

ELIMINATION OF THE POTENTIAL HAZARD OF THE LONG MARCH 4 LAUNCH VEHICLE'S ON-ORBIT BREAKUP

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Abstract

On Oct.4,1990, the upper stage of a Long March 4(A) launch vehicle broke up on its orbit. This event attracted extra attention from the National Aerospace Administration of China. Based on the analyses of the breakup cause, Shanghai Academy of Spaceflight Technology has improved the design of the Long March 4. A system venting the residual propellants from the tank and the residual gas from the pressurization bottles is added to LM-4's upper stage, thus making the orbit-injected upper stage rocket passivated. After four years' efforts, a venting system has been successfully developed. This paper gives a brief introduction to the technical scheme of LM-4's venting system and a brief review on its development work.

1. LM-4 Launch Vehicle

LM-4 is a multipurpose three-stage launch vehicle developed and produced by Shanghai Academy of Spaceflight technology. It is specially suitable for launching polar orbit satellites and sun-synchronous orbit satellites. In 1988 and 1990, it precisely put two FY-1 meteorological satellites into their sun-synchronous orbits respectively. In the 1990 mission, besides the FY-1 meteorological satellite, two High Atmosphere Experimental Satellites were put into their desired orbits simultaneously (Fig. 1).

The typical payload capability of LM-4 is to put a payload of 1650 Kg into the 900 Km

sun-synchronous orbit or to put a payload of 4680 Kg into the 200 Km circular orbit.

LM-4 uses N_2O_4 /UDMH as its propellants. Its lift-off mass is 250 t and lift-off thrust, 2961.6KN.

LM-4 is a multipurpose launch vehicle with high reliability, low launching cost and high performance.

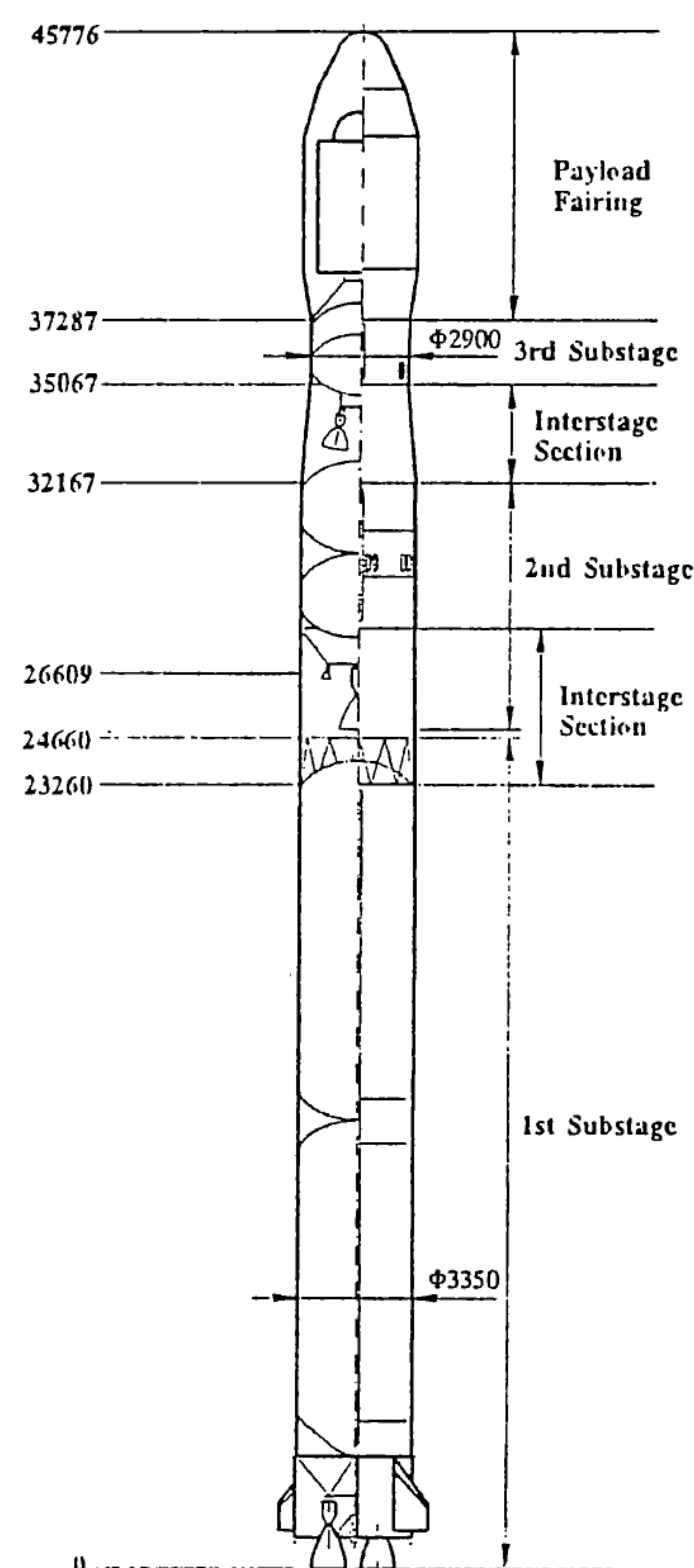


Fig. 1 LM-4 Outline

2. Background

On September 3, 1990, the second LM-4 put a FY-1 meteorological satellite into its orbit. After 32 days' operation in orbit, the upper stage rocket broke up on orbit on October 4, 1990. Both the Space Surveillance Network of the United States and the Satellite Observation Network of China obtained the breakup parameters of this discarded rocket. In view of the present situation of the space debris environment is serious and the orbit life of these fragments induced by this event will be very long. Though among the many known on-orbit breakup events of upper stages, only this one belongs to China, it has attracted extra attention from the National Aerospace Administration of China.

China has paid great attention to the protection of the earth outer space environment. China holds that protecting the earth outer space environment is the extension of protecting the earth environment on which the humanity subsists, that is, protecting the common benefits of the humanity. Both the Shanghai Academy of Spaceflight Technology and the designer in chief of LM-4 have paid great attention to this event. They have awarded that it is their responsibility, to eliminate the potential hazard of its upper stage rocket's on-orbit breakup. They determined to make improvement on LM-4.

Shanghai Academy of Spaceflight Technology has organized the breakup cause analyses in which all of the experts concerned in LM-4's development work took part in. The results of these analyses indicate that the principal cause of on-orbit breakup is the unexpected mix of two kinds propellants in the tank. In the concrete, when the common bulkhead of the tank is damaged due to some cause, the two kinds residual propellants will mix, then breakup event will happen.

In order to eliminate the potential hazard of another on-orbit breakup, it is decided to add a Venting System to LM-4's upper stage after comparison of many schemes. The venting system is a functional system to be used to

vent the residual propellants left in the upper stage rocket tanks and the residual gas left in the pressurization bottles after vehicle /satellite separation.

3. The Technical Scheme of LM-4's Upper Stage Rocket Venting System

In order to develop a venting system for LM-4 which has fulfilled two successful missions, the selection of technical scheme is constrained by many factors. During the development of LM-4's venting system, series of studies were carried out with emphasis laid on the following two problems:

- (1). Ensure that LM-4's reliability of putting payloads into orbit would not be affected by adding the venting system;
- (2). Design a reasonable venting operation program to ensure that the operation of an orbit-injected payload would not be affected by the operation of the venting system.

The final technical scheme of LM-4's venting system is that to add a set of special venting electrical explosion valves and venting pipes on the pressurization feeding system of the upper stage rocket. The residual fuel and oxidizer will be vented out of the rocket body respectively (Fig. 2).

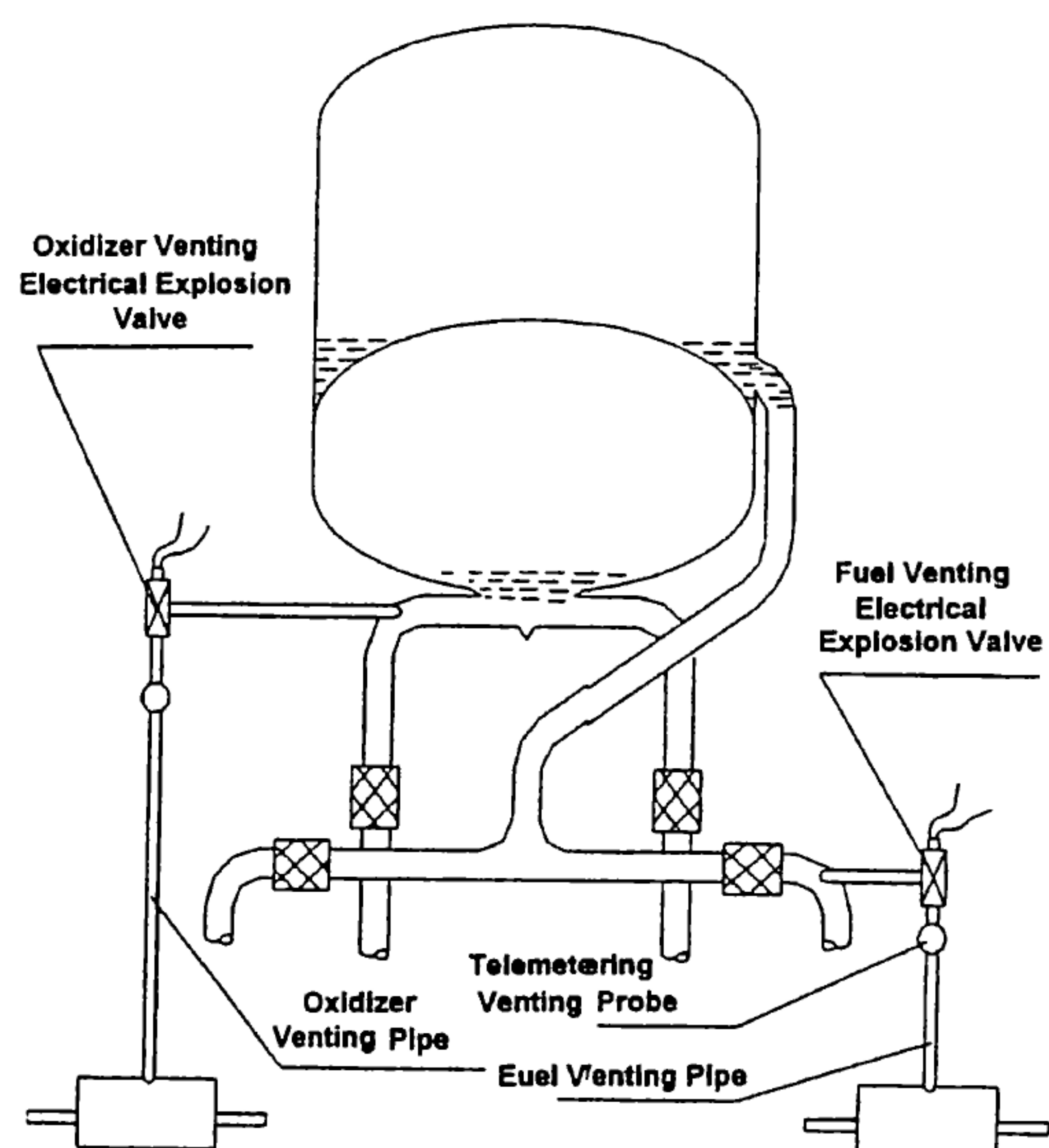


Fig. 2 Venting System Scheme

The advantages of this scheme are: less technical modification to LM-4's upper stage rocket, no effect on LM-4's operation reliability of putting payloads into orbits. It is expected to vent the residual propellants in the tank out of the rocket body in about 10 minutes after vehicle/satellite separation. Thus the potential on-orbit breakup hazard of upper stage rocket will be eliminated.

LM-4's upper stage rocket tank is a common bulkhead structure. To ensure that the common bulkhead will not lose stability, a venting operation program is set, that is, venting the fuel first and then venting the oxidizer after the fuel tank is emptied. Besides, a special telemetering channel is set on LM-4's upper stage rocket to verify the operation effectiveness of the venting system during flight missions.

The venting system development work includes the hardware and software. In the fields of hardware, we developed special venting pipes, big-diameter venting electrical explosive valves, venting probes and venting balancers. The venting balancer can remarkably reduce the unbalanced interferential force produced during venting. In the field of software, we developed the optimum venting operation program, the control program of the residual propellants in the tank under microgravity condition and the pressurization operation program of the upper stage rocket's tank.

The possible contamination on the orbit-injected payload caused by the venting operation has been assessed. This assessment including a series of theoretic analyses and test verification is a very important work in the venting system development and has been studied as a special project. During the development of the venting system, through deep and carefully study, this problem was solved and the technical bases on which the venting operation program would be designed were obtained at last.

4. Conclusion

LM-4's venting system is designed on the basis of the vehicle's characteristics, making the orbit-injected upper stage rocket passivated at lower cost. In the great majority of cases, the flight missions of LM-4 will carry out at the altitudes between 400Km to 1500Km. This is the densest region of space debris and most valuable region for human space activities. The passivation treatment of LM-4's upper stage rocket, as a powerful measure to eliminate the potential hazard of on-orbit breakup, will bring very apparent technical results.

Following the successful development of LM-4's venting system, Shanghai Academy of Spaceflight technology made a decision that whenever a payload with a perigee higher than 450 Km is to be launched, a venting system must be added to LM-4's upper stage rocket, so as to eliminate the potential hazard of on-orbit breakup.

The successful development and the application of LM-4's venting system show that the National Aerospace Administration of China has paid a great attention to the protection of the earth outer space environment and has actively taken part in the international cooperation in reducing the large production of space debris in the earth outer space. As a participating country of IADC, China will continue to make her contribution with all the member countries to an unimpeded road to space.