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Author: Mr. Aamir Yusuf
Liquid Propulsion System centre, India, yusuf.aamir52@gmail.com

Mr. Kamatchi Kamatchi
Liquid Propulsion System centre, India, kkamatchi62@gmail.com
Mr. Gopinathan P K
Liquid Propulsion System centre, India, pkgopinathan_in@yahoo.com
Mr. Jose Paul
Indian Space Research Organization (ISRO), Liquid Propulsion Systems Centre (LPSC), India, josepaul@lpsc.gov.in
Mr. GANAPATHY NARAYANAN NAGESWARAN
Liquid Propulsion System centre, India, g_nageswaran@lpsc.gov.in
Dr. NARAYANAN V
Liquid Propulsion System centre, India, v_narayanan@lpsc.gov.in

# DESIGN & DEVELOPMENT OF PROPELLANT INTAKE DEVICE FOR CRYO UPPER STAGE LOX TANK

**Abstract**

In any launch vehicle, upper stage dry mass affects the payload capability and is optimized through improved materials, structural design and manufacturing processes. Efficient utilization of propellant through reduction in the left out unused propellant mass is also equally essential to improve payload capability. Cryogenic or semi-cryogenic propulsion engines use liquid Oxygen (LOX) and gas entry into feed lines due to drain vortex results in reduction of pump delivery head, leading to engine shutdown. Efficient utilization of liquid propellant requires accurate estimate of left out unusable LOX inside the tank feed system, at the time of engine shutdown. Propellant intake device (PID) is employed in propellant tanks for efficient supply of liquid propellant to engine system. Optimized design of PID enables maximum liquid utilization, with gas entry at lower critical height and minimal flow pressure drop. An improved design of PID for cryogenic stage of ISRO launch vehicles was attempted in depth, with bell mouth sizing through parametric studies to reduce critical height, flow area assessment for flow pressure drop consideration and parabolic profiling to minimize re-circulation zones. CFD analysis was carried out on the finalised design, to confirm critical height estimated from closed form relations. A proto hardware was realized and integrated in a 1:1 scale tank for expulsion tests. Using similarity parameters for the fluids used and acceleration field differences, water expulsion tests were carried out to evaluate the critical height at gas entry, for 3 different flow rates. The results matched well with CFD results. The test evaluated left out propellant at gas entry into LOX feed system under flight condition showed significant reduction from 100 kg to 45 kg with reference to the old design. This paper outlines the design considerations, optimization parameters used as well as test results. The data reduction methodology and confirmation of left out mass for flight conditions are also presented.