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Scientific ballooning in India – Recent developments

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Abstract

Established in 1971, the National Balloon Facility operated by TIFR in Hyderabad, India, is a unique facility in the country, which provides a complete solution in scientific ballooning. It is also one of its kind in the world since it combines both, the in-house balloon production and a complete flight support for scientific ballooning. With a large team working through out the year to design, fabricate and launch scientific balloons, the Hyderabad Facility is a unique centre of expertise where the balloon design, research and development, the production and launch facilities are located under one roof. Our balloons are manufactured from 100% indigenous components. The mission specific balloon design, high reliability control and support instrumentation, in-house competence in tracking, telemetry, telecommand, data processing, system design and mechanics is its hallmark. In the past few years, we have executed a major programme of upgradation of different components of balloon production, telemetry and telecommand hardware and various support facilities. This paper focuses on our increased capability of balloon production of large sizes up to 780,000 m^3 using Antrix film, development of high strength balloon load tapes with the breaking strength of 182 kg, and the recent introduction of S-band telemetry and a commandable timer cut-off unit in the flight hardware. A summary of the various flights conducted in recent years will be presented along with the plans for new facilities.

Keywords: Stratospheric balloons; Scientific ballooning; S-band telemetry; Mechanical properties of thin polypropylene films

1. Introduction

Scientific ballooning is an important element in any space science programme and it provides frequent and low-cost opportunities for space science research and offers a quick-response method for doing scientific investigations. The large variety of science disciplines studied using scientific balloons include the study of the Sun, the near Earth space environment – ionosphere, magnetosphere, aerosol research etc., space plasma – its physics and chemistry, space biology, astronomy and the high energy astrophysics. The balloon borne instruments also serve as a technology test bed for instruments that may ultimately fly on orbital spacecraft. This reduces the cost and the technological risks, associated with the development of future science missions. It also provides opportunity to train young man-power for the space science programme by providing the hands-on experience in the instrumentation technology of space-based payloads. With the development of mini, micro and nano satellites in the foreseeable future and increase in the opportunities for the small autonomous payloads on multi-purpose missions, the use of scientific ballooning in space research will continue to be an important vehicle for future space-based experimental programs.

The development of the large volume zero pressure plastic balloons in India for cosmic ray research started almost 5 decades ago at the Tata Institute of Fundamental Research. During 1960s, the main emphasis of research using high altitude balloons shifted to the study of high energy cosmic rays and the observations of cosmic X-ray sources in the hard X-rays band above 20 keV. A permanent integrated balloon facility was therefore, set up at Hyderabad (17.5°N, 78.6°E) and which has been operated as the National Balloon Facility (NBF), providing the complete balloon fabrication facilities and the flight sup-

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port to the National and International groups for conducting experiments in the X-/γ-ray astronomy, infrared astronomy, solar physics, atmospheric physics and astrobiology. Being close to the equator, Hyderabad balloon Facility is well suited for experiments in the field of X-ray and γ-ray astronomy due to high geomagnetic cut off rigidity of 16.8 GV, which reduces a large fraction of the detector background due to secondary charged particles thereby improving the detection threshold. In addition, celestial sources both in the northern as well as the southern hemisphere are easily accessible.

Ever since its inception at Hyderabad in 1971, the National Balloon Facility has been operating with the user's requirements in focus. There has been continuous R&D effort in upgrading and improving the reliability of various aspects of balloon production, balloon control instrumentation and telemetry system to derive maximum benefit out of every balloon flight within our allowed air-corridor of 400 km × 400 km. In particular, the research and development efforts in the flight system involve the basic investigation and development of new materials and techniques for balloon fabrication and the associated mechanical and electronics hardware. The R and D efforts in flight support electronics consist of design, fabrication, testing, and operation of ground support equipment and electronic systems for data collection, simulation, command, and control of flight operations. Under these sustained efforts, the development of the indigenous plastic material code named ANTRIX film, with suitable mechanical properties, as an alternative to SF-372, and ASTRO-E2 was achieved 5 years ago and has been described elsewhere (Damle and Joshi, 1998). Since then we have concentrated our efforts in further optimization of the film, manufacture of the load tapes and other components of balloon manufacture. In this paper, we describe some of the recent developments in balloon production and improvements in the telemetry and tracking station at Hyderabad.

2. Balloon production and engineering

In recent years, we have achieved a hundred percent performance rate for our balloons manufactured at NBF. For this, a strict execution of quality assurance routine during the balloon fabrication, packaging and storage are the key components. A round the clock visual and electronic inspection of the balloon film during the extrusion process by the NBF staff, further assures the basic quality of the material used for balloon fabrication. Testing of the film material is rigorously adhered to at the facility. During last year, we have further improved the sealing technique by controlling the sealing temperature to a constant level within <0.5° by installing temperature sensors in closed loop control in the sealing machines. In addition we have introduced the sample film testing of yield strength and percentage elongation for every extrusion run, as per the ASTM 802 standards. A sample data is shown in Fig. 1. At room temperature, the mechanical properties of Antrix film in the longitudinal direction, are inferior to SF372, however, at low temperatures of −80 °C, its properties are far superior. In the transverse direction, the mechanical properties are almost similar for the two.

2.1. Manufacture of large volume balloons

To meet the growing demand from user scientists in X-ray Astronomy for carrying up to 700 kg telescope along with flight support accessories to an altitude of 43 km, the balloon production building was extended further by 27 m to accommodate 178 m long balloon work table required for manufacturing large volume balloons. Balloons of volume up to 740,000 m^3 with single cap can now be fabricated 'in house'. This size of the balloon is about 70% larger than the largest balloons fabricated earlier. Further, to overcome our limitations in manufacture of multiple caps for large size balloons, we have optimized the shell and the single cap thickness to 15 and 38 μm,

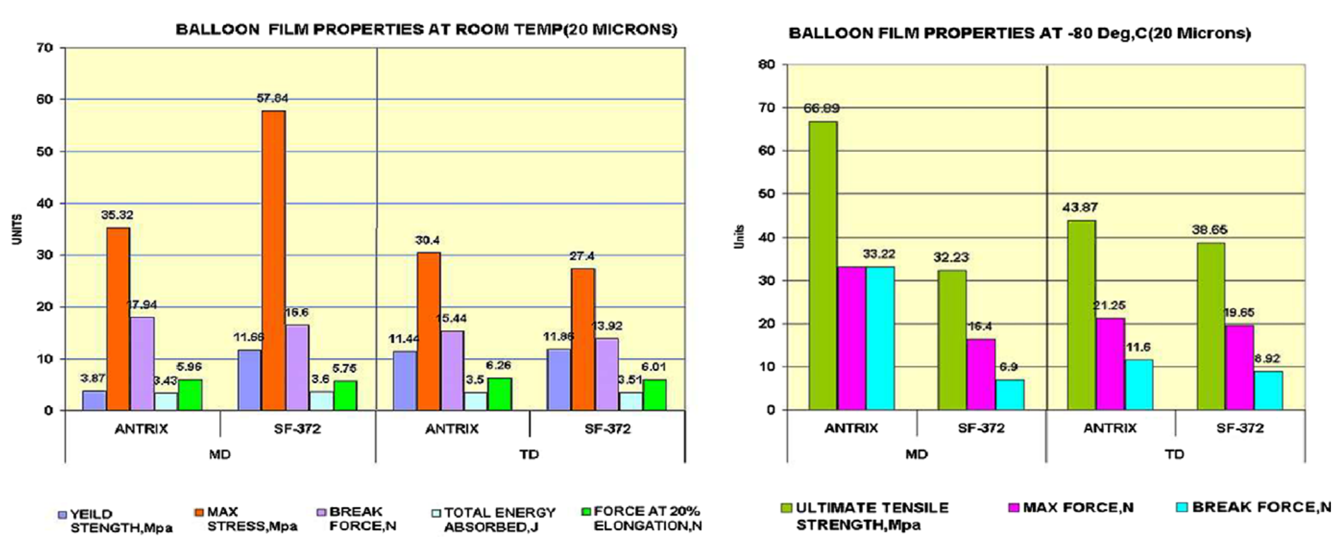

Fig. 1. A comparison of the Antrix film with SF372 at 25 and −80 °C.