Liquid Propulsion System-
Gross Tasks- A SORAC White Paper
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I will address the tasks to be performed on a Pressurized Propellant Delivery System. Following this paper will be one that addresses the major issues in a Pump-Fed Delivery System.

The specific areas of design are:

1. Pressurant Storage and Fill and Dump
    a. Tanks of Highest Pressure capability compatible with fill system. Highest Strength:Weight ratio in materials compatible with gas used.
    b. Tank size to pressurize entire system at end of run to feed pressure and at final gas temperature.
    c. Automatic Disconnect preferred on fill.
    d. Dump valve is remotely activated.
    e. Dump into a diffuser to control resultant thrust.
2. Pressurant Regulation and Control
    a. Regulator must be large enough to handle high flow rates required by Liquid Propulsion Systems.
    b. Control valve should be low pressure drop, often a pyro valve.
3. Delivery and Back-Flow Prevention (Check-Valves)
    a. Each line to Ox and Fuel tanks must have separate check valves; Separate tanks for pressurizing each system a good idea.
4. Heat Exchanger
    a. All gases will drop in pressure as tank is vented during operation due to reduced temperature. A heat exchanger will bring the gas temperature back up and save much weight in gas used. Heat can come from a gas generator used for one of the tank pressurants, from the thrust chamber as two choices.
5. Diffuser
    a. Used to prevent bubbling in the tank that is being pressurized, also limits the amount of gas to be dissolved or frozen in the cryogenic side. Use of a non-condensing gas in the tank's ullage on a cryogenic propellant (LOX) will minimize the amount of condensed pressurant during the run.
6. Oxidizer Storage and Fill and Dump
    a. The Fill and Dump valves must be remotely actuated and remotely disconnected where necessary.

    b. The oxidizer dump must flow to appropriate storage containers or to a disposal area.
    c. Oxidizers are usually corrosive or cryogenic. They require then consideration of material for compatibility. Aluminum alloys and stainless steels are the two traditional materials but are being challenged by composites of various types.
7. Oxidizer Flow Regulation and Control
    a. Precise regulation is required for setting thrust level; control is required to assure that both propellant will be expended at the same time ensuring the most efficient usage. The control may not necessarily go to shut-off but may have a turn-down ratio (throttling) of from 3:1 lto 10:1. Often burst diaphragms are used for the simplest systems the initiation of pressurization starts the entire system.
8. Oxidizer Delivery and Back-Flow Prevention
    a. Lines must be large enough (4 times injector area in cross section) to deliver oxidizer with a low pressure drop. Long runs must have supports often at random intervals to prevent harmonic vibration and "Q" amplification.
    b. Check valves are necessary to prevent propellants from feeding back into their opposing lines (ox into fuel etc.) especially during a hard start or delayed ignition or restart.
9. Heat Exchanger (where oxidizer is part of the pressurization or gas igniter)
    a. When the oxidizer is part of a gas generator system, it may be possible to use the hot output gases to contribute the heat in a pressurant warming system.
    b. In the case of using a gaseous oxidizer from a cryogenic oxidizer, a heat exchanger is used to create the gas.
10. Fuel Storage and Fill and Dump
    a. Fuel fill should be remotely disconnected and actuated.
    b. Dump should be remotely actuated and flow into appropriate storage containers or disposal area.
    c. Fuel tank may have a wider range of material possibilities than the Oxidizer Tank.
11. Fuel Regulation and Control
    a. Fuel flow rate must be regulated for proper thrust level and controlled to assure depletion simultaneous to Oxidizer.
    b. Valve may be mechanical, pyro or a simple burst diaphragm.
    c. Valve may be required for turn-down or shut down.
12. Fuel Delivery and Back-Flow Prevention
    a. Fuel lines must be sized for low pressure drop.
    b. Check valve must be incorporated close to the thrust chamber.

13. Purging System
    a. A dry Nitrogen purge should be introduced to the feed system for both oxidizer and fuel lines just aft (thrust chamber side) of the check valves. This is run to completely clear the system of any potential leakage of propellants or any gaseous residue that may have accumulated in the thrust chamber.
14. Injection System and Throttling
    a. Injection system provides first atomization and then mixing of propellants. The injector may also provide BLC (Boundary Layer Cooling) where the region nearest the chamber wall is very fuel rich.
    b. Injector may also provide throttling capability as in a Pintle Injector.
15. Thrust Chamber and Thrust Mount
    a. Thrust chamber should be robust and cooled against the 5000°F plus gas temperatures.
    b. Thrust mounts must be strong and inflexible.
    c. In some cases the thrust mount will be made to gimbal for attitude control.
16. Ignition and Restart
    a. Pyro ignition is simple and effective but difficult to use for restart.
    b. Hypergolic ignition is reliable but uses corrosive, toxic and pyrophoric fluids.
    c. Electric ignition is reliable, usable for restart but is bulky.
17. Special Provisions
    a. Tri-propellant systems
    b. Blow-down (regulation by means of orifices or cavitating venturis)
    c. Bladder positive expulsion tanks
    d. Ullage motors (small solid motors) used to create settling of the propellant on the tank outlets in zero-gravity conditions.
    e. Capillary Feed for tanks to be used under zero-gravity conditions (fine mesh screen configured to do so)

This is meant to be a primer only; this should be enough of an introduction to allow one to converse intelligently on the subject if not engage in an actual design process.