfaces on object

'IM vent ABEF31'
1      Number of different outgassing surfaces on object
PlateB
1 0
0. 0. 0. 0. 1. 0. 9.64E+18 100. outgas rate
(Number/m2/sec), ref temp(C)

'IM vent CDEF31'
0      Number of different outgassing surfaces on object

'IM vent ACE31'
0      Number of different outgassing surfaces on object

'IM vent BDF31'
0      Number of different outgassing surfaces on object

'HALOE mount ACFG4'
2      Number of different outgassing surfaces on object
PlateB
0 0
0. 0. 0. 0. 1. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
PlateB
1 4
0. 0. 0. 1. 0. 0. 7.35E+17 100. outgas rate
(Number/m2/sec), ref temp(C)
140.36 -17.31 -63.83 pointA HALOE blanket vent
140.36 -17.31 -63.58 pointB
137.82 -21.24 -65.59 pointC
137.82 -21.24 -65.34 pointD

'HALOE mount CDGH4'
2      Number of different outgassing surfaces on object
PlateB
0 0
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
0. 0. 0. 1. 0. 0. 3.62E+14 100. outgas rate
(Number/m2/sec), ref temp(C)
PlateB
1 4
0. 0. 0. 1. 0. 0. 7.35E+17 100. outgas rate
(Number/m2/sec), ref temp(C)
132.24 -17.31 -63.83 pointA
132.24 -17.31 -63.58 pointB
134.78 -21.24 -65.59 pointC
134.78 -21.24 -65.34 pointD

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Table 7: Input Data Listing—Surface Temperatures (3 pgs.)

|     |                                        |      |                                      |
|-----|----------------------------------------|------|--------------------------------------|
| -7  | 'Main block top plate ABCD0'           | 7    | 'left-hand HGA-end box AFD110'       |
| -22 | 'Main block side Zmax DCHG0'           | -22  | 'left-hand HGA-end box ABDE10'       |
| -25 | 'Main block side Zmin ABEF0'           | -22  | 'left-hand HGA-end box BCE10'        |
| 4   | 'Main block bottom EIHJ0'              | -7   | 'left/right-hand HGA-end box ABFG10' |
| 7   | 'Main block Xmin ADEH0'                | -7   | 'left/right-hand HGA-end box BCGH10' |
| 9   | 'Main block Xmax BCFG0'                | 9    | 'left-hand HGA-end box CHEJ10'       |
| 7   | 'Front small plate Xmin ABCD1'         | 4    | 'left/right-hand HGA-end box DEIJ10' |
| 9   | 'Front small plate Xmax EFGH1'         | -25  | 'right-hand HGA-end box GHJK11'      |
| 4   | 'Front small plate Ymin DCHG1'         | -22  | 'right-hand HGA-end box CEF11'       |
| -7  | 'Front small plate Ymax ABEF1'         | -25  | 'right-hand HGA-end box HIKL11'      |
| -25 | 'Front small plate Zmin AEDH1'         | 9    | 'right-hand HGA-end box CIFL11'      |
| -22 | 'Front small plate Zmax BFCG1'         | 4    | 'right-hand HGA-end box EFKL11'      |
| -34 | 'CLAES big cap'                        | 9    | 'HGA-end nose box CIMN11'            |
| -60 | 'CLAES fat cylindrical part'           | 9    | 'HGA-end nose box MNEF11'            |
| -60 | 'CLAES small cylindrical part'         | 9    | 'HGA-end nose box CMF11'             |
| -60 | 'CLAES Ring'                           | 9    | 'HGA-end nose box INL11'             |
| -34 | 'CLAES small cap'                      | -25  | 'solar panel mount ABCD12'           |
| -7  | 'CLAES shield plate'                   | -22  | 'solar panel mount EFGH12'           |
| -76 | 'Battery package ABCD3'                | 9    | 'solar panel mount AECG12'           |
| 11  | 'Battery package CDEF3'                | 7    | 'solar panel mount BFDH12'           |
| -14 | 'Battery package EFGH3'                | -7   | 'solar panel mount ABEF12'           |
| -55 | 'Battery package GHIJ3'                | 9    | 'solar panel support IJ12'           |
| 11  | 'Battery package IJKL3'                | 9    | 'solar panel support JK12'           |
| -32 | 'Battery package KLMN3'                | 9    | 'solar panel support JL12'           |
| -2  | 'Battery package MNOP3'                | 9    | 'solar panel support JM12'           |
| 3   | 'Battery package OPQR3'                | 30   | 'solar panel support NOQ12'          |
| -39 | 'Battery package QRAB3'                | 9    | 'solar panel support RS12'           |
| -41 | 'Battery package side AGCE3 lower X'   | 9    | 'solar panel support RI2'            |
| -7  | 'Battery package side GIMK3 lower X'   | 9    | 'solar panel support SI2'            |
| -2  | 'Battery package side MOAQ3 lower X'   | 4    | 'HRDI telescope mount AB13'          |
| -37 | 'Battery package side BDHF3 higher X'  | 4    | 'HRDI telescope mount BC13'          |
| 1   | 'Battery package side HJNL3 higher X'  | 4    | 'HRDI telescope mount FGK13'         |
| 3   | 'Battery package side NPBR3 higher X'  | 4    | 'HRDI telescope mount HILM13'        |
| 1   | 'Battery package side AGM3 lower X'    | 4    | 'HRDI telescope mount FGH113'        |
| -75 | 'Battery cylindrical MMS'              | 4    | 'HRDI telescope mount JKLM13'        |
| -64 | 'Battery MMS plane bottom'             | 4    | 'HRDI telescope mount GIKM13'        |
| -25 | 'HALOE mount ABC4'                     | 4    | 'HRDI telescope mount FHJL13'        |
| -25 | 'HALOE mount ACD4'                     | 4    | 'HRDI telescope mount HIRS13'        |
| -25 | 'HALOE mount CDE4'                     | 4    | 'HRDI telescope mount NOTU13'        |
| -25 | 'HALOE mount BCE4'                     | 4    | 'HRDI telescope mount IOSU13'        |
| -44 | 'NEPS ABCD5'                           | 4    | 'HRDI telescope mount HNRT13'        |
| -8  | 'NEPS BFDH5'                           | 4    | 'HRDI telescope mount RSTU13'        |
| -3  | 'NEPS FEHG5'                           | -15  | 'HRDI telescope mount knob'          |
| -28 | 'NEPS FAGG5'                           | -15  | 'HRDI telescope mount knob'          |
| 6   | 'NEPS JLIK5'                           | -15  | 'HRDI telescope mount knob'          |
| 7   | 'Thin box under main block ABCD6'      | 4    | 'HRDI telescope mount PQW13'         |
| 4   | 'Thin box under main block CDHG6'      | 4    | 'HRDI telescope mount LMXY13'        |
| -25 | 'Thin box under main block DHB6'       | 4    | 'HRDI telescope mount QMWY13'        |
| -22 | 'Thin box under main block EAGC6'      | 4    | 'HRDI telescope mount PLVX13'        |
| -22 | 'Box under main block AECG7'           | 4    | 'HRDI telescope mount VMXY13'        |
| 9   | 'Box under main block EFGH7'           | -15  | 'HRDI telescope mount knob'          |
| -25 | 'Box under main block BFDH7'           | -15  | 'HRDI telescope mount knob'          |
| 7   | 'Box under main block IJCD7'           | -15  | 'HRDI telescope mount knob'          |
| 4   | 'Box under main block CGDH7'           | -34  | 'HRDI telescope D13'                 |
| 4   | 'HRDI interferometer ABCD8'            | -34  | 'HRDI telescope E13'                 |
| -29 | 'HRDI interferometer BFDH8'            | -35  | 'HRDI telescope box abcd13'          |
| -45 | 'HRDI interferometer AECG8'            | -35  | 'HRDI telescope box efgh13'          |
| 14  | 'HRDI interferometer HGFE8'            | -35  | 'HRDI telescope box aceg13'          |
| -65 | 'HRDI interferometer AECG8'            | -35  | 'HRDI telescope box bdfh13'          |
| -25 | 'HRDI interferometer AEJL8'            | -72  | 'HRDI telescope box cdgh13'          |
| -15 | 'HRDI interferometer CDGH8'            | 13   | 'SSPP box ABCD14'                    |
| 4   | 'cylindrical truss #1 at X = 0.'       | -88  | 'SSPP box EFGH14'                    |
| 4   | 'cylindrical truss #2 at X = 0.'       | -12  | 'SSPP box ABEF14'                    |
| -25 | 'cylindrical truss #3 at X = 0.'       | 50   | 'SSPP box CDGH14'                    |
| -25 | 'cylindrical truss #4 at X = 0.'       | -11  | 'SSPP box BFDH14'                    |
| -7  | 'cylindrical truss #5 at X = 0.'       | -127 | 'SSPP box AECG14'                    |
| -7  | 'cylindrical truss #6 at X = 0.'       |      | 'ISAMS box ABCD15'                   |
| 4   | 'Sphere junctn betwn trusses 1-2(X=0)' |      |                                      |
| -25 | 'Sphere junctn betwn trusses 3-4(X=0)' |      |                                      |
| -7  | 'Sphere junctn betwn trusses 5-6(X=0)' |      |                                      |

|      |                                 |  |
|------|---------------------------------|--|
| -41  | 'ISAMS box EFGH15'              |  |
| -9   | 'ISAMS box BFHD15'              |  |
| -2   | 'ISAMS box ABEF15'              |  |
| -18  | 'ISAMS box AKEM15'              |  |
| -127 | 'ISAMS box CDKL15'              |  |
| -41  | 'ISAMS box GHNM15'              |  |
| -14  | 'ISAMS box KLMN15'              |  |
| -9   | 'ISAMS box IJPR15'              |  |
| -2   | 'ISAMS box DHIJ15'              |  |
| 9    | 'HGA antenna AB16'              |  |
| 11   | 'HGA antenna B16'               |  |
| 13   | 'HGA antenna CD16'              |  |
| 13   | 'HGA antenna C16'               |  |
| 15   | 'HGA antenna D16'               |  |
| 17   | 'HGA antenna DE16'              |  |
| 20   | 'HGA antenna E16'               |  |
| -22  | 'CLAES lower mount, ABC17'      |  |
| -22  | 'CLAES lower mount, DEF17'      |  |
| -22  | 'CLAES lower mount, ACD17'      |  |
| -22  | 'CLAES lower mount, BCEF17'     |  |
| -22  | 'CLAES upper mount, GHI17'      |  |
| -22  | 'CLAES upper mount, JKL17'      |  |
| -22  | 'CLAES upper mount, GJLI17'     |  |
| -22  | 'CLAES upper mount, HIKLI17'    |  |
| -9   | 'WINDII base, ABCD18'           |  |
| -11  | 'WINDII base, OPQR18'           |  |
| -24  | 'WINDII base, DBOPI18'          |  |
| -24  | 'WINDII base, ACRQ18'           |  |
| -24  | 'WINDII base, DFO18'            |  |
| -24  | 'WINDII base, CQ18'             |  |
| -24  | 'WINDII base, FNO18'            |  |
| -24  | 'WINDII base, ENQ18'            |  |
| -66  | 'WINDII base, HFN18'            |  |
| -66  | 'WINDII base, GEM18'            |  |
| -66  | 'WINDII base, CDEF18'           |  |
| -11  | 'WINDII base, MNQOI18'          |  |
| -11  | 'WINDII base, MNKLI18'          |  |
| -35  | 'WINDII base, GHIJ18'           |  |
| -79  | 'WINDII base, IJLKI18'          |  |
| -30  | 'WINDII base, HJNLI18'          |  |
| -9   | 'WINDII base, IGKMI18'          |  |
| -37  | 'PEM-AXIS base, ABCD19'         |  |
| -37  | 'PEM-AXIS base, EFGH19'         |  |
| -37  | 'PEM-AXIS base, AECG19'         |  |
| -37  | 'PEM-AXIS base, BFDH19'         |  |
| -37  | 'PEM-AXIS base, CDGH19'         |  |
| -37  | 'PEM-AXIS base, AEBF19'         |  |
| -37  | 'PEM-AXIS base, KLMN19'         |  |
| -37  | 'PEM-AXIS base, OPQR19'         |  |
| -37  | 'PEM-AXIS base, KOMQ19'         |  |
| -37  | 'PEM-AXIS base, LPNR19'         |  |
| -37  | 'PEM-AXIS base, MNQR19'         |  |
| -37  | 'PEM-AXIS antenna JI19'         |  |
| -43  | 'PEM-AXIS antenna J19'          |  |
| -37  | 'PEM-AXIS base, STI9'           |  |
| -7   | 'PEM-ZEPS base, ABC20'          |  |
| -25  | 'PEM-ZEPS base, ABD20'          |  |
| -25  | 'PEM-ZEPS base, BCE20'          |  |
| -25  | 'PEM-ZEPS base, BDE20'          |  |
| -7   | 'PEM-ZEPS base, FG20'           |  |
| -2   | 'PEM-ZEPS box HIJK20'           |  |
| -9   | 'PEM-ZEPS box LMNO20'           |  |
| -2   | 'PEM-ZEPS box JKNQ20'           |  |
| -7   | 'PEM-ZEPS box HJLM20'           |  |
| -1   | 'PEM-ZEPS box ILMN20'           |  |
| -7   | 'PEM-ZEPS box ILMQ20'           |  |
| -7   | 'PEM-ZEPS shaft (approx.) PQ20' |  |
| -85  | 'MLS gizmo box ABCD21'          |  |
| -40  | 'MLS gizmo box EFGH21'          |  |
| -32  | 'MLS gizmo box EFAB21'          |  |
| -46  | 'MLS gizmo box BFHD21'          |  |
| -45  | 'MLS gizmo box AECG21'          |  |
| -66  | 'MLS gizmo box CDGH21'          |  |
| -37  | 'MLS box behind antenna IJKL21' |  |
| -37  | 'MLS box behind antenna JNLP21' |  |
| -37  | 'MLS box behind antenna KOLP21' |  |
| -37  | 'MLS box behind antenna IJMN21' |  |
| -37  | 'MLS cylinder QR21'             |  |
| -37  | 'MLS cylinder end'              |  |
| -77  | 'MLS LHS box ABCD22'            |  |
| -21  | 'MLS LHS box ABEF22'            |  |
| -60  | 'MLS LHS box CDGH22'            |  |
| -40  | 'MLS LHS box BFHD22'            |  |
| -42  | 'MLS LHS box AECG22'            |  |
| -37  | 'MLS LHS box EFIJ22'            |  |
| -21  | 'MLS LHS box IJQK22'            |  |
| -40  | 'MLS LHS box GHRL22'            |  |
| -37  | 'MLS LHS box JKHL22'            |  |
| -37  | 'MLS LHS box IQGR22'            |  |
| -21  | 'MLS LHS box QKOM22'            |  |
| -60  | 'MLS LHS box RLPN22'            |  |
| -42  | 'MLS LHS box QORP22'            |  |
| -28  | 'MLS large antenna BCDE24'      |  |
| -28  | 'MLS large antenna DEHI24'      |  |
| -28  | 'MLS large antenna HIL24'       |  |
| -28  | 'MLS large antenna BCFG24'      |  |
| -28  | 'MLS large antenna FGJK24'      |  |
| -28  | 'MLS large antenna JKM24'       |  |
| -37  | 'MLS large antenna BCDE24'      |  |
| -37  | 'MLS large antenna DEHI24'      |  |
| -37  | 'MLS large antenna HIL24'       |  |
| -37  | 'MLS large antenna BCFG24'      |  |
| -37  | 'MLS large antenna FGJK24'      |  |
| -37  | 'MLS large antenna JKM24'       |  |
| -32  | 'MLS large antenna CCEB24'      |  |
| -32  | 'MLS large antenna EEII24'      |  |
| -32  | 'MLS large antenna BDD24'       |  |
| -32  | 'MLS large antenna DDHH24'      |  |
| -32  | 'MLS large antenna CCG24'       |  |
| -32  | 'MLS large antenna GKK24'       |  |
| -32  | 'MLS large antenna BBFF24'      |  |
| -32  | 'MLS large antenna FFJJ24'      |  |
| -32  | 'MLS large antenna IILL24'      |  |
| -32  | 'MLS large antenna KKM24'       |  |
| -32  | 'MLS large antenna HHL24'       |  |
| -32  | 'MLS large antenna JMM24'       |  |
| -37  | 'MLS small antenna OPQR24'      |  |
| -37  | 'MLS small antenna QRU24'       |  |
| -28  | 'MLS small antenna OPQR24'      |  |
| -28  | 'MLS small antenna QRU24'       |  |
| -37  | 'MLS small antenna STV24'       |  |
| -28  | 'MLS small antenna OPST24'      |  |
| -28  | 'MLS small antenna STV24'       |  |
| -32  | 'MLS small antenna PPR24'       |  |
| -32  | 'MLS small antenna PPT24'       |  |
| -32  | 'MLS small antenna RRU24'       |  |
| -32  | 'MLS small antenna TTV24'       |  |
| -32  | 'MLS small antenna OQQ24'       |  |
| -32  | 'MLS small antenna OOS24'       |  |
| -32  | 'MLS small antenna QQU24'       |  |
| -32  | 'MLS small antenna SSV24'       |  |
| -28  | 'MLS antenna arm, RHS ABCD25'   |  |
| -28  | 'MLS antenna arm, RHS EF25'     |  |
| -28  | 'MLS antenna arm, RHS E25'      |  |
| -28  | 'MLS antenna arm, RHS F25'      |  |

|      |                                 |
|------|---------------------------------|
| -28  | 'MLS antenna arm, back GH25'    |
| -28  | 'MLS antenna arm, back IJ25'    |
| -28  | 'MLS antenna arm, back H25'     |
| -28  | 'MLS antenna arm, back J25'     |
| -28  | 'MLS antenna arm, back G25'     |
| -28  | 'MLS antenna arm, back I25'     |
| -28  | 'MLS antenna arm, between GK25' |
| -28  | 'MLS antenna arm, between IL25' |
| -28  | 'MLS antenna arm, side K25'     |
| -28  | 'MLS antenna arm, side L25'     |
| -7   | 'HGA-side bracework AB23'       |
| -7   | 'HGA-side bracework CB23'       |
| -7   | 'HGA-side bracework EB23'       |
| -7   | 'HGA-side bracework GB23'       |
| 4    | 'HGA-side bracework IJ23'       |
| 4    | 'HGA-side bracework KJ23'       |
| 4    | 'HGA-side bracework MJ23'       |
| 4    | 'HGA-side bracework OJ23'       |
| -25  | 'HGA-side bracework QR23'       |
| -25  | 'HGA-side bracework SR23'       |
| -7   | 'Sphere junctn B23'             |
| 4    | 'Sphere junctn J23'             |
| -25  | 'Sphere junctn R23'             |
| -7   | 'Dish above CLAES'              |
| -55  | 'Thrusters, AC26'               |
| -55  | 'Thrusters, BD26'               |
| -27  | 'HALOE mount A27'               |
| -27  | 'HALOE mount AB27'              |
| -27  | 'HALOE mount B27'               |
| -27  | 'HALOE mount BC27'              |
| -27  | 'HALOE mount C27'               |
| -27  | 'HALOE mount CD27'              |
| -27  | 'HALOE mount D27'               |
| -27  | 'HALOE mount DE27'              |
| -27  | 'HALOE mount E27'               |
| -24  | 'HALOE mount FGH127'            |
| -24  | 'HALOE mount JKL127'            |
| -24  | 'HALOE mount FGJ27'             |
| -24  | 'HALOE mount HIL27'             |
| -21  | 'HALOE mount FNR27'             |
| -21  | 'HALOE mount NFR27'             |
| -21  | 'HALOE mount HLQ27'             |
| -21  | 'HALOE mount RJTU27'            |
| -21  | 'HALOE mount NRPT27'            |
| -19  | 'HALOE mount VM27'              |
| -19  | 'HALOE mount V27'               |
| -19  | 'HALOE mount VX27'              |
| -19  | 'HALOE mount X27'               |
| -44  | 'HALOE box ABCD28'              |
| -19  | 'HALOE box GHIJ28'              |
| -17  | 'HALOE box BDEF28'              |
| -44  | 'HALOE box CDEF28'              |
| -36  | 'HALOE box IJKL28'              |
| -10  | 'HALOE box CEIK28'              |
| -17  | 'HALOE box EFJL28'              |
| -36  | 'HALOE box MNOP28'              |
| -36  | 'HALOE box QRST28'              |
| -9   | 'HALOE box QUVW28'              |
| -10  | 'HALOE box STWX28'              |
| -44  | 'HALOE box RVTX28'              |
| -19  | 'HALOE box QUSW28'              |
| -44  | 'HALOE box ABCD29'              |
| -10  | 'HALOE box EFGH29'              |
| -9   | 'HALOE box ABEF29'              |
| -17  | 'HALOE box BDFH29'              |
| -9   | 'HALOE box DHLM29'              |
| -44  | 'HALOE cover IJ29'              |
| -24  | 'HALOE cover JK29'              |
| -44  | 'HALOE aperture K29'            |
| -17  | 'HALOE sun-sensor NOPQ29'       |
| -9   | 'HALOE sun-sensor NORS29'       |
| -10  | 'HALOE sun-sensor PQTU29'       |
| -44  | 'HALOE sun-sensor NRPT29'       |
| -9   | 'HALOE sun-sensor OSQU29'       |
| -44  | 'HALOE aperture cover L29'      |
| -11  | 'SSPP support'                  |
| -127 | 'ISAMS box DIOP15'              |
| -41  | 'ISAMS box HJQR15'              |
| -127 | 'ISAMS box OPST15'              |
| -41  | 'ISAMS box QRUW15'              |
| -127 | 'ISAMS box STWX15'              |
| -41  | 'ISAMS box UVYZ15'              |
| -9   | 'ISAMS box PRTV15'              |
| -14  | 'ISAMS box SUTV15'              |
| -127 | 'ISAMS box OLS15'               |
| -41  | 'ISAMS box QNU15'               |
| -44  | 'NEPS DCIJ15'                   |
| -3   | 'NEPS DGKL15'                   |
| -28  | 'NEPS CGJL15'                   |
| -8   | 'NEPS DHIK15'                   |
| -7   | 'Dish above CLAES'              |
| -7   | 'Dish above CLAES'              |
| -37  | 'PEM-AXIS antenna J19'          |
| -37  | 'PEM-AXIS antenna J719'         |
| -35  | 'HRDI telescope box abef13'     |
| -21  | 'HALOE mount GIKM27'            |
| -21  | 'HALOE mount PQTU27'            |
| -66  | 'CLAES Neon vent A30'           |
| -66  | 'CLAES Neon vent AB30'          |
| -66  | 'CLAES Neon vent B30'           |
| -66  | 'CLAES CO2 vent CD30'           |
| -66  | 'CLAES CO2 vent D30'            |
| -22  | 'IM vent ABEF31'                |
| -22  | 'IM vent CDEF31'                |
| -22  | 'IM vent ACE31'                 |
| -22  | 'IM vent BDF31'                 |
| -27  | 'HALOE mount ACFG4'             |
| -27  | 'HALOE mount CDGH4'             |

Table 8: Typical Elemental Sonic Orifice Data

| Data                  |      |      |    |    |    | Description                       |
|-----------------------|------|------|----|----|----|-----------------------------------|
| 0.0254                |      |      |    |    |    | scale                             |
| 0.                    | -1.  | 0.   |    |    |    | jet direction cosine, $Ne$ vent   |
| 71.0                  | 1.7  | 53.0 |    |    |    | jet center                        |
| 1.                    |      |      |    |    |    | jet radius                        |
| 3.28E+20              |      |      |    |    |    | jet density [molecules/ $m^3$ ]   |
| 377.                  |      |      |    |    |    | jet velocity [ $m/sec$ ]          |
| 207.                  |      |      |    |    |    | jet exit temperature [ $K$ ]      |
| 0.                    | 1.   | 0.   | 0. | 0. | 0. | species fraction in jet           |
| -0.4924 0.6428 0.5868 |      |      |    |    |    | jet direction cosine, $CO_2$ vent |
| 65.1                  | 36.6 | 26.2 |    |    |    | jet center                        |
| 0.5                   |      |      |    |    |    | jet radius                        |
| 4.04E+20              |      |      |    |    |    | jet density [molecules/ $m^3$ ]   |
| 244.                  |      |      |    |    |    | jet velocity [ $m/sec$ ]          |
| 207.                  |      |      |    |    |    | jet exit temperature [ $K$ ]      |
| 0.                    | 0.   | 1.   | 0. | 0. | 0. | species fraction in jet           |

Table 9: Input Data Listing—General Preprocessor Input

```

*-----data to model gas around UARS
*
*-----CONVENTION:
*-----GAS species # 1: O
*-----GAS species # 2: Ne
*-----GAS species # 3: CO2
*-----GAS species # 4: outgas # 1 molecular mass = 100
*-----GAS species # 5: outgas # 2 molecular mass = 150
*-----GAS species # 6: outgas # 3 molecular mass = 200
*-----No Internal energy, no chemistry
*
*-----Carbon Dioxide CO2
n = indexCO2
SP(1,n) = ( 44.01 * 1.e-3 ) / avogadro
SP(2,n) = 5.41e-10
SP(3,n) = 0.
SP(4,n) = 0.
SP(5,n) = 0.
SP(6,n) = 0.
SP(7,n) = 0.
SP(8,n) = 0.
SP(9,n) = 0.
*
*-----Outgassing gas # 1
n = indexO1
SP(1,n) = ( 100.0 * 1.e-3 ) / avogadro
SP(2,n) = SP(2,indexO) * (SP(1,n)/SP(1,indexO))**.3333
SP(3,n) = 0.
SP(4,n) = 0.
SP(5,n) = 0.
SP(6,n) = 0.
SP(7,n) = 0.
SP(8,n) = 0.
SP(9,n) = 0.
*
*-----Outgassing gas # 2
n = indexO2
SP(1,n) = ( 150.0 * 1.e-3 ) / avogadro
SP(2,n) = SP(2,indexO) * (SP(1,n)/SP(1,indexO))**.3333
SP(3,n) = 0.
SP(4,n) = 0.
SP(5,n) = 0.
SP(6,n) = 0.
SP(7,n) = 0.
SP(8,n) = 0.
SP(9,n) = 0.
*
*-----Outgassing gas # 3
n = indexO3
SP(1,n) = ( 200.0 * 1.e-3 ) / avogadro
SP(2,n) = SP(2,indexO) * (SP(1,n)/SP(1,indexO))**.3333
SP(3,n) = 0.
SP(4,n) = 0.
SP(5,n) = 0.
SP(6,n) = 0.
SP(7,n) = 0.
SP(8,n) = 0.
SP(9,n) = 0.
*
*-----max. no. of tables for rot. & vib. relaxation (SPRR)
MRCFF= max(itable,1)
*
*-----Data for Tref, W, molecular diam.: from J. Moss
Tref=300.
W = 0.75
*
*-----Neon Ne
n = indexNe
SP(1,n) = ( 20.179 * 1.e-3 ) / avogadro
SP(2,n) = 2.72e-10
SP(3,n) = 0.
SP(4,n) = 0.
*
*-----Monatomic Oxygen O
n = indexO
SP(1,n) = ( 16.0 * 1.e-3 ) / avogadro
SP(2,n) = 3.0e-10
SP(3,n) = 0.
SP(4,n) = 0.
SP(5,n) = 0.
SP(6,n) = 0.
SP(7,n) = 0.
SP(8,n) = 0.
SP(9,n) = 0.
*
*-----Neon Ne
n = indexNe
SP(1,n) = ( 20.179 * 1.e-3 ) / avogadro
SP(2,n) = 2.72e-10
SP(3,n) = 0.
SP(4,n) = 0.
*
*-----data to model gas around UARS
*
*-----CONVENTION:
*-----GAS species # 1: O
*-----GAS species # 2: Ne
*-----GAS species # 3: CO2
*-----GAS species # 4: outgas # 1 molecular mass = 100
*-----GAS species # 5: outgas # 2 molecular mass = 150
*-----GAS species # 6: outgas # 3 molecular mass = 200
*-----No Internal energy, no chemistry
*
*-----IRA = 1 means chemistry is on
IRA = 0
*
*-----MVRT = maximum # of vibrational degrees of freedom in any species
MVRT = 0
*
*-----SP(1,L)= mass of a molecule of species L (Kg)
*-----SP(2,L)= diameter of a molecule of species L at T = TREF (meter)
*
*-----SP(3,L)= # of rotational deg. of freedom for species L
*-----SP(4,L)= index K pointing to the table of SPRR for rot. rel. of L
*-----IRROT(1)= switch for the # of collisions to relax rot. energy
*-----SPRR(K,1)= # of collisions to relax rotational energy
*-----SPRR(K,2)= polynomial coefficient; first order of temp
*-----SPRR(K,3)= polynomial coefficient; second order of temp
*-----SPRR(K,4)= polynomial coefficient; third order of temp
*
*-----SP(5,L)= index M pointing to the table of SPRR for vib. rel. of L
*-----IRVIB(1)= switch for the # of collisions to relax vib. energy
*-----SPRR(M,1)= # of collisions to relax vibrational energy
*-----SPRR(M,2)= polynomial coefficient; first order of temp
*-----SPRR(M,3)= polynomial coefficient; second order of temp
*-----SPRR(M,4)= polynomial coefficient; third order of temp
*-----SP(6,L)= Vibrational temperature
*
*-----indexO = 1
*-----indexNe = 2
*-----indexCO2 = 3
*-----indexO1 = 4
*-----indexO2 = 5
*-----indexO3 = 6
*
*-----avogadro = 6.02252e+23
*-----boltzmann = 1.38054e-23
*
*-----counter for internal energy table
itable = 0
*
*-----Monatomic Oxygen O
n = indexO
SP(1,n) = ( 16.0 * 1.e-3 ) / avogadro
SP(2,n) = 3.0e-10
SP(3,n) = 0.
SP(4,n) = 0.
SP(5,n) = 0.
SP(6,n) = 0.
SP(7,n) = 0.
SP(8,n) = 0.
SP(9,n) = 0.
*
*-----Neon Ne
n = indexNe
SP(1,n) = ( 20.179 * 1.e-3 ) / avogadro
SP(2,n) = 2.72e-10
SP(3,n) = 0.
SP(4,n) = 0.
*

```

110 continue

Table 10: Outgassing Species Information

| Species                                                                                | GMW   | d<br>[Å] | Mass Flux Rates<br>at 100°C [gm/cm <sup>2</sup> /sec]     |
|----------------------------------------------------------------------------------------|-------|----------|-----------------------------------------------------------|
| fictional organic volatile species<br>representing products from MLI                   | 100   | 5.33     | $4.33 \times 10^{-13}$<br>to $6.01 \times 10^{-12}$       |
| fictional organic volatile species<br>representing products from solar array adhesives | 100   | 5.33     | $1.83 \times 10^{-10}$                                    |
| fictional organic volatile species<br>representing products from IM and MLI vents      | 100   | 5.33     | $1.60 \times 10^{-7}$ (IM)<br>$1.22 \times 10^{-8}$ (MLI) |
| fictional organic volatile species<br>representing products from MMS vents             | 100   | 5.33     | $3.67 \times 10^{-11}$<br>to $1.22 \times 10^{-10}$       |
| fictional organic volatile species<br>representing products from Chemglaze Z306        | 150   | 6.33     | $7.70 \times 10^{-11}$                                    |
| fictional organic volatile species<br>representing products from S/13G/LO-V10          | 200   | 6.96     | $4.30 \times 10^{-11}$<br>to $5.39 \times 10^{-11}$       |
| neon vented from<br>CLAES experiment                                                   | 20.18 | 2.72     | $4.14 \times 10^{-4*}$                                    |
| carbon dioxide vented from<br>CLAES experiment                                         | 44.01 | 5.41     | $7.20 \times 10^{-4*}$                                    |

\* rate at operating temperature  $T_{\text{exit}} = 207K$

Table 11: Gas Species Data

|                         |                                                                                           |
|-------------------------|-------------------------------------------------------------------------------------------|
| 0                       | spatial resolution switch: body-0, gas-1                                                  |
| 7.                      | max no. of Megabytes for body defn.                                                       |
| 30000                   | ratio to compute mean no. of subcells/cell                                                |
| 0.5                     | ratio of cells near body                                                                  |
| 0                       | initially uniform freestream or vacuum                                                    |
| 6                       | total no. of molecular species                                                            |
| 2                       | no. of jet species (subset of total no. of species)                                       |
| 132                     | GAS?.FOR file (species-dependent gas info.)                                               |
| 7500.                   | free stream velocity                                                                      |
| 0.                      | angle of incidence alpha (deg)                                                            |
| 0.                      | roll angle phi (deg)                                                                      |
| 6.e+12 1000.            | freestream density, temp.                                                                 |
| 1. 0. 0. 0. 0. 0.       | fraction of each species in freestream                                                    |
| 300.                    | surface temp.                                                                             |
| 300.                    | mean expected temp. in flow                                                               |
| 2 2 2 0 2 2             | boundary conds. at -X, -Y, -Z, +X, +Y, +Z                                                 |
| 1. 1. 1000.             | safety factors for max no. of molecules,<br>timestep, FNUM                                |
| 20. 10. 10. 10. 10. 10. | clearances for -X, +X, -Y, +Y, -Z, +Z edges                                               |
| 350000                  | no. of subcells within computational domain                                               |
| 2                       | scale ratio between inner & outer domains                                                 |
| 3. 0.28                 | anticipated density enhancements: peak, mean<br>(used to estimate cell and subcell sizes) |
| 1.                      | fraction of total volume to be used                                                       |
| 2 50                    | no. of timesteps between sampling,<br>no. of samples between saved states                 |
| 2                       | parameter used to size pixel element arrays                                               |

**Table 12: Mass Flux Rates Intercepted at HALOE Aperture**

| Species                                                                    | Mass Flux Rates [ $gm/cm^2/sec$ ] |                          |                          |
|----------------------------------------------------------------------------|-----------------------------------|--------------------------|--------------------------|
|                                                                            | Case #1                           | Case #2                  | Case #3                  |
| monatomic oxygen from freestream distribution                              | $1.2 \times 10^{-10}$             | $1.0 \times 10^{-10}$    | $< 4.2 \times 10^{-14}*$ |
| monatomic oxygen from surface-accommodated distribution                    | $9.3 \times 10^{-12}$             | $7.5 \times 10^{-12}$    | $5.4 \times 10^{-12}$    |
| neon vented from CLAES experiment (return flux)                            | $1.9 \times 10^{-11}$             | $5.9 \times 10^{-12}$    | $< 2.1 \times 10^{-12}*$ |
| neon vented from CLAES experiment (direct flux)                            | $1.3 \times 10^{-11}$             | $5.9 \times 10^{-12}$    | $< 2.1 \times 10^{-12}*$ |
| carbon dioxide vented from CLAES experiment                                | $< 5.8 \times 10^{-12}*$          | $< 6.5 \times 10^{-12}*$ | $< 4.6 \times 10^{-12}*$ |
| fictitious organic volatile species representing all $GMW = 100$ materials | $9.2 \times 10^{-14}$             | $1.8 \times 10^{-13}$    | $8.4 \times 10^{-14}$    |
| fictitious organic volatile species representing $GMW = 150$ material      | $3.9 \times 10^{-15}$             | $1.1 \times 10^{-14}$    | $1.4 \times 10^{-14}$    |
| fictitious organic volatile species representing $GMW = 200$ material      | $4.3 \times 10^{-13}$             | $1.8 \times 10^{-14}$    | $2.7 \times 10^{-13}$    |

\* no samples collected

**Table 13a: Subassembly Contributions to Cumulative Contaminant Deposition (Case #1)**

| Subassembly                                         | Percent Contribution to Contaminant Flux |             |             |
|-----------------------------------------------------|------------------------------------------|-------------|-------------|
|                                                     | $GMW = 100$                              | $GMW = 150$ | $GMW = 200$ |
| Solar Panel<br>( $\Omega = 0.527$ steradians)       | 56                                       | —           | 81          |
| Instrument Module<br>( $\Omega = 0.719$ steradians) | 13                                       | —           | 19          |
| HALOE                                               | 25                                       | 73          | —           |
| NEPS                                                | 3                                        | 27          | —           |
| ISAMS                                               | 3                                        | —           | —           |

**Table 13b: Subassembly Contributions to Cumulative Contaminant Deposition (Case #2)**

| Subassembly                                         | Percent Contribution to Contaminant Flux |                  |                  |
|-----------------------------------------------------|------------------------------------------|------------------|------------------|
|                                                     | <i>GMW</i> = 100                         | <i>GMW</i> = 150 | <i>GMW</i> = 200 |
| Solar Panel<br>( $\Omega = 0$ steradians)           | 92                                       | —                | —                |
| Instrument Module<br>( $\Omega = 0.292$ steradians) | —                                        | —                | 100              |
| HALOE                                               | 8                                        | 80               | —                |
| NEPS                                                | —                                        | 20               | —                |

**Table 13c: Subassembly Contributions to Cumulative Contaminant Deposition (Case #3)**

| Subassembly                                          | Percent Contribution to Contaminant Flux |                  |                  |
|------------------------------------------------------|------------------------------------------|------------------|------------------|
|                                                      | <i>GMW</i> = 100                         | <i>GMW</i> = 150 | <i>GMW</i> = 200 |
| Solar Panel<br>( $\Omega = 0.412$ steradians)        | 75                                       | —                | 94               |
| Instrument Module<br>( $\Omega = 0.0354$ steradians) | 13                                       | —                | 6                |
| HALOE                                                | 12                                       | 100              | —                |

**Table 14: Cumulative Volatile Organic Contaminant Deposition at HALOE Aperture**  
(values based on  $d_0$  in parentheses)

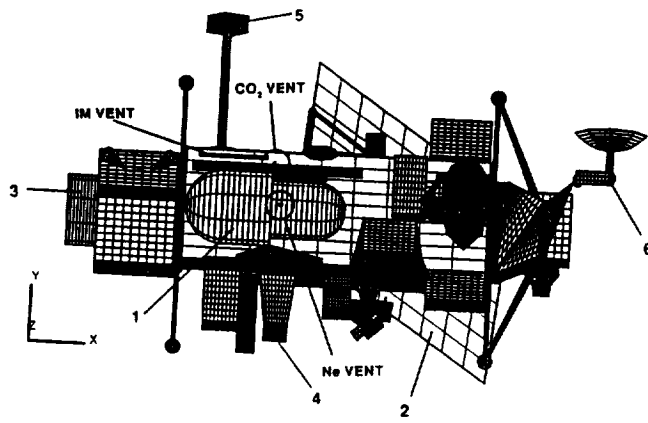
| Species                                                                            | Cumulative Depth Over 35 Months [ $\text{\AA}$ ] |                 |                 |
|------------------------------------------------------------------------------------|--------------------------------------------------|-----------------|-----------------|
|                                                                                    | Case #1                                          | Case #2         | Case #3         |
| fictitious organic volatile species<br>representing all <i>GMW</i> = 100 materials | 9496<br>(1602)                                   | 9787<br>(1652)  | 4663<br>(787)   |
| fictitious organic volatile species<br>representing <i>GMW</i> = 150 material      | 683<br>(173)                                     | 408<br>(103)    | 524<br>(133)    |
| fictitious organic volatile species<br>representing <i>GMW</i> = 200 material      | 13355<br>(4507)                                  | 489<br>(165)    | 7460<br>(2518)  |
| total extrapolated<br>accumulation per run                                         | 23534<br>(6282)                                  | 10684<br>(1920) | 12647<br>(3438) |

**Table 15: Cumulative Volatile Organic Contaminant Deposition  
at HALOE Aperture—Arrival at Case-Averaged Total Deposition**  
(values based on  $d_O$  in parentheses)

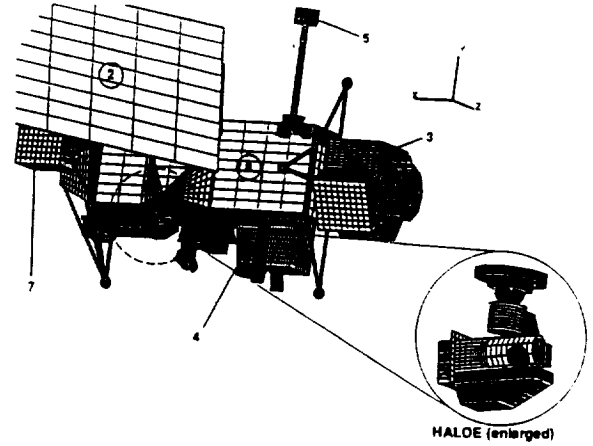
| Item                                                       | Amount Based<br>On $l = 10 \text{ \AA}$ [ $\text{\AA}$ ] | Amount Based<br>On $d_O = 3.0 \text{ \AA}$ [ $\text{\AA}$ ] |
|------------------------------------------------------------|----------------------------------------------------------|-------------------------------------------------------------|
| Average for runs #1 & #2                                   | 17109                                                    | (4101)                                                      |
| Avg. $\times (1 - \tau_{\text{stow}}/\tau_{\text{orbit}})$ | 2673                                                     | (641)                                                       |
| Average for run #3                                         | 12647                                                    | (3438)                                                      |
| Avg. $\times \tau_{\text{stow}}/\tau_{\text{orbit}}$       | 10671                                                    | (2901)                                                      |
| Case-averaged Total Deposition                             | 13344                                                    | (3542)                                                      |

**Table 16: Simulation Set-Up and Performance**

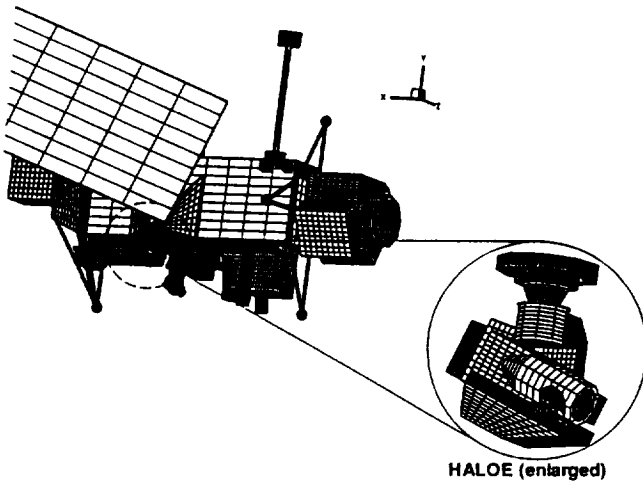
| Item                                                     | Inner Domain                     | Outer Domain                      |
|----------------------------------------------------------|----------------------------------|-----------------------------------|
| $\Delta t$ [sec]                                         | $1.35 \times 10^{-5}$            | $2.69 \times 10^{-5}$             |
| $FNUM$                                                   | $2.08 \times 10^{13}$            | $4.17 \times 10^{13}$             |
| Volume [ $m^3$ ]                                         | $11.21 \times 6.97 \times 15.75$ | $21.20 \times 21.20 \times 21.20$ |
| CCM Resolution                                           | $74 \times 46 \times 104$        | $70 \times 70 \times 70$          |
| FCM Resolution w/in CCM                                  | $3 \times 3 \times 3$            | $1 \times 1 \times 1$             |
| No. of cells                                             | 34,900                           | 7,530                             |
| No. of simulated molecules                               | 329,000                          | 404,000                           |
| Total CPU time [hrs]                                     | 191                              | 150                               |
| Memory required [Mbytes]                                 | 60                               | 40                                |
| Performance [ $\mu\text{sec}/\text{particle}/\Delta t$ ] | 44                               | 29                                |



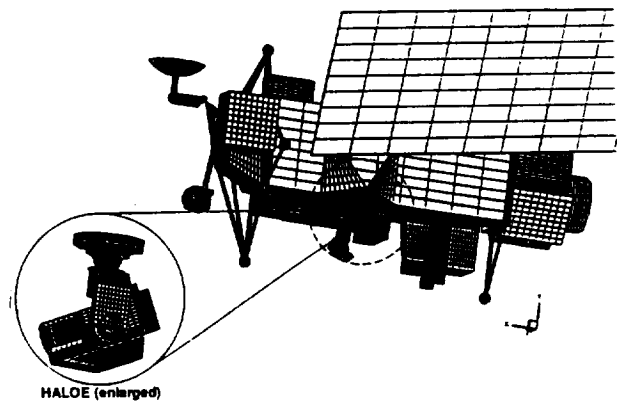
(a)



(b)

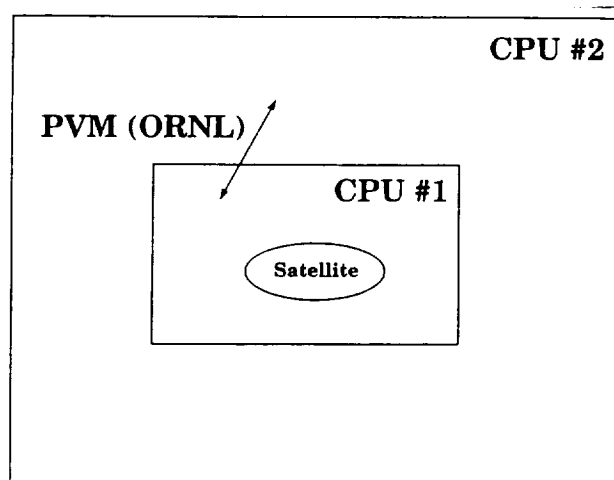


(c)

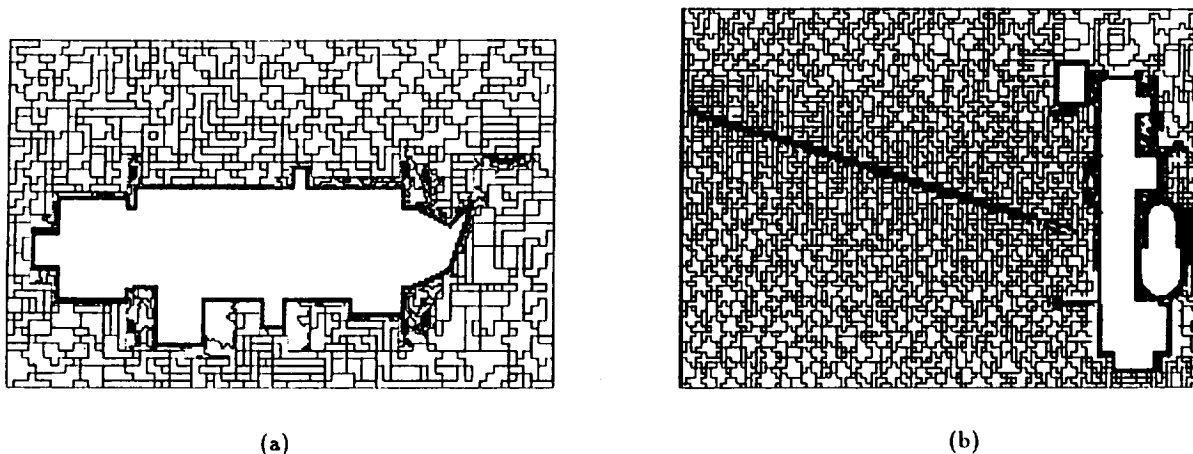


(d)

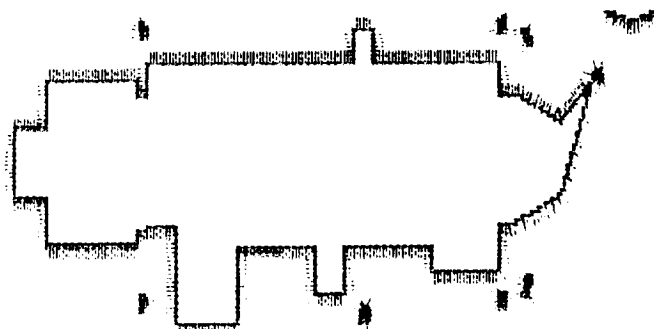
**Figure 1.** UARS model used in DSMC simulation: (a) +Z side, Case 1; (b) -Z side, Case 1; (c) -Z side, Case 2; (d) -Z side, Case 3. Key: 1-Cryogenic Limb Array Etalon Spectrometer (CLAES), 2-Solar panel (SP), 3-Multi-mission Modular Spacecraft (MMS), 4-Nadir Energetic Particle Spectrometer (NEPS), 5-Zenith Energetic Particle Spectrometer (ZEPS), 6-High Gain Antenna (HGA), 7-Solar/Stellar Positioning Platform (SSPP), and 8-Instrument Module (IM).



**Figure 2.** Schematic representation of computational flowfield volume used with parallelization routines.



**Figure 3.** Representative cross-sections of computational grid for DSMC simulation; (a) inner domain at  $Z = 0$ , (b) inner domain at  $Y = 0$ .



**Figure 4.** Representative cross-section of UARS geometric model discretized for incorporation into DSMC code. Outward-pointed normals included with surface pixel locations.

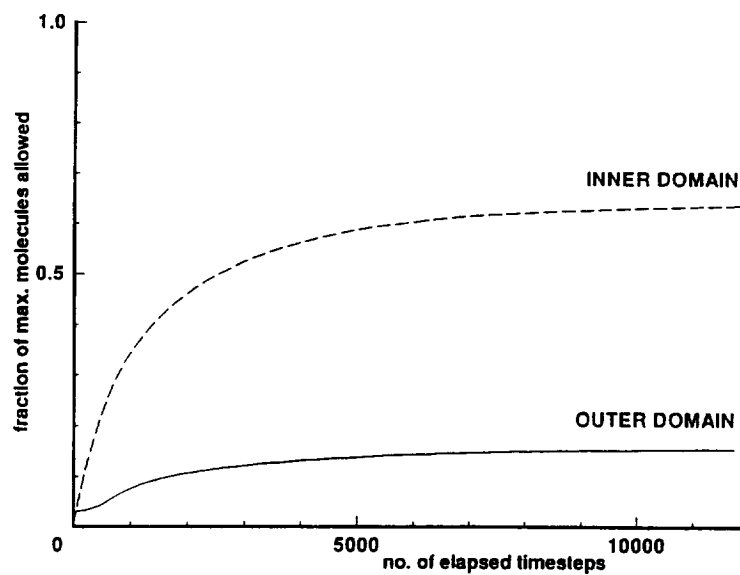


Figure 5. Typical behavior for number of particles per timestep versus simulated elapsed time as steady state is approached.

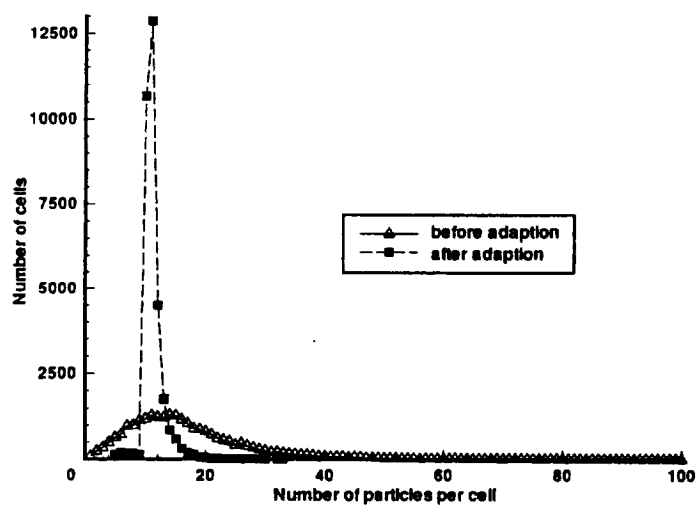
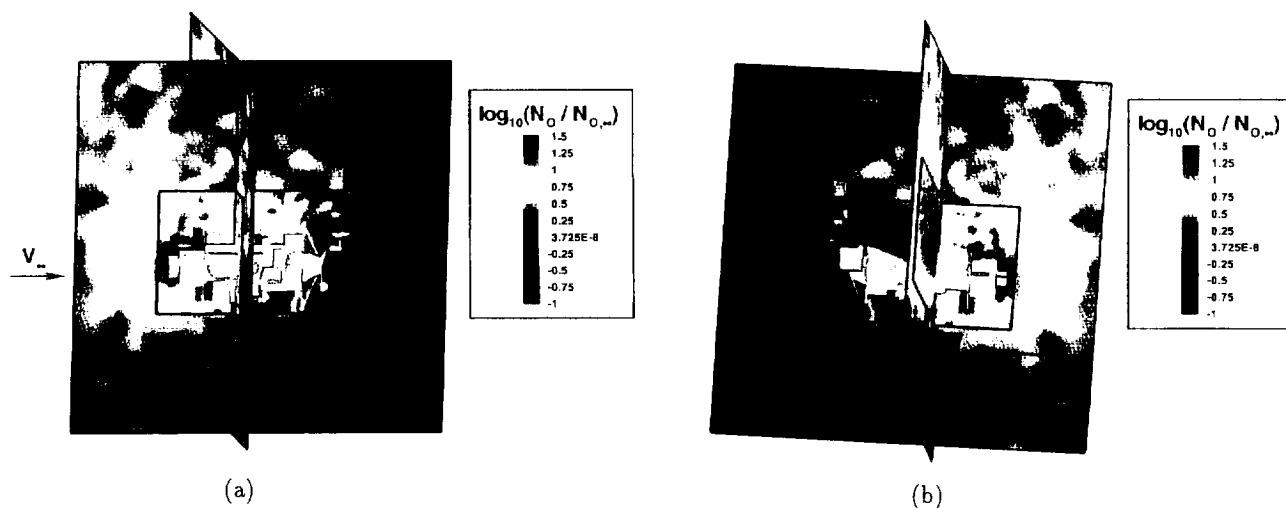
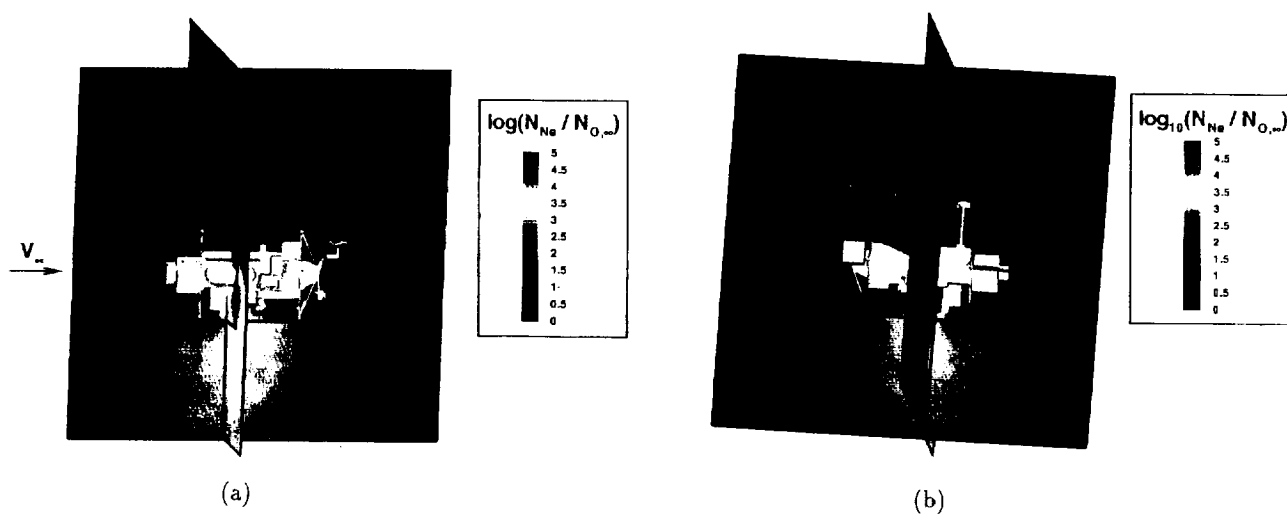


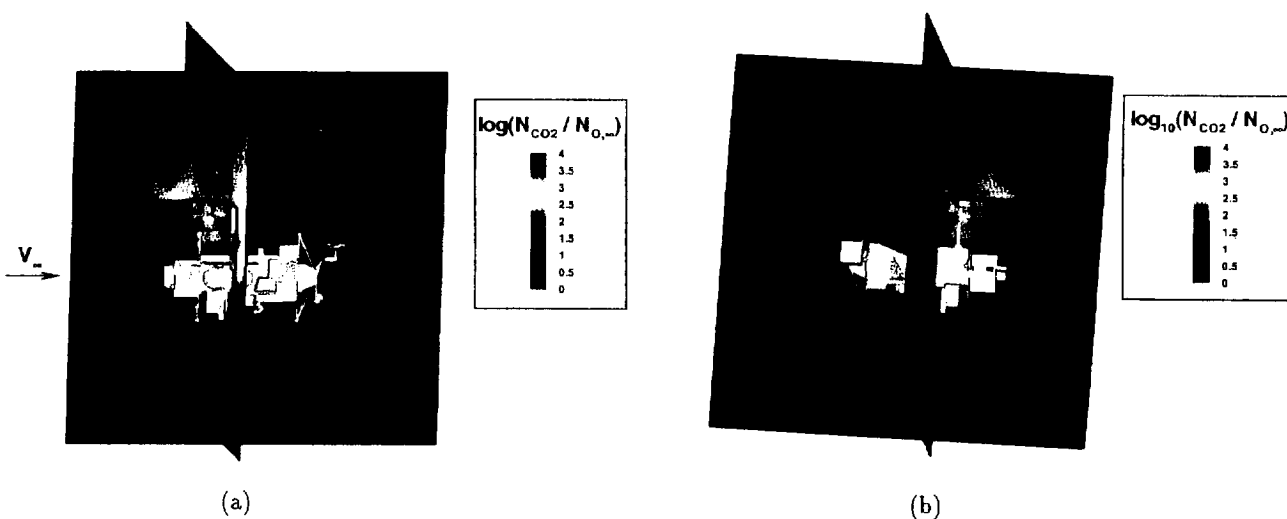
Figure 6. Typical distribution of particles per inner-domain cell before and after grid adaption.



**Figure 7.** Case 1 number density contours of freestream species  $O$ , logarithmic scale nondimensionalized by freestream number density  $[O]_{\infty}$ : (a) +Z side, (b) -Z side.

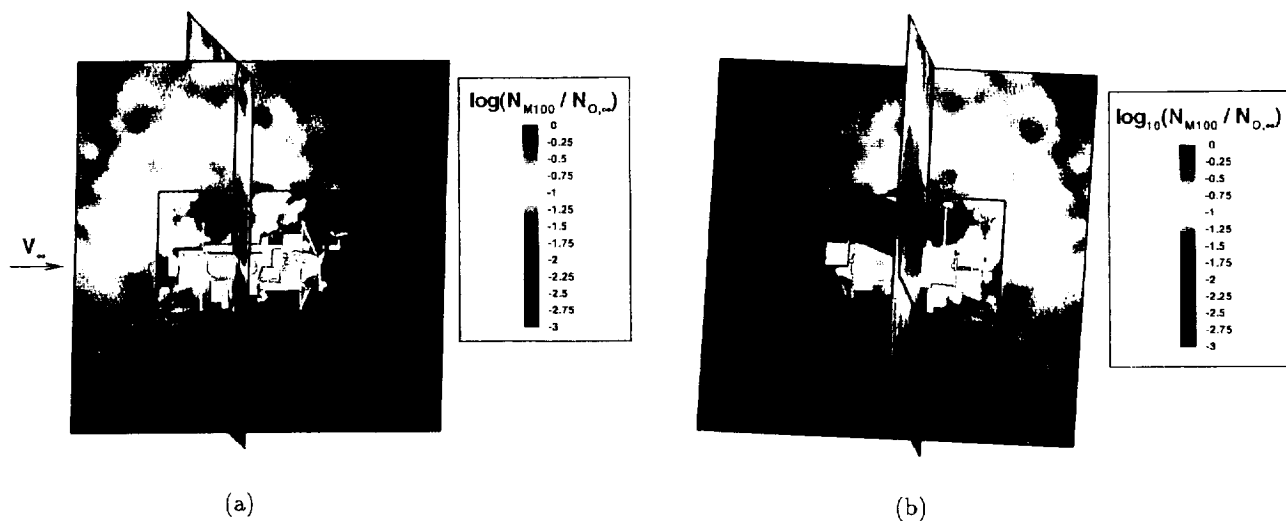


**Figure 8.** Case 1 number density contours of neon, logarithmic scale nondimensionalized by  $[O]_{\infty}$ : (a) +Z side, (b) -Z side.

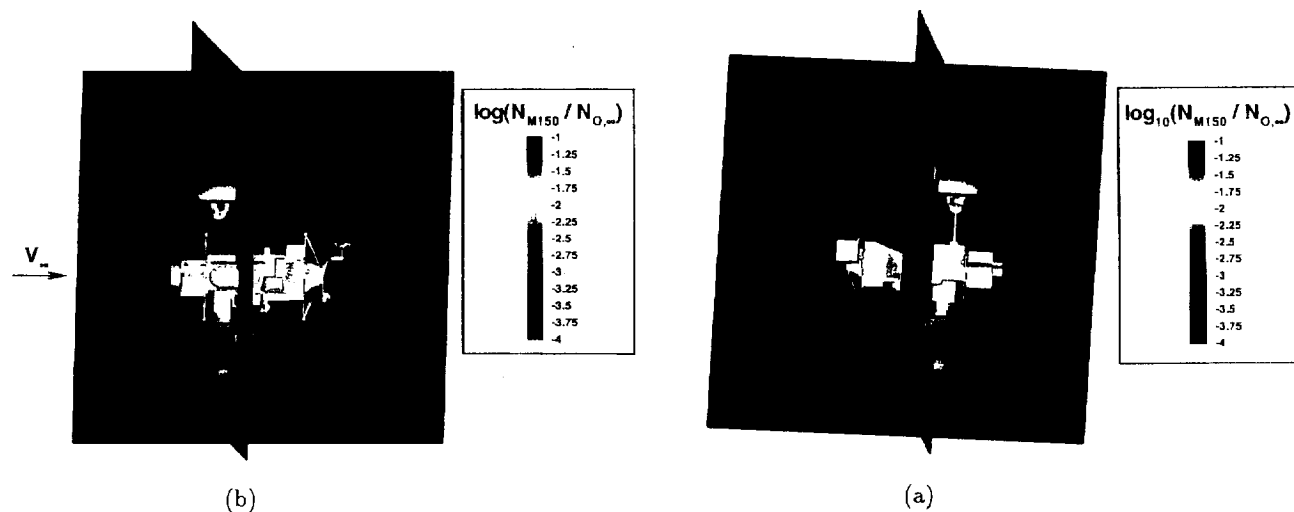


**Figure 9.** Case 1 number density contours of carbon dioxide, logarithmic scale nondimensionalized by  $[O]_{\infty}$ : (a) +Z side, (b) -Z side.

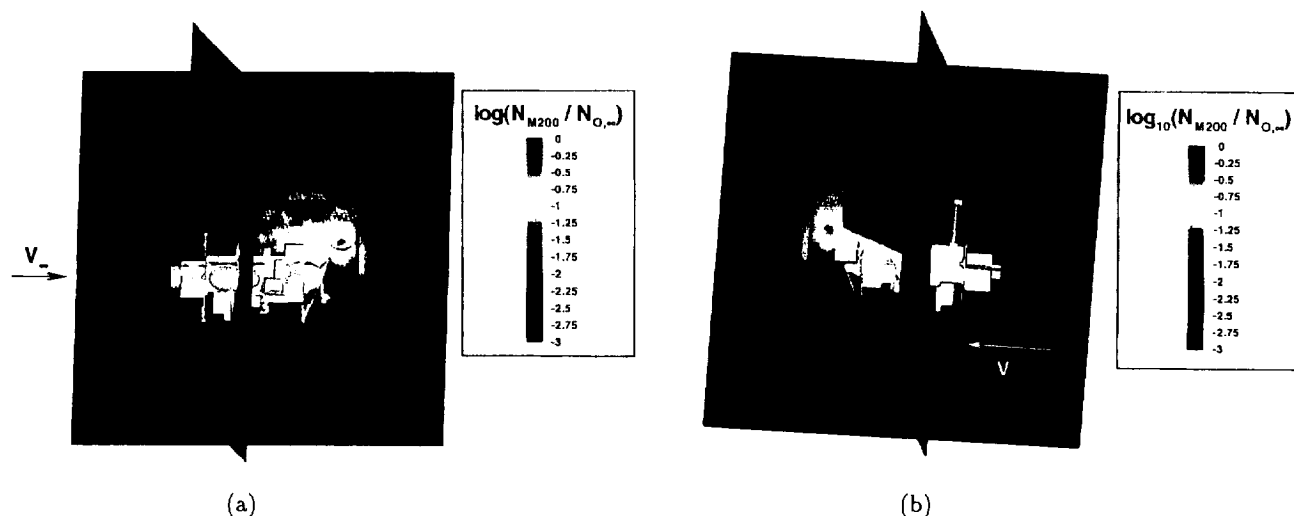




**Figure 10.** Case 1 number density contours of  $GMW = 100$  outgassing species, logarithmic scale nondimensionalized by  $[O]_\infty$ : (a) +Z side, (b) -Z side.

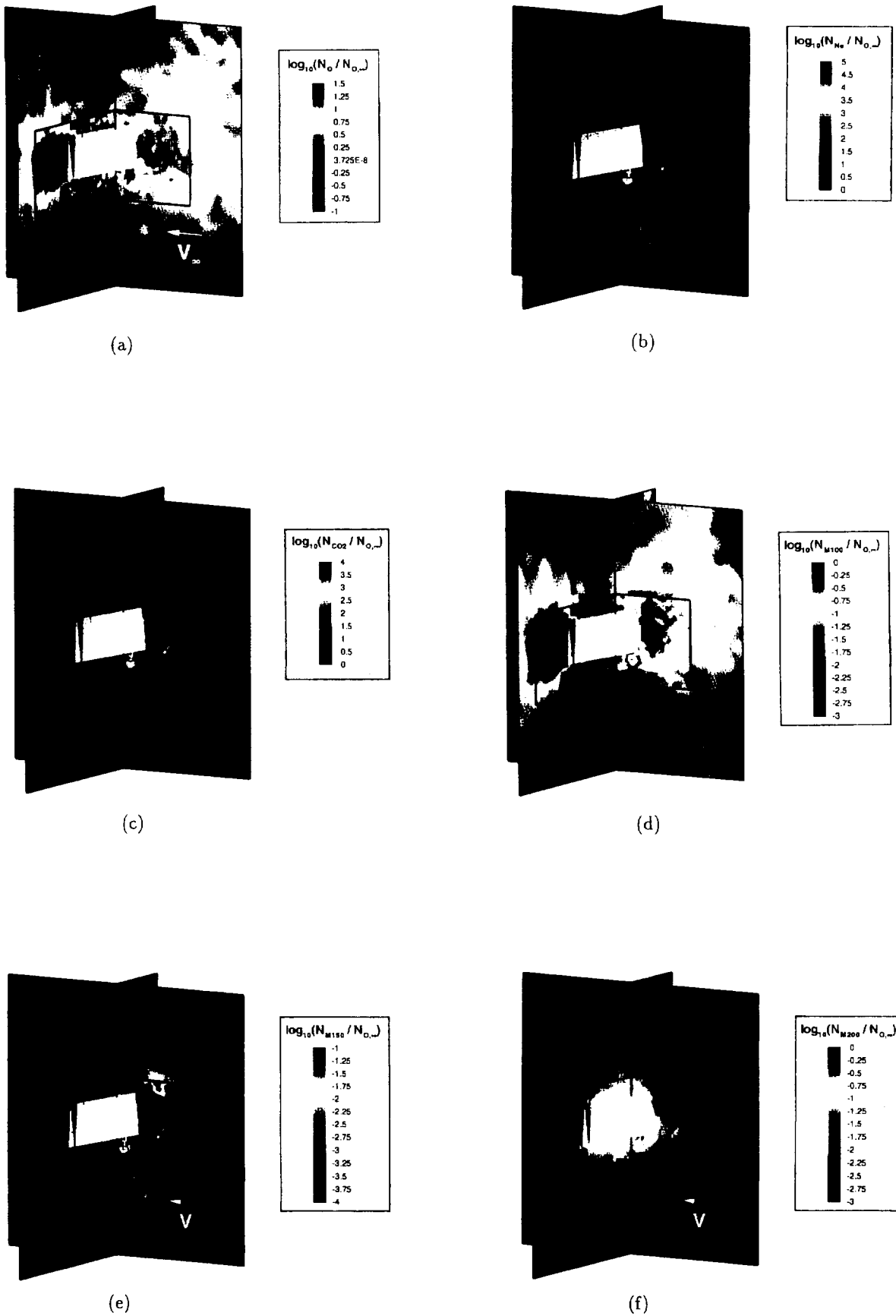


**Figure 11.** Case 1 number density contours of  $GMW = 150$  outgassing species, logarithmic scale nondimensionalized by  $[O]_\infty$ : (a) +Z side, (b) -Z side.



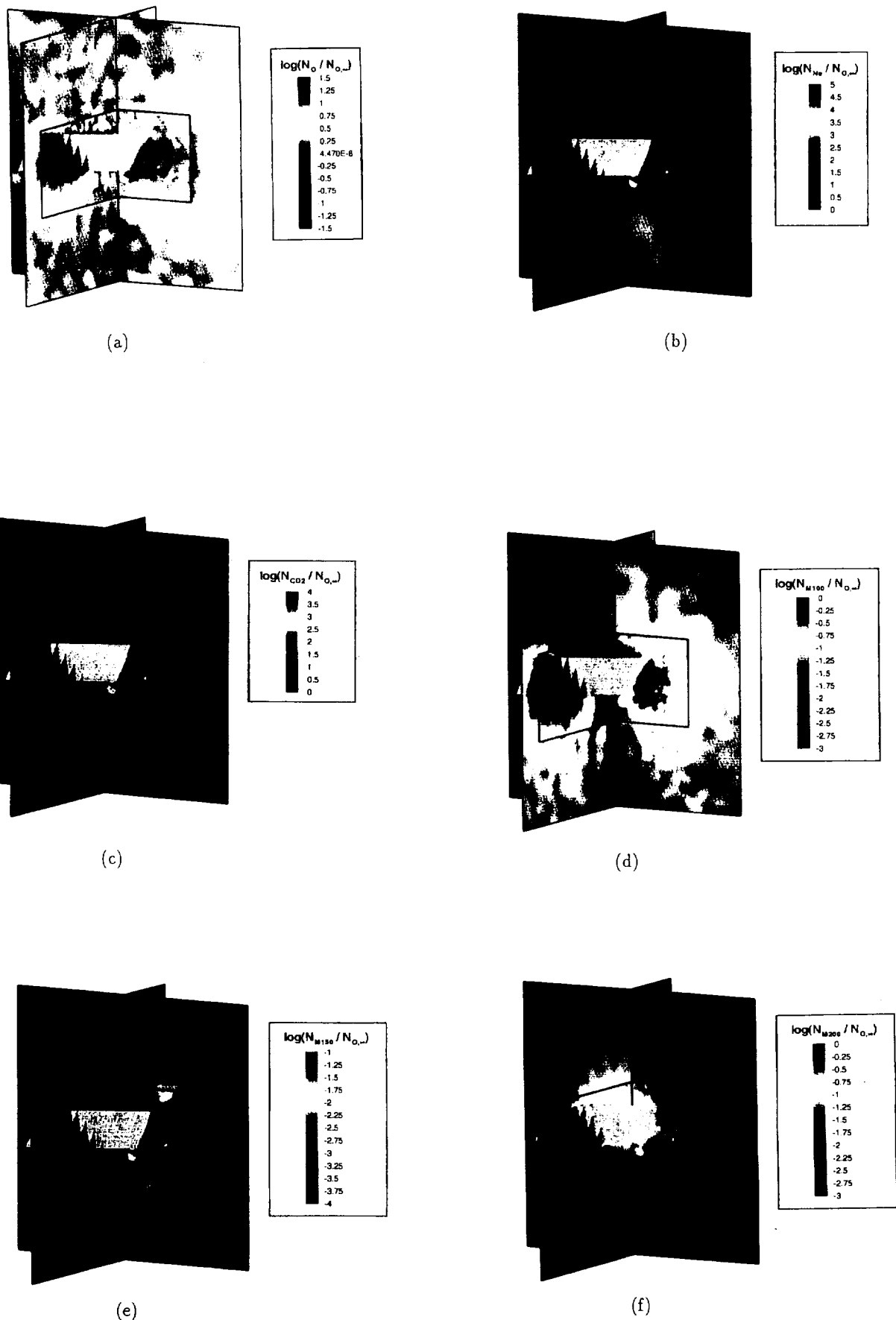
**Figure 12.** Case 1 number density contours of  $GMW = 200$  outgassing species, logarithmic scale nondimensionalized by  $[O]_\infty$ : (a) +Z side, (b) -Z side.





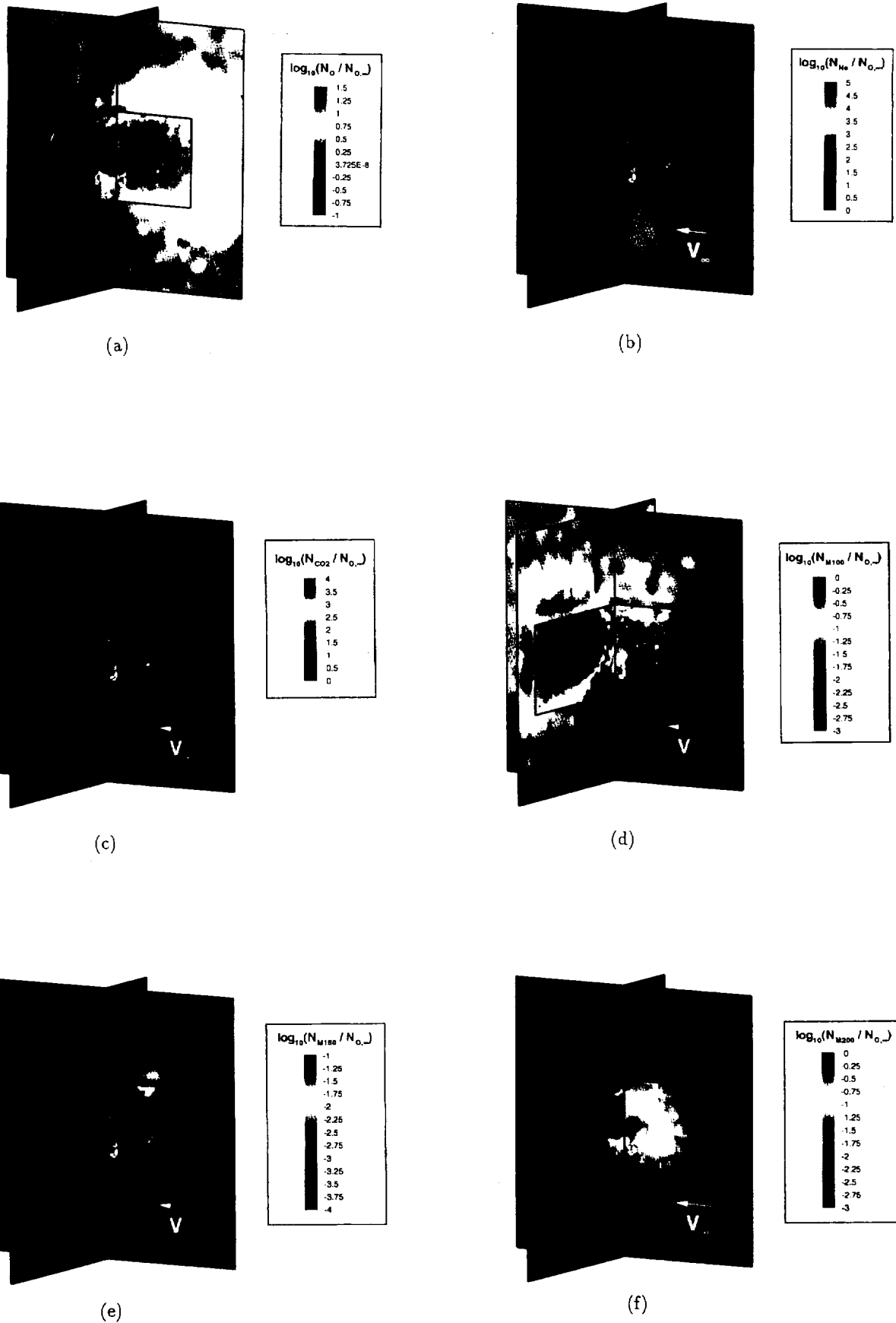
**Figure 13.** Case 1 species number density contour maps emphasizing the HALOE aperture environment. Logarithmic scale nondimensionalized by freestream number density  $[O]_{\infty}$ : (a) monatomic oxygen, (b) neon, (c) carbon dioxide, (d)  $GMW = 100$  species, (e)  $GMW = 150$  species, and (f)  $GMW = 200$  species.





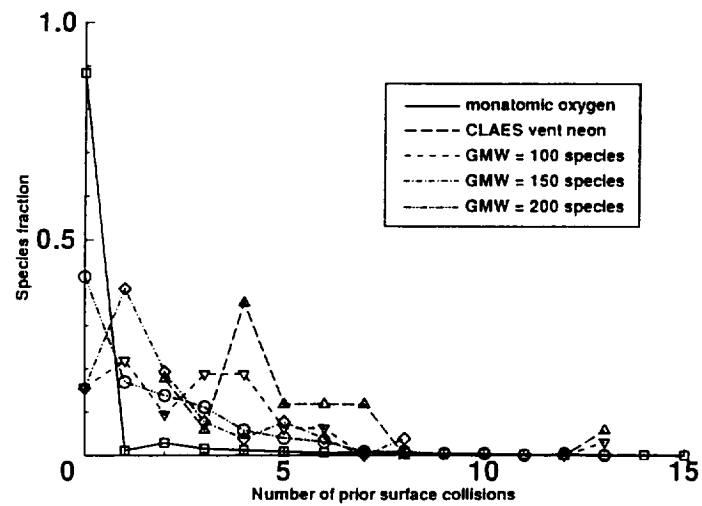
**Figure 14.** Case 2 species number density contour maps emphasizing the HALOE aperture environment. Logarithmic scale nondimensionalized by freestream number density  $[O]_{\infty}$ : (a) monatomic oxygen, (b) neon, (c) carbon dioxide, (d) GMW = 100 species, (e) GMW = 150 species, and (f) GMW = 200 species.



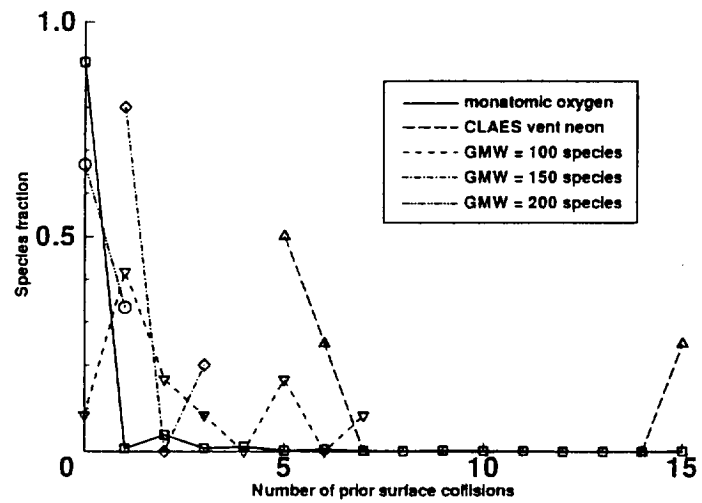


**Figure 15.** Case 3 species number density contour maps emphasizing the HALOE aperture environment. Logarithmic scale nondimensionalized by freestream number density  $[O]_\infty$ : (a) monatomic oxygen, (b) neon, (c) carbon dioxide, (d)  $GMW = 100$  species, (e)  $GMW = 150$  species, and (f)  $GMW = 200$  species.

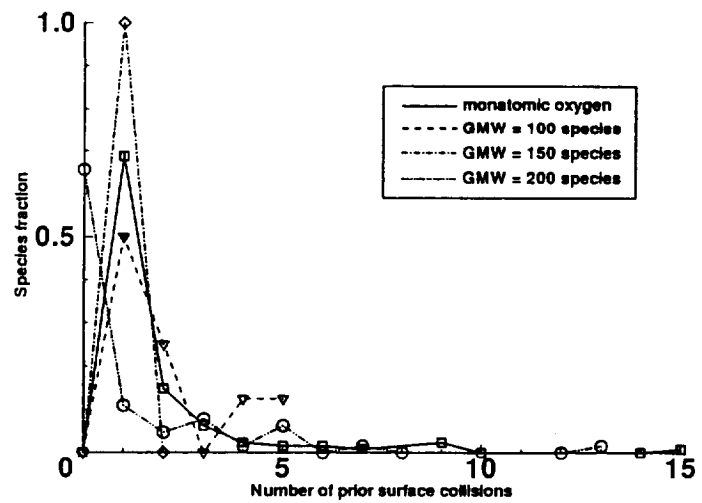




(a)



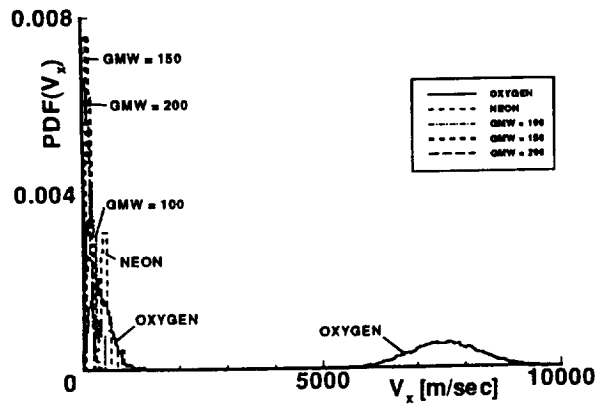
(b)



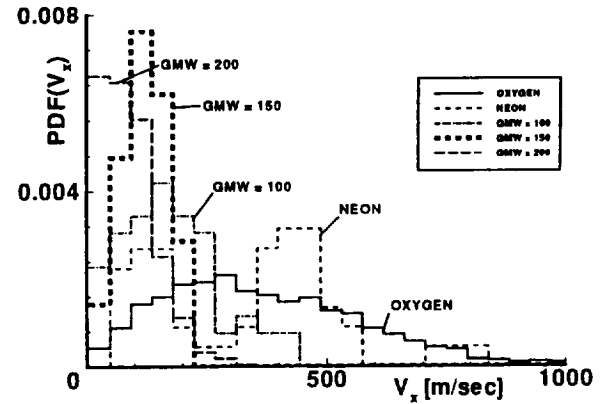
(c)

**Figure 16.** Number of surface collisions encountered by particles prior to striking the HALOE aperture: (a) Case 1, (b) Case 2, and (c) Case 3.

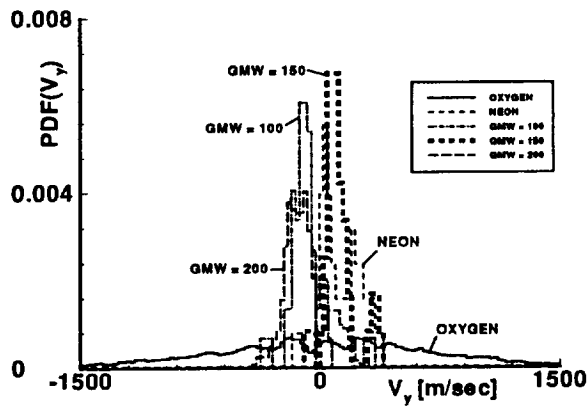




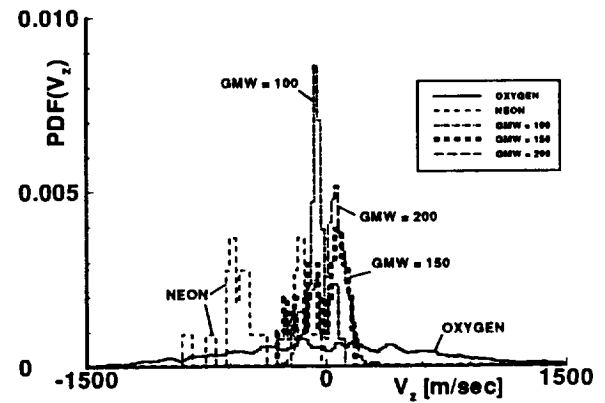
(a)



(b)

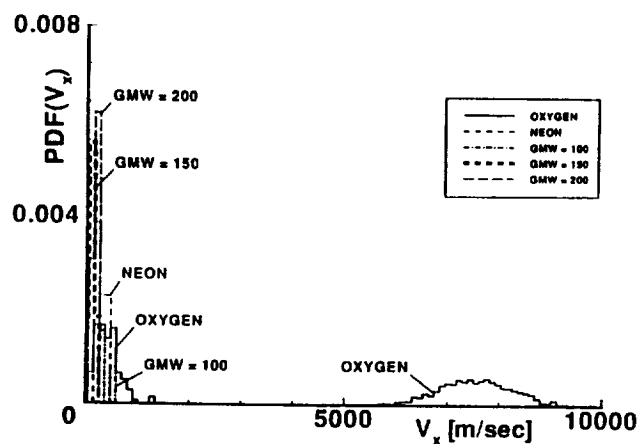


(c)

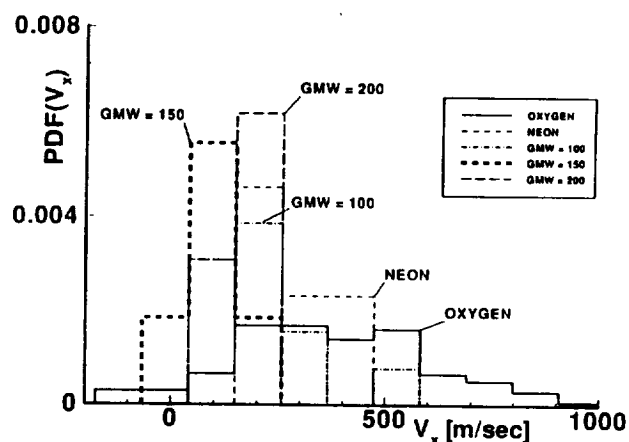


(d)

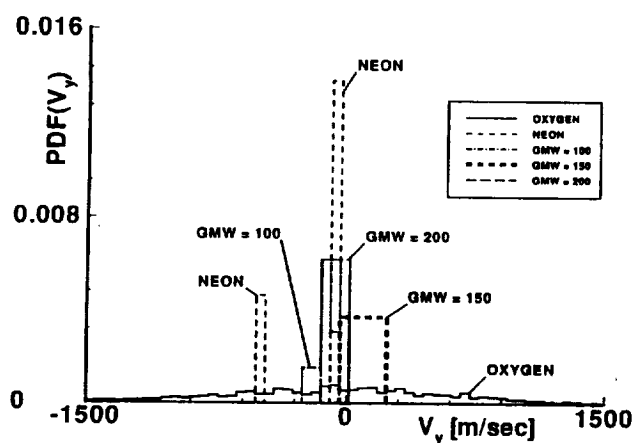
**Figure 17.** Case 1 histograms representing velocity distribution functions for particles striking the HALOE aperture: (a) X direction, (b) Y direction, (c) Z direction.



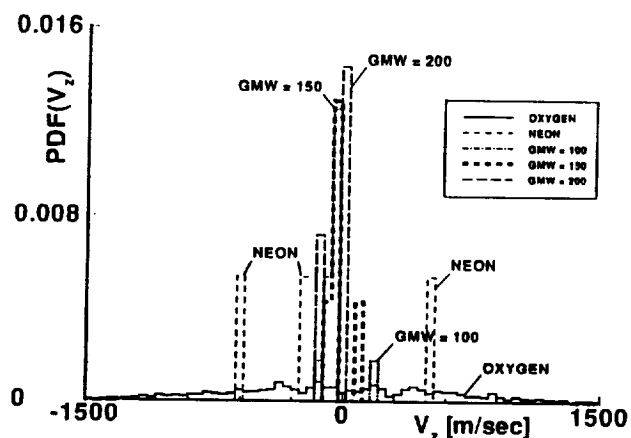
(a)



(b)

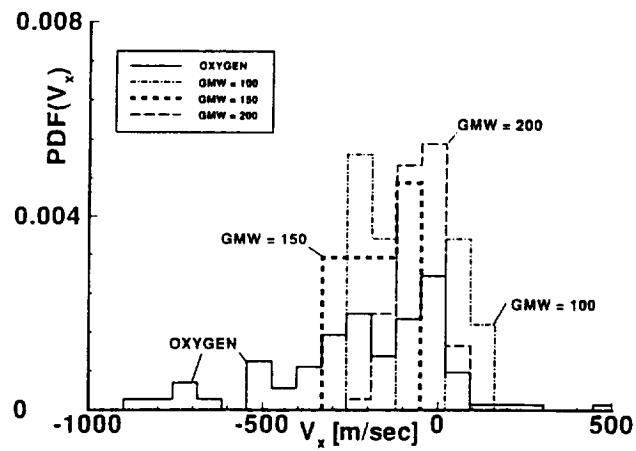


(c)

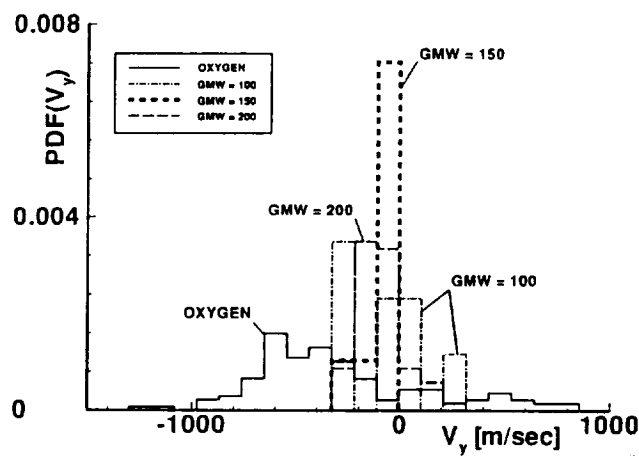


(d)

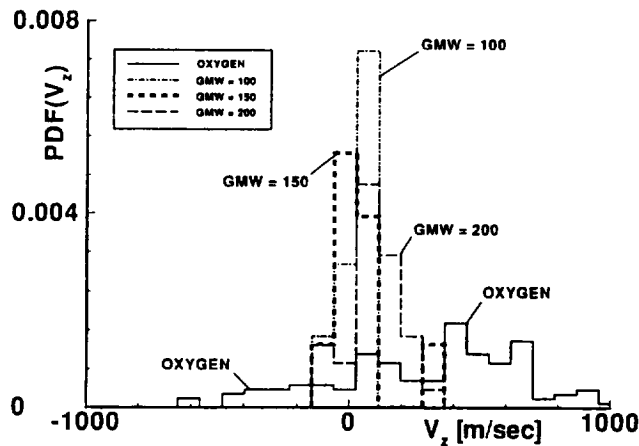
**Figure 18.** Case 2 histograms representing velocity distribution functions for particles striking the HALOE aperture: (a) X direction, (b) Y direction, (c) Z direction.



(a)

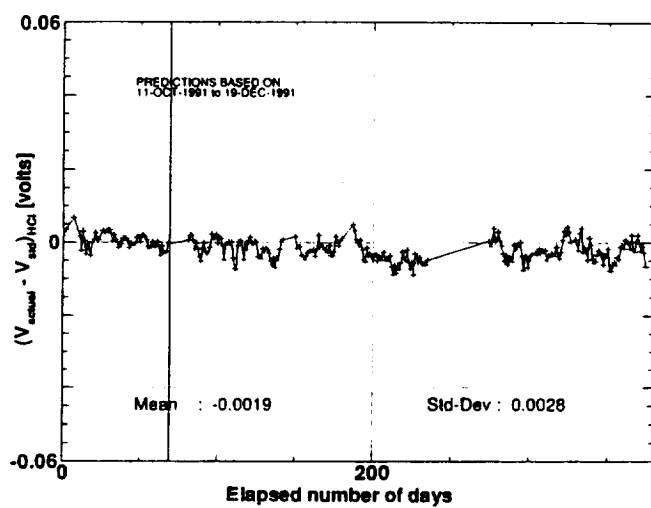
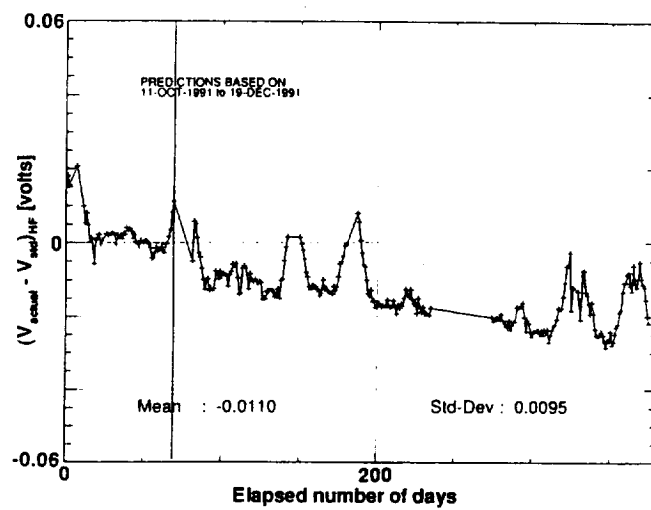


(b)



(c)

**Figure 19.** Case 3 histograms representing velocity distribution functions for particles striking the HALOE aperture: (a) X direction, (b) Y direction, (c) Z direction.



**Figure 20.** Actual HALOE signal attenuation measurements between October 11, 1991 and October 20, 1992 for (a) *HF* and (b) *HCl* species.



| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                             |                                            | Form Approved<br>OMB No. 0704-0188                                    |                                                          |
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| 13. ABSTRACT (Maximum 200 words)<br>A three-dimensional version of the direct simulation Monte Carlo method is adapted to assess the contamination environment surrounding a highly detailed model of the Upper Atmosphere Research Satellite. Emphasis is placed on simulating a realistic, worst-case set of flow field and surface conditions and geometric orientations for the satellite in order to estimate an upper limit for the cumulative level of volatile organic molecular deposits at the aperture of the Halogen Occultation Experiment. A detailed description of the adaptation of this solution method to the study the satellite's environment is also presented. Results pertaining to the satellite's environment are presented regarding contaminant cloud structure, cloud composition, and statistics of simulated molecules impinging on the target surface, along with data related to code performance. Using procedures developed in standard contamination analyses, along with many worst-case assumptions, the cumulative upper-limit level of volatile organic deposits on HALOE's aperture over the instrument's 35-month nominal data collection period is estimated at about 13,350 A. |                                                             |                                            |                                                                       |                                                          |
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