

CHAPTER 4

PAYLOAD FAIRING

4.1 Fairing Introduction

4.1.1 Summary

The spacecraft is protected by a fairing that shields it from various interference from the atmosphere, which includes high-speed air-stream, aerodynamic loads, aerodynamic heating and acoustic noises, etc.. While the LV ascending through the atmosphere, the fairing provides SC with good environment.

The aerodynamic heating is absorbed or isolated by the fairing. The temperature inside the fairing is controlled under the allowable range. The acoustic noises generated by air-stream and LV engines are declined to the allowable level for the SC by the fairing.

The fairing is jettisoned when LM-3C launch vehicle flies out of the atmosphere. The exact time of fairing jettisoning is determined by the requirement that aerodynamic heat flux at fairing jettisoning is lower than 1135 W/m^2 .

22 types of tests have been performed during LM-3C fairing development, including fairing wind-tunnel test, thermal test, acoustic test, separation test, model survey test and strength test, etc.

LM-3C provides four types of fairing: Fairing 4000F, Fairing 4000Z, Fairing 4200F, and Fairing 4200Z. (See **Figure 4-1** and **Figure 4-2**) These fairings are introduced in **Table 4-1**.

Table 4-1 LM-3C Fairing Types

Name	Description
4000F	Fairing Diameter 4000mm. Fairing is encapsulated on the launch pad. (Encapsulation-on-pad)
4000Z	Fairing Diameter 4000mm. Fairing is encapsulated in BS3. (Encapsulation-in-BS3)
4200F	Fairing Diameter 4200mm. Fairing is encapsulated on the launch pad. (Encapsulation-on-pad)
4200Z	Fairing Diameter 4200mm. Fairing is encapsulated in BS3. (Encapsulation-in-BS3)

The fairing encapsulation procedures are introduced in **Chapter 8**.

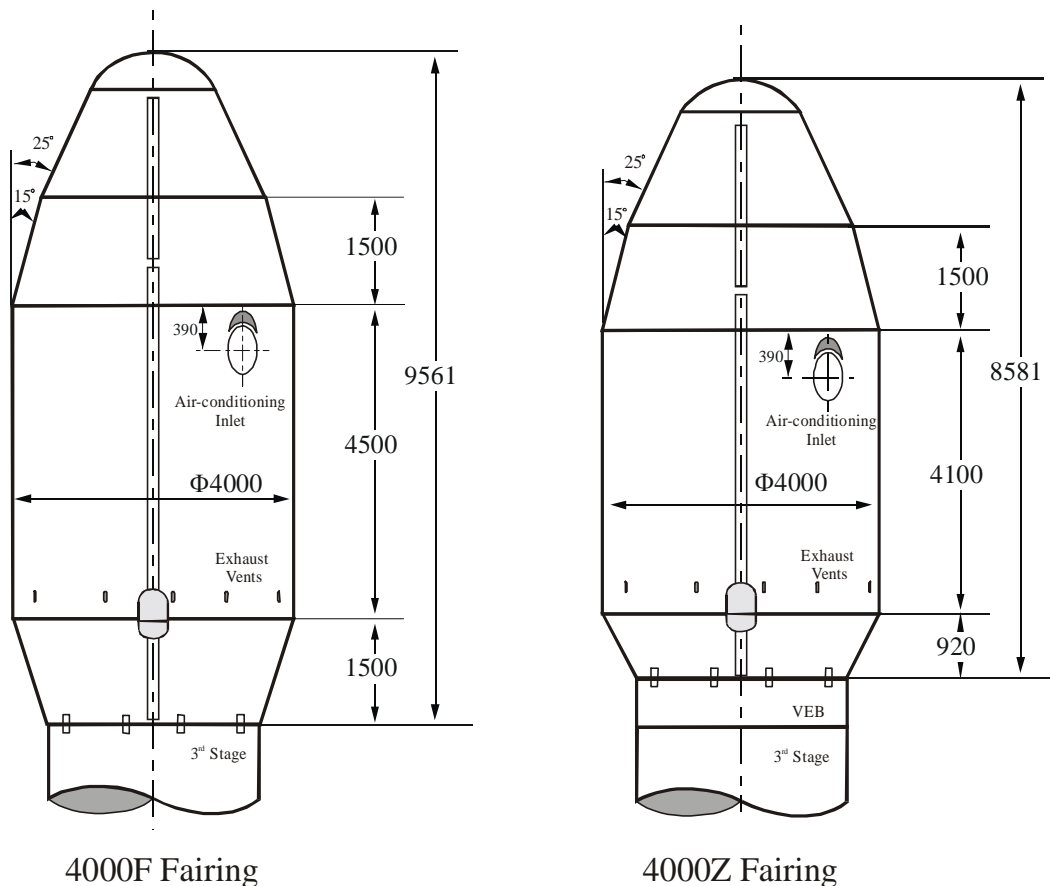


Figure 4-1 Fairing Configurations of 4000F and 4000Z

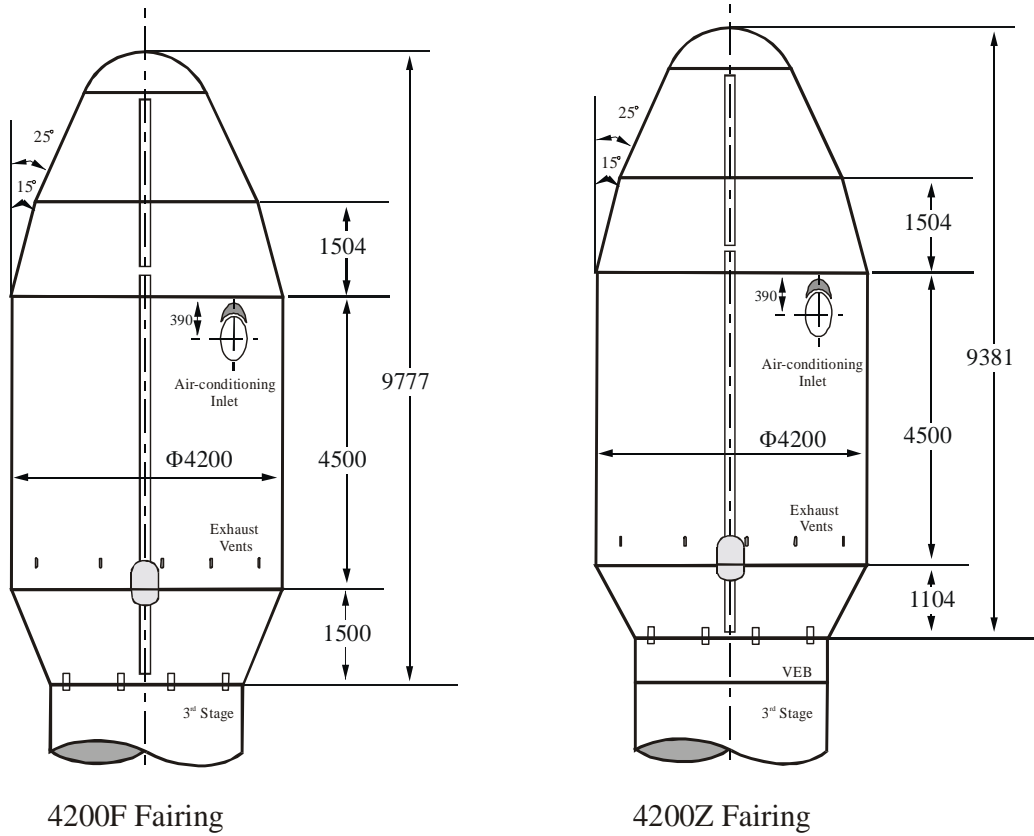


Figure 4-2 Fairing Configurations of 4200F and 4200Z

4.1.2 4000F Fairing

The outer diameter of Fairing 4000F is 4000mm, and its height is 9561mm. It will be encapsulated on the launch pad. The configuration is shown in **Figure 4-1**. The envelope is shown in **Figure 4-3a** and **Figure 4-3b**. The fairing supports 937B, 1194, 1194A and 1666 interfaces.

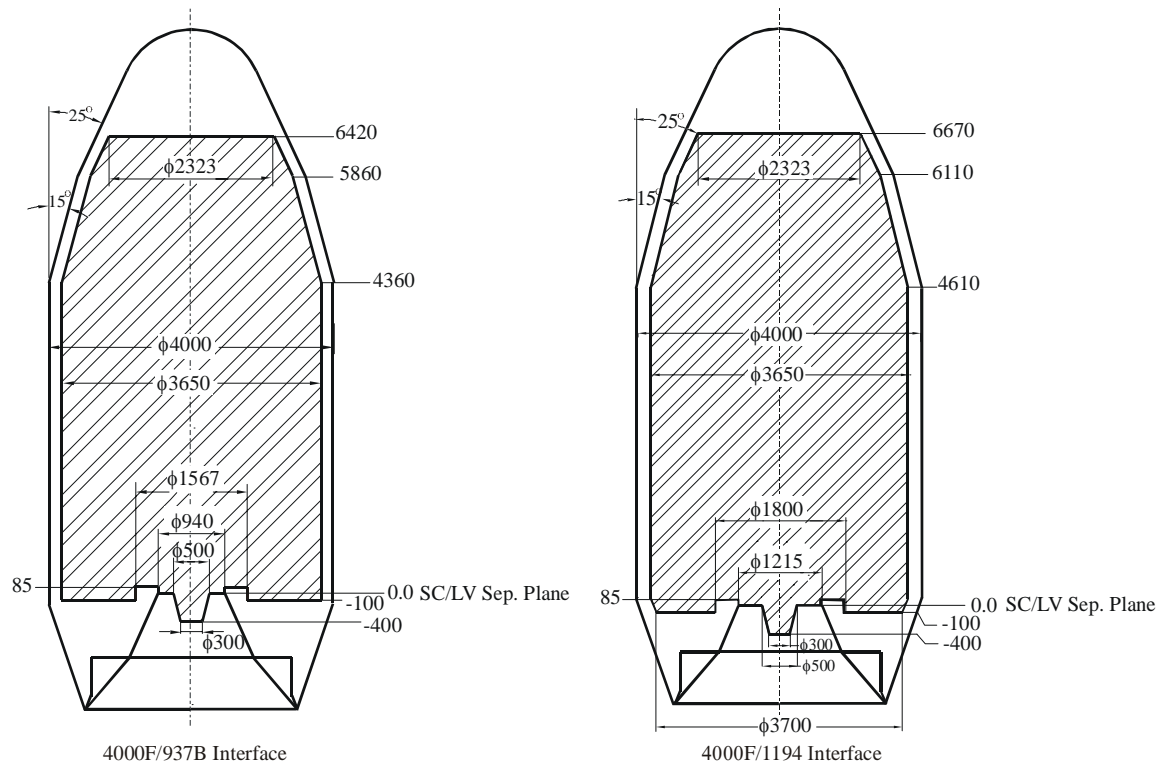


Figure 4-3a 4000F Fairing Envelope (937B Interface and 1194 Interface)

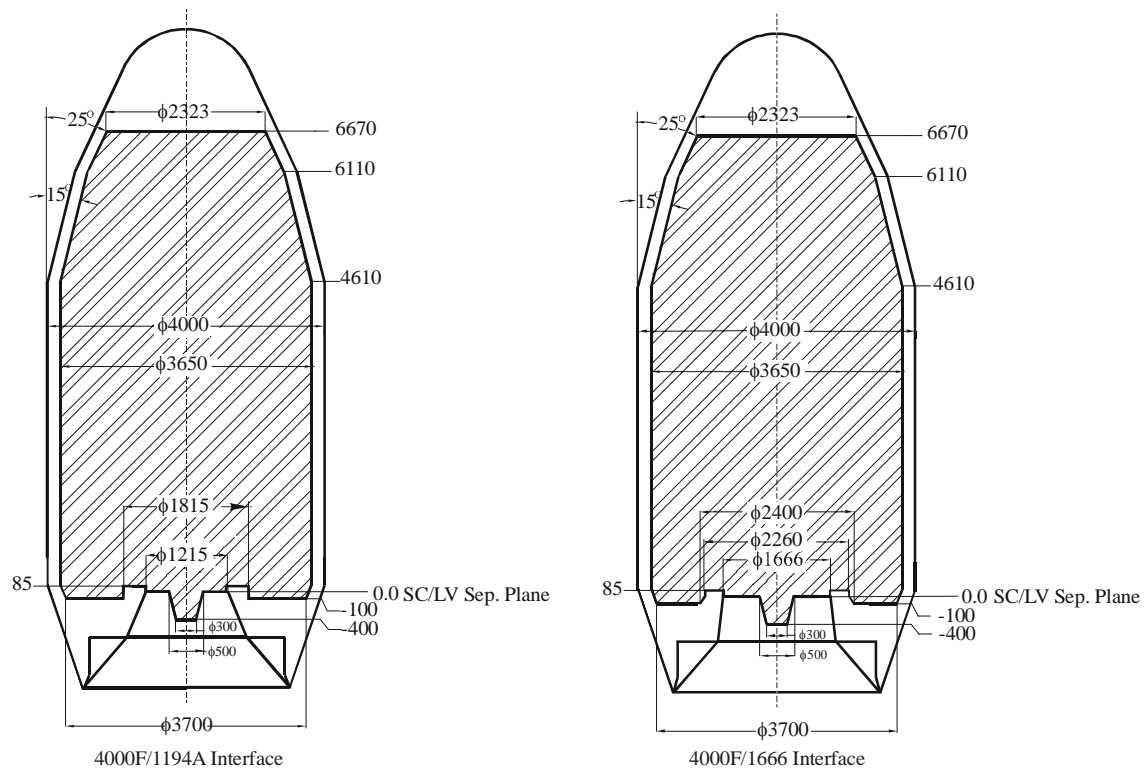


Figure 4-3b 4000F Fairing Envelope (1194A Interface and 1666 Interface)

4.1.3 4000Z Fairing

The outer diameter of Fairing 4000Z is 4000mm, and its height is 8981mm. It will be encapsulated in BS3. The configuration is shown in **Figure 4-1**, and the envelope is shown in **Figure 4-4**. The fairing supports 1194A and 1666 interfaces.

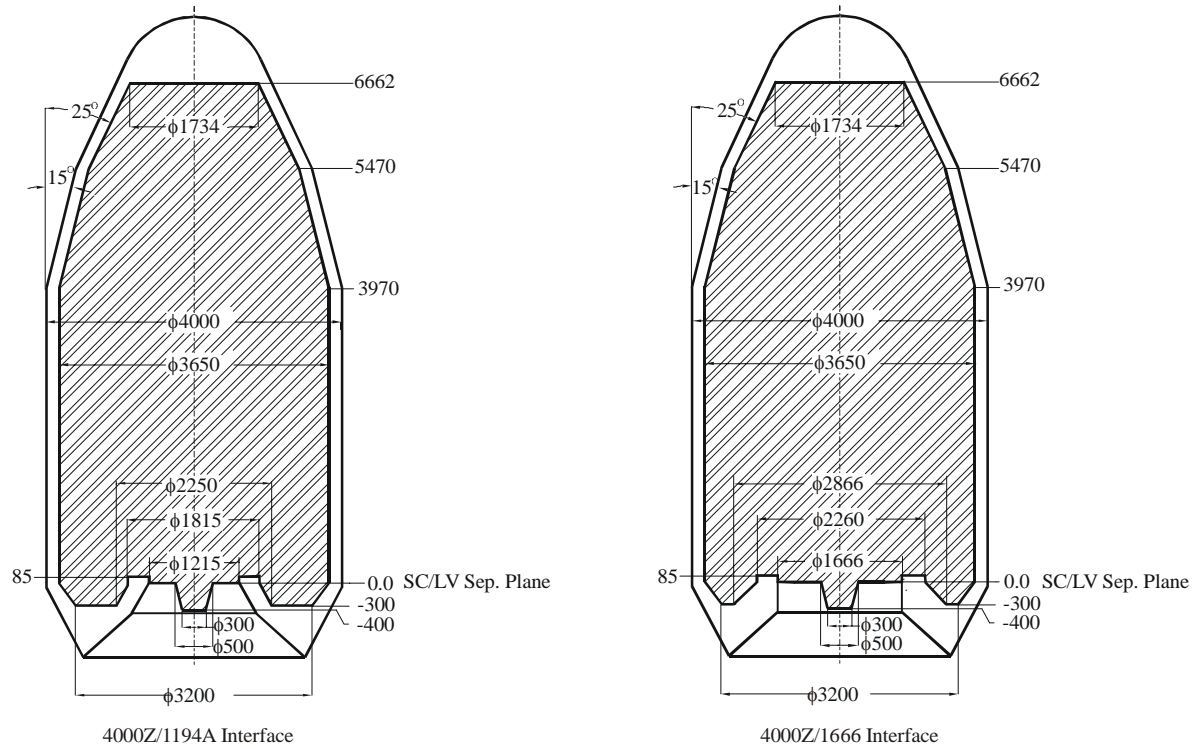


Figure 4-4 4000Z Fairing Envelope (1194A Interface and 1666 Interface)

4.1.4 4200F Fairing

The outer diameter of Fairing 4200F is 4200mm, and its height is 9777mm. It will be encapsulated on the launch pad. The configuration is shown in **Figure 4-2**, and envelope is shown in **Figure 4-5**. The fairing supports 1194A and 1666 interfaces.

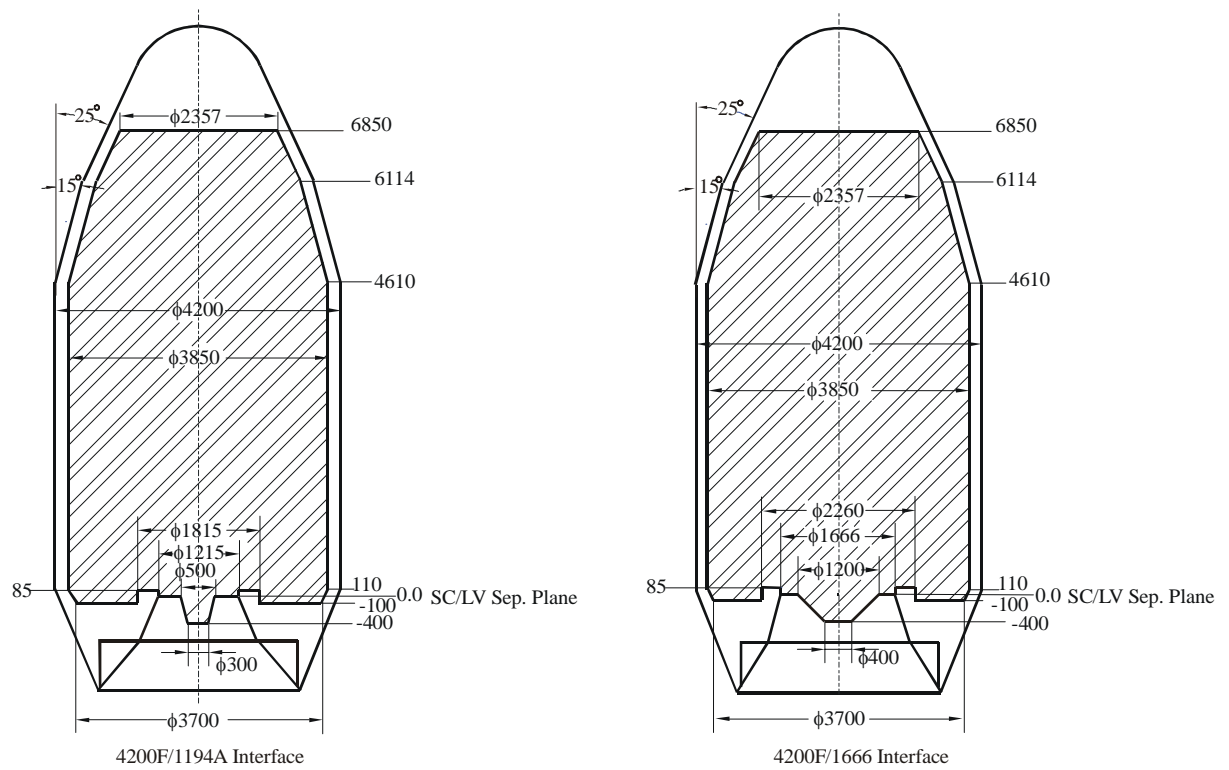


Figure 4-5 4200F Fairing Envelope (1194A Interface and 1666 Interface)

4.1.5 4200Z Fairing

The outer diameter of Fairing 4200Z is 4200mm, and its height is 9381mm. It will be encapsulated in BS3. The configuration is shown in **Figure 4-2**, and envelope is shown in **Figure 4-6**. The fairing supports 1194A and 1666 interfaces.

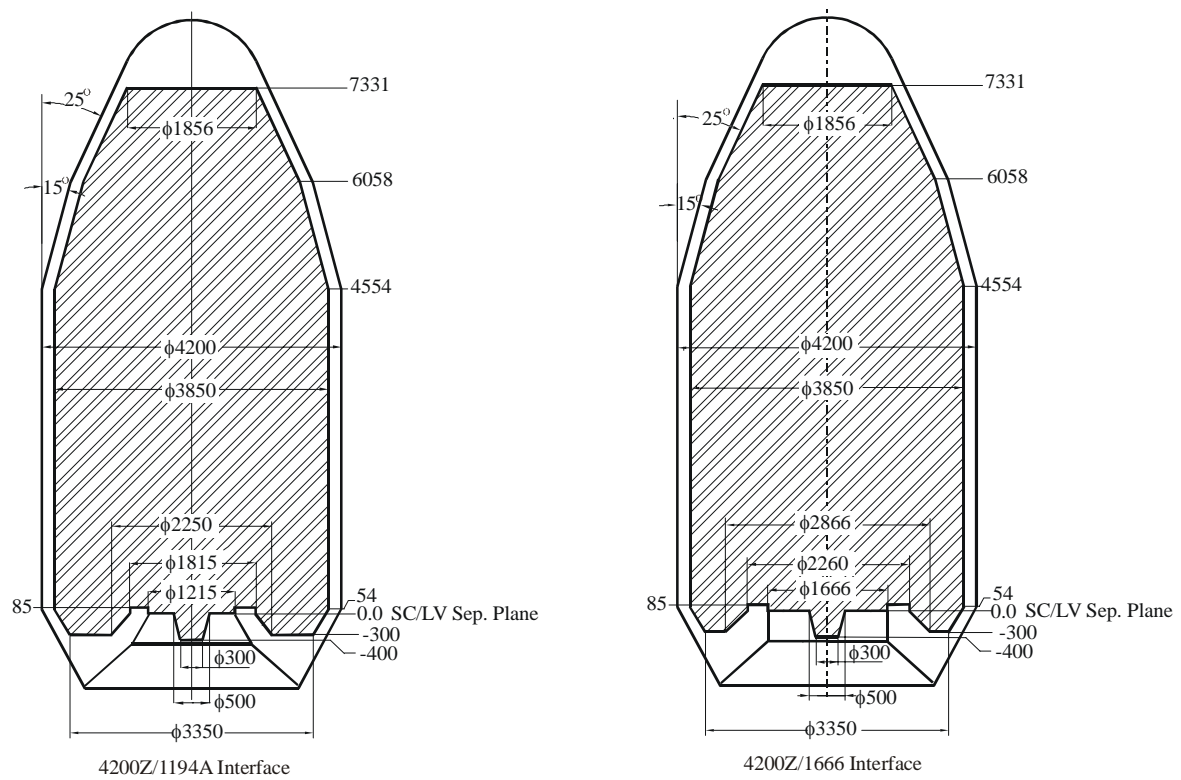


Figure 4-6 4200Z Fairing Envelope (1194A Interface and 1666 Interface)

4.1.6 How to Use the Fairing Static Envelope

The static envelope of the fairing is the limitation to the maximum dimensions of SC configuration. The static envelope is determined by consideration of estimated dynamic and static deformation of the fairing/payload stack generated by a variety of interference during flight. The envelopes vary with different fairing and different types of payload adapters.

It is allowed that a few extrusions of SC can exceed the maximum static envelope ($\Phi 3650$ or $\Phi 3850$) in the fairing cylindrical section. However, the extrusion issue shall be resolved by technical coordination between SC side and CALT.

4.2 Fairing Structure

The structures of 4000F, 4000Z, 4200F and 4200Z fairings are similar. They all consist of dome, biconic section, and cylindrical section and reverse cone section. Refer to **Figure 4-7**.

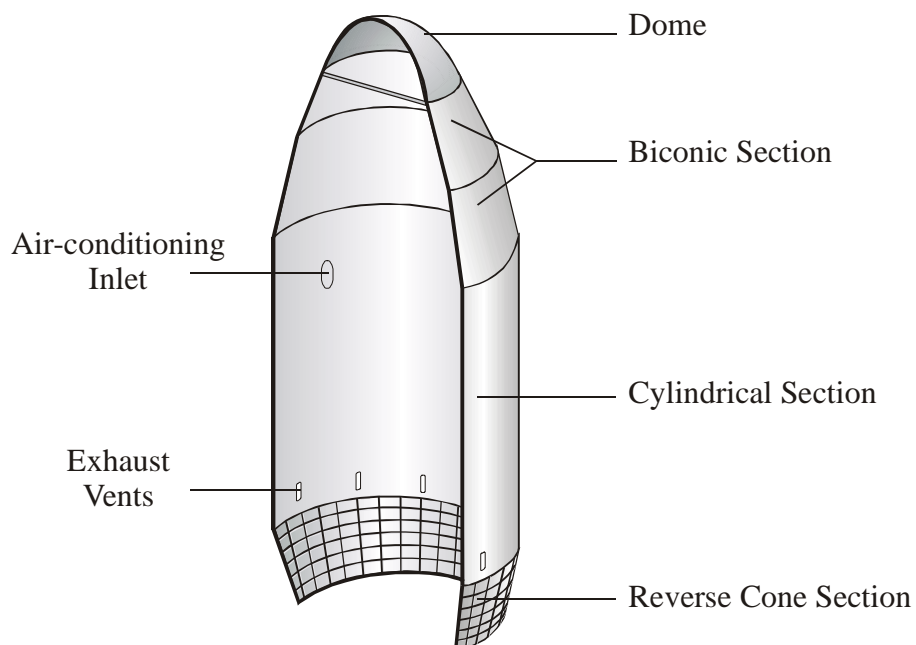


Figure 4-7 Fairing Structure

4.2.1 Dome

The dome is a semi-sphere body with radius of 1000mm, height of 661mm and base ring diameter of $\phi 1890\text{mm}$. It consists of dome shell, base ring, encapsulation ring and stiffeners. Refer to **Figure 4-8**.

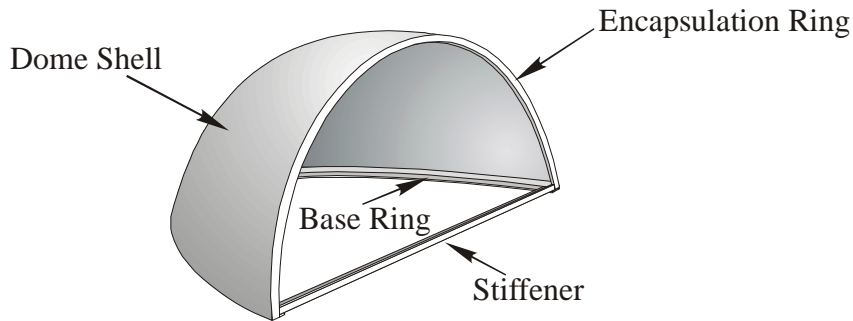


Figure 4-8 Structure of the Fairing Dome

The dome shell is an 8mm-thick fiberglass structure. The base ring, encapsulation ring and stiffener are made of high-strength aluminum alloys. A silica-rubber wind-belt covers on the outside of the split line, and a rubber sealing belt is compressed between the two halves. The outer and inner sealing belts keep air-stream from entering the fairing during launch vehicle flight.

4.2.2 Biconic Section

The upper part of the biconic section is a 25° -cone with height of 1400mm, and the lower part is a 15° -cone with height of 1500mm. The upper part and the lower part are jointed together. The diameter of the top ring is 1890mm, and the diameter of the bottom ring is 4000mm.

4.2.3. Cylindrical Section

The structure of the cylindrical section is identical to that of biconic section, i.e. aluminum honeycomb sandwich. There are two air-conditioning inlets opened on the upper part of the cylindrical section, and 10 exhaust vents with total area of 191cm² on the lower part. Refer to **Figure 4-1**, **Figure 4-2**.

4.2.4 Reverse Cone Section

The reverse cone section is a ring-stiffened semi-monocoque structure. It is composed of top ring, intermediate ring, bottom ring, inner longitudinal stiffeners and chemical-milled skin. For fairings 4000F and 4200F, several access doors are available on this section. For fairings 4000Z and 4200Z, there is no access door available on this section.

4.3 Heating-proof Function of the Fairing

The outer surface of the fairing, especially the surface of the dome and biconic section, is heated by high-speed air-stream during LV flight. Therefore, heating-proof measures are adopted to assure the temperature of the inner surface be lower than 80°C.

The outer surface of the biconic and cylindrical sections are covered by special cork panel. The cork panel on the biconic section is 1.2mm thick, and 1.0 mm thick on the cylindrical section.

4.4 Fairing Jettisoning Mechanism

The fairing jettisoning mechanism consists of lateral unlocking mechanism and longitudinal unlocking mechanism and separation mechanism. Refer to **Figure 4-9a,b,c&d**.

4.4.1 Lateral Unlocking Mechanism

For the fairings 4000F and 4200F, the base ring of the fairing is connected with forward short skirt of the third stage cryogenic tank by 12 non-contamination explosive bolts. For the 4000Z and 4200Z fairings, the base ring of the fairing is connected with the top ring of the VEB by 12 non-contamination explosive bolts. The

distribution of the explosive bolts is shown in **Figure 4.9b**. The reliability of the explosive bolt is 0.9999.

4.4.2 Longitudinal Unlocking Mechanism

The longitudinal separation plane of the fairing is II-IV quadrant (XOZ). The longitudinal unlocking mechanism consists of notched bolts, hoses with explosive cords and initiators, initiator bracket and two explosive bolts, etc. see **Figure 4.9c**.

The two steel hoses go along the split line of the fairing. Two insensitive initiators are attached at the each end of the explosive cords. When unlocking, the two non-contamination explosive bolts are detonated and cut off firstly. The initiators ignite the explosive cords, and high-pressure gas is generated instantly, which makes the steel hoses expand, and the notched bolts are broken. In that sequence, the fairing separates into two halves. The gas generated by the explosive cords is sealed in the steel hoses, so there is no contamination to the SC.

One of the two explosive cords can be ignited only if one of the four attached initiators is fired. If one explosive cord works, all the notched bolts can be broken, i.e. fairing can separate. Therefore, the reliability of the longitudinal separation is very high.

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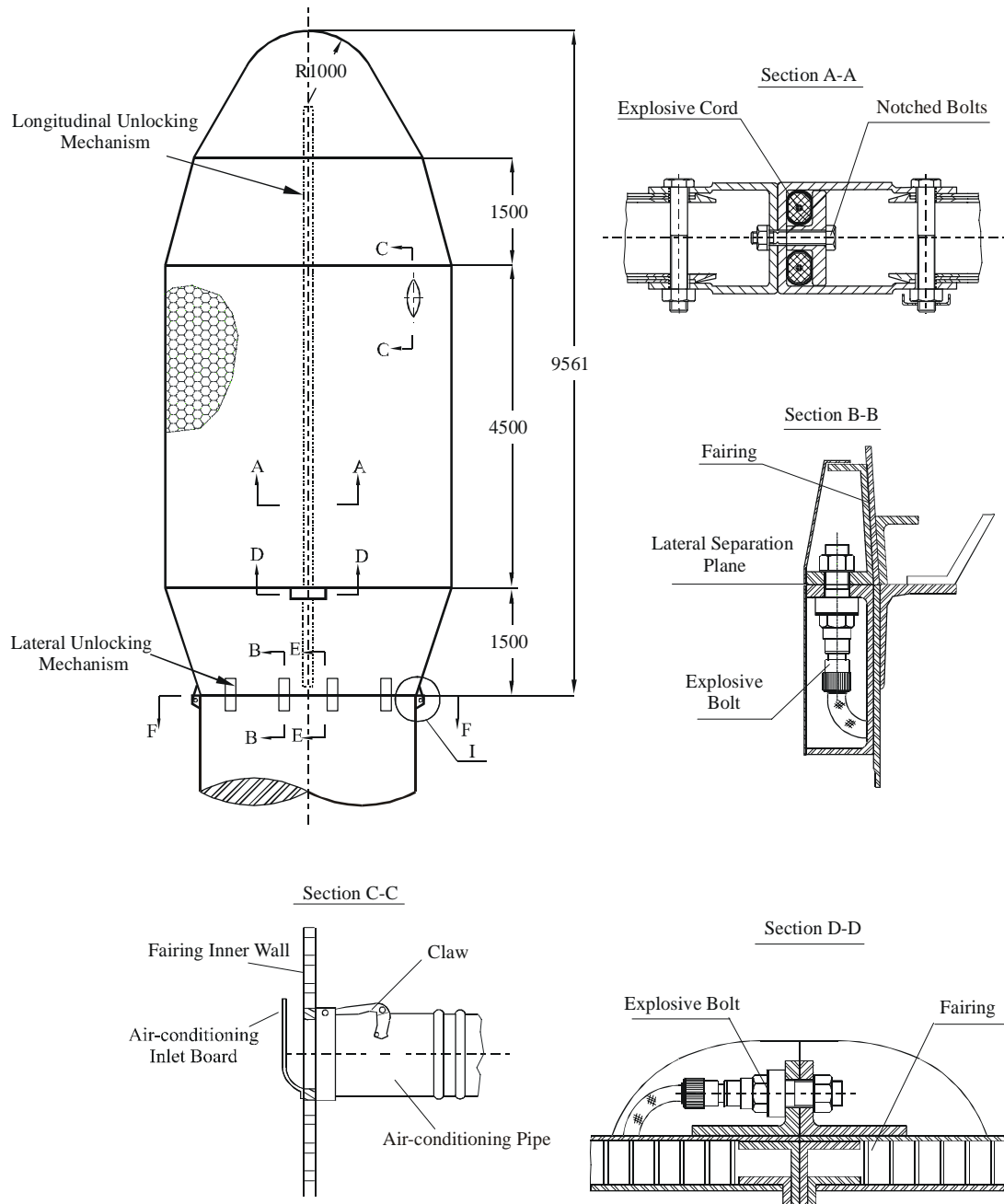


Figure 4-9a Fairing Unlocking Mechanism

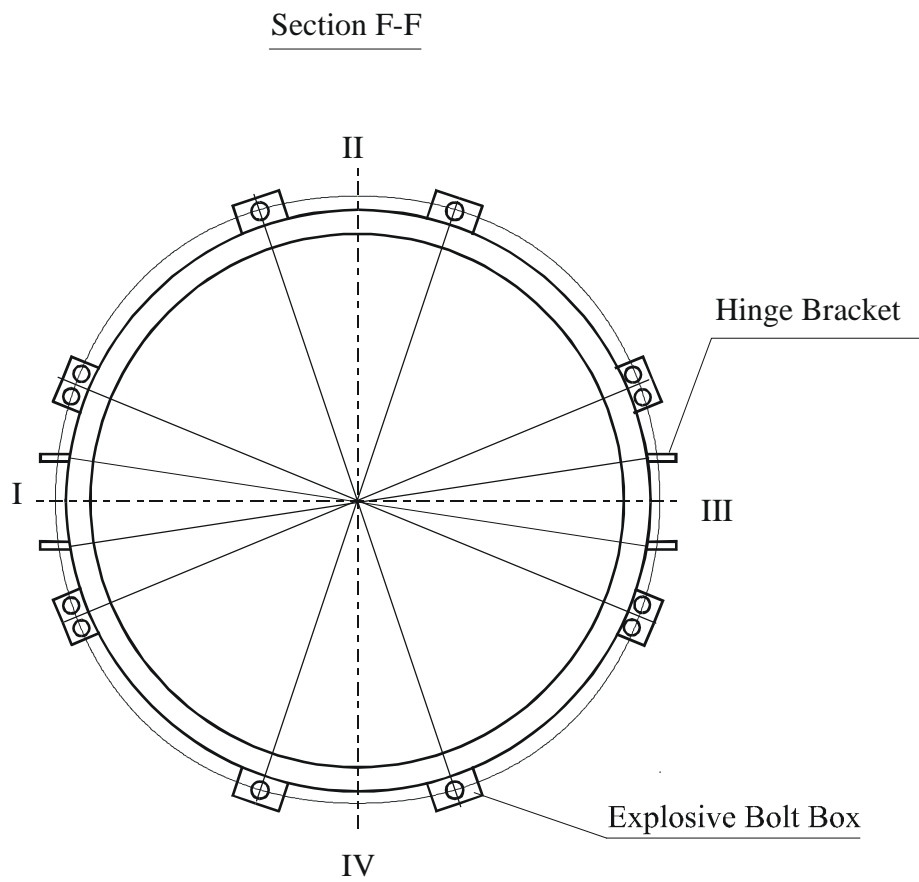


Figure 4-9b Distribution of the LV Lateral Unlocking Explosive Bolts

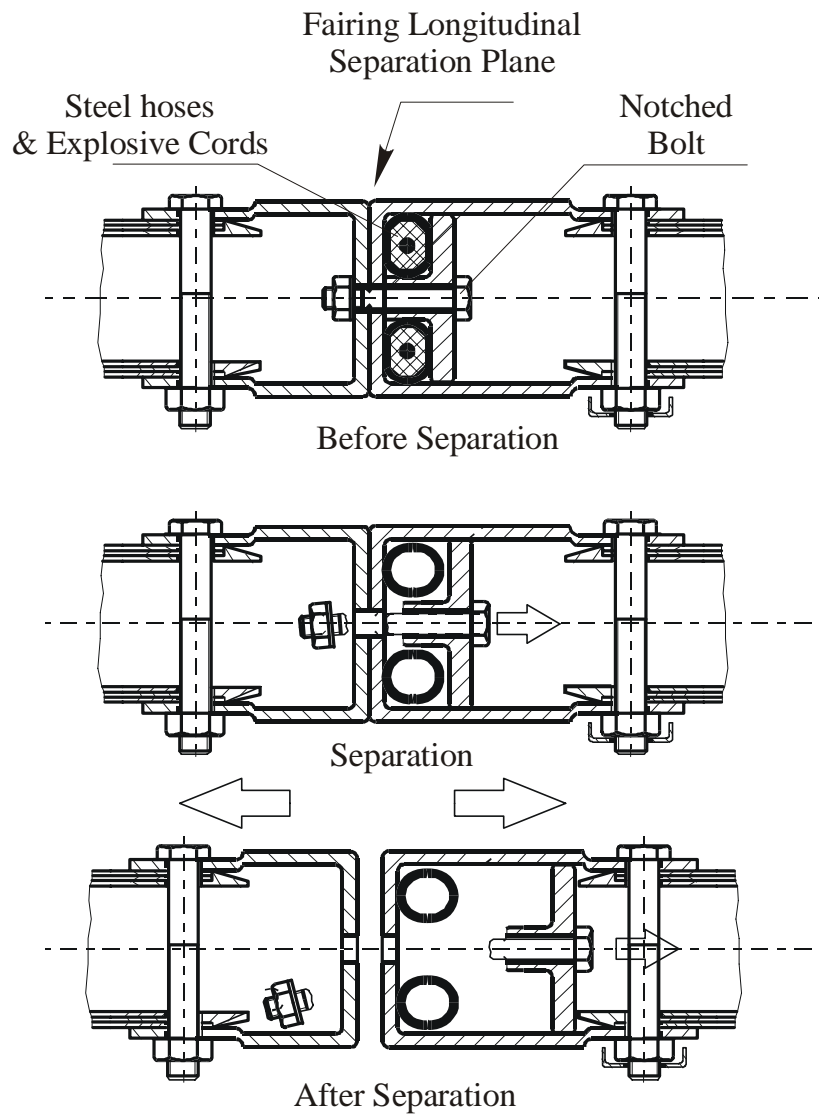


Figure 4-9c LV Longitudinal Unlocking Illustration

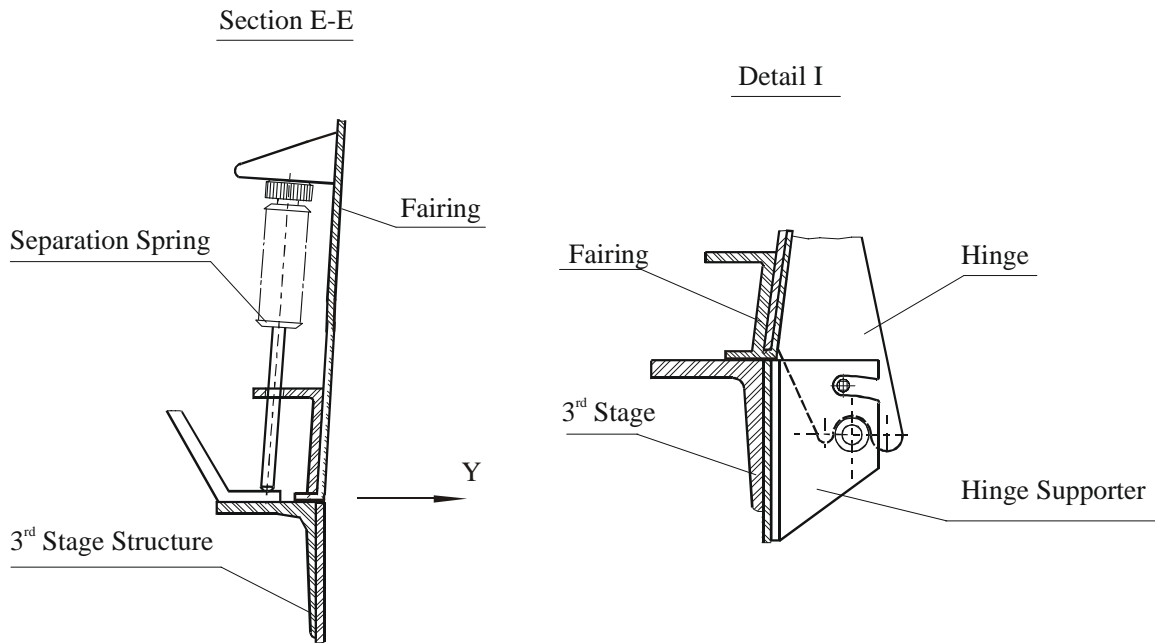


Figure 4-9d Fairing Separation Mechanism

4.4.3 Fairing Separation Mechanism

The fairing separation mechanism is composed of hinges and springs, see **Figure 4-9a,c&d**. Each half of the fairing is supported by two hinges, which locate at quadrant I and III. There are 6 separation springs mounted on each half of the fairing, the maximum acting force of each spring is 37.8kN. After fairing unlocking, each half of the fairing turns around the hinge. When the roll-over rate of the fairing half is larger than $18^\circ/s$, the fairing is jettisoned. The kinematical process is shown in **Figure 4-10**.

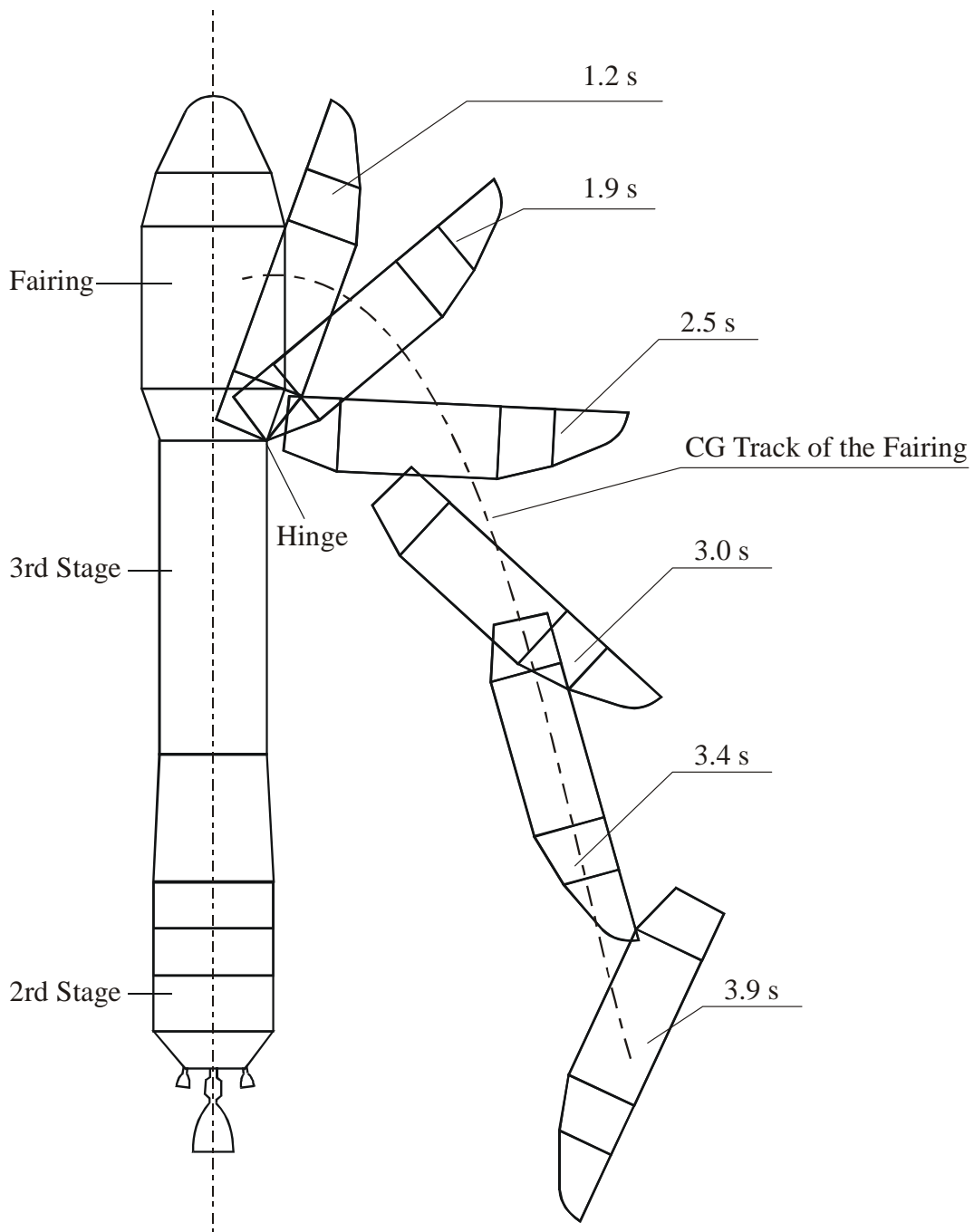


Figure 4-10 Fairing Separation Dynamic Process

4.5 RF Windows and Access Doors

Radio frequency (RF) transparent windows can be incorporated into the fairing biconic section and cylindrical section to provide SC with RF transmission through the fairing, according to user's needs. The RF transparent windows are made of fiberglass, of which the RF transparency rate is shown in the **Table 4-2**.

Table 4-2 RF Transparent Rate

Frequency(GHz)	0.4	4	8	10	13	15	17
Insertion loss (dB)	-0.25	-0.47	-0.52	-1.63	-1.4	-2.73	-4.11
Transparency Rate	0.94	0.89	0.88	0.68	0.72	0.53	0.38

Access doors can be provided in the cylindrical section to permit limited access to the spacecraft after the fairing encapsulation, according to user's needs. Some area on the fairing can not be selected as the locations of RF windows and access doors, see **Figure 4-11**. User can propose the requirements on access doors and RF windows to CALT. However, such requirements should be finalized 8 months prior to launch.

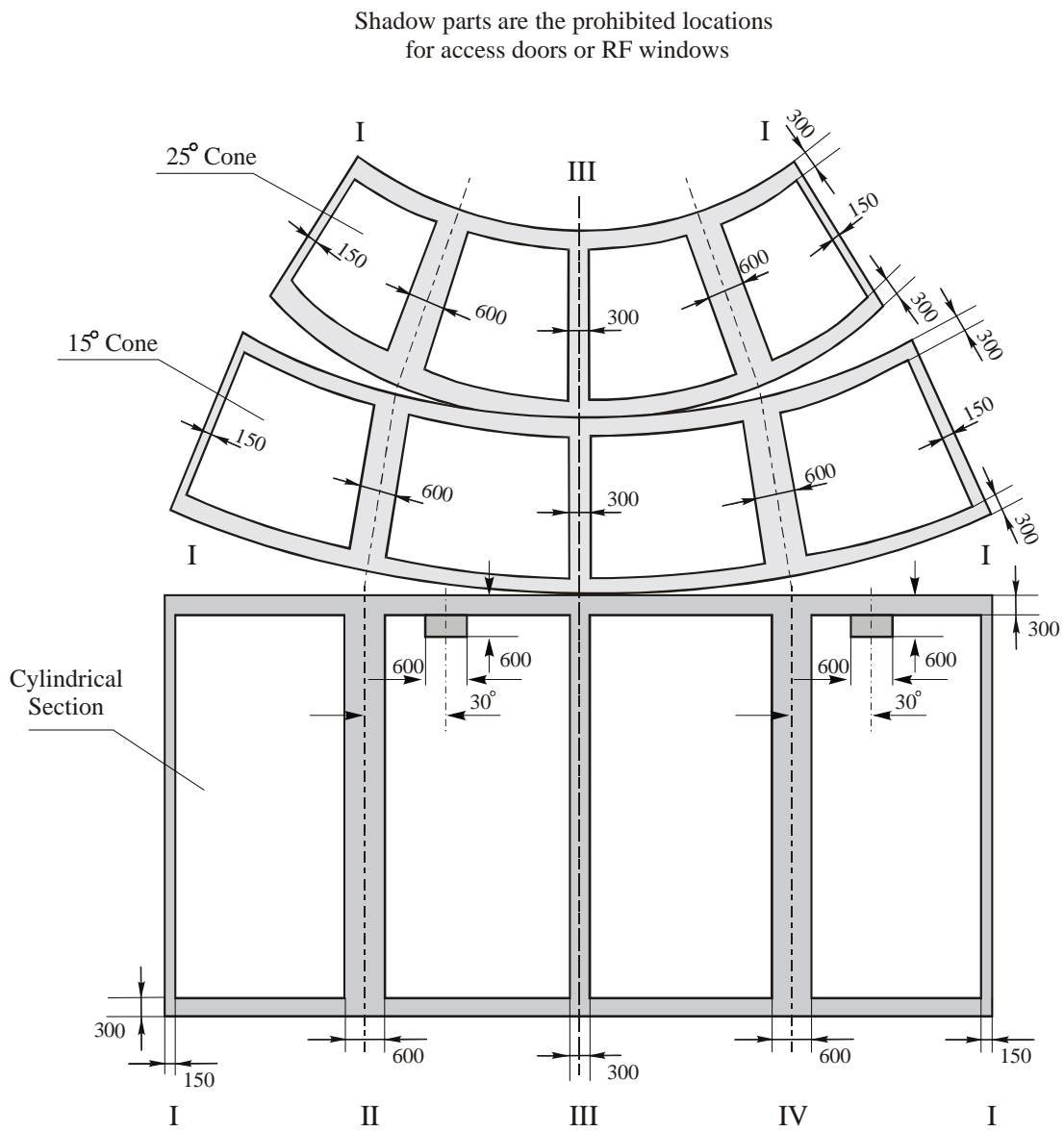


Figure 4-11 Prohibited Locations for Access Doors and RF Windows