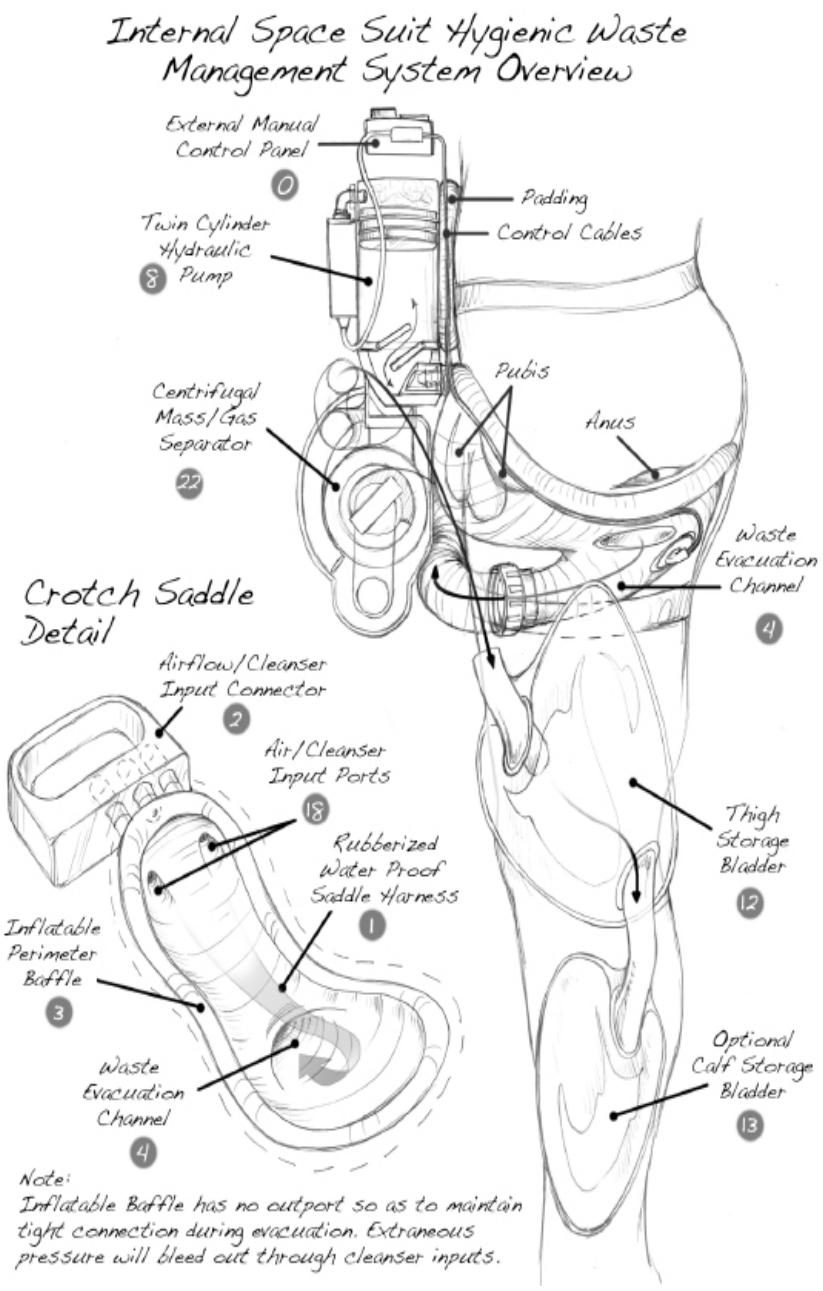
INTERNAL SPACE SUIT HYGIENIC WASTE MANAGEMENT SYSTEM

Intro

We have designed a comprehensive hygienic system complete with maintenance, set-up, and usage options. While the detailed technical and efficiency descriptions might seem complicated, the concept and user experience are quite simple.

High Level Concept

- The astronaut says “spacesuit” followed by the desired sequence command (“*#1, #2, clean,* or *dry.*”)
- The suit’s programmed response removes waste, cleans, and/or dries per the spoken command.
- If any discomfort remains, the astronaut may ask the suit to repeat or cease the desired sequences until satisfied.
- Details explained in-depth below.



BENEFITS & SOLUTIONS

Additional Benefits

- Odorous gases are separated from waste and recycled in a closed loop to treat future waste. This means little valuable 02 is used or exposed to odor.
- Solid waste is dessicated/liquified for easy maneuverability/storage through flexible tubes.
- The system is ergonomically designed to utilize unused space in non-restrictive areas.
- The system is unisex and flexible. Underwear sizes are customized to comfortably all astronaut body types.
- There is little to no change in existing waste disposal process due to easily-replaceable waste bags and filter materials.
- 100% internal to the suit, meaning no risk of suit breach.
- 100% independent of other systems. A waste system failure would not compromise other life support systems.
- The equipment only adds an approximate 12 lbs on Earth when dry.
- The full system is mobile and quick enough to hook up that it can be held in reserve as an emergency-only option. Our water-tight undergarment solution will serve as a replacement to the current diaper for daily non-emergency scenarios, if desired.

Solved Challenges

- Basic requirements of hands-free removal of waste from the body, keeping astronaut clean and dry.
- Isolated system does not depend on any spaceship machinery to function in case emergency scenario knocks out spaceship life support.
- Waste is moved with suction/airflow, but air is removed before waste is stored, as air takes up valuable space.
- Odorous gases are recycled through a closed loop deodorization process in order to maintain suit pressure, minimize 02 use, and limit odors.
- Existing technology and procedures are innovatively modified to meet both the safety and suit integration timing requirements.
- “Plunger” feature allows a hands-free option to reverse, repeat, and stutter the closed system to loosen any blockage.
- Ergonomic design to fit comfortably and allow astronaut maneuverability.
- Easy hook up design to connect astronaut to system in well under the 5 minute requirement.

Dual Action Hydraulic Evacuation Pump

Simultaneously creates measurably consistent pressure and suction (push and pull) when activated.

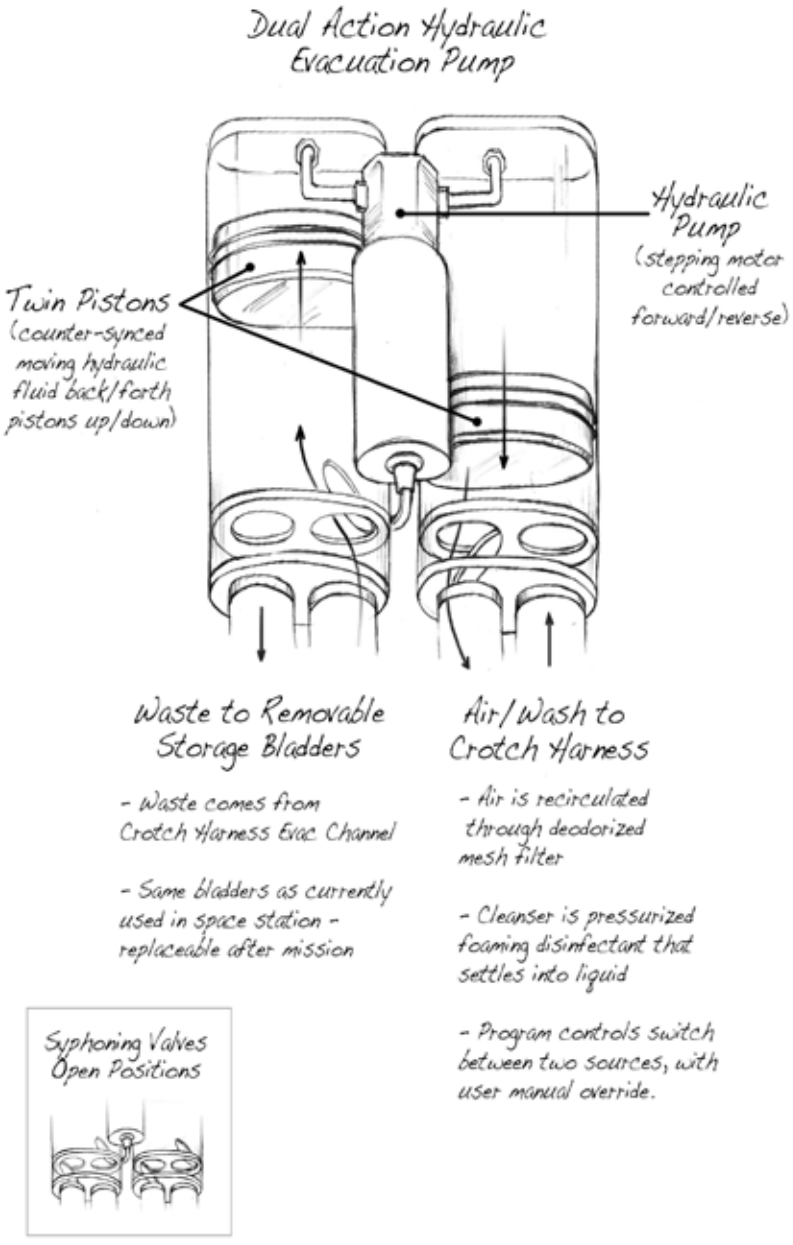
Using alternating single direction airflow valves, the pump simultaneously pushes and pulls air in a single direction through a closed loop.

Pressure/Push: moves air and/or cleanser towards the crotch saddle.

If there is waste/mass ready to be stored, a valve redirects the push towards waste storage bags located on the legs.

Suction/Pull: picks up the pushed air in the crotch saddle and pulls air/waste out the evacuation channel, through the Centrifugal Gas/Mass Separator. Separated gas is sucked back into the hydraulic pump to be pushed towards the saddle again.

Separated mass is sucked up into the pump to be pushed towards the waste collector bags.



Underwear

The Astronaut is wearing comfortably tight stretch-briefs made of water resistant material

Saddle (1): the crotch and anus area of boxer-briefs are made of a flexible plastic.

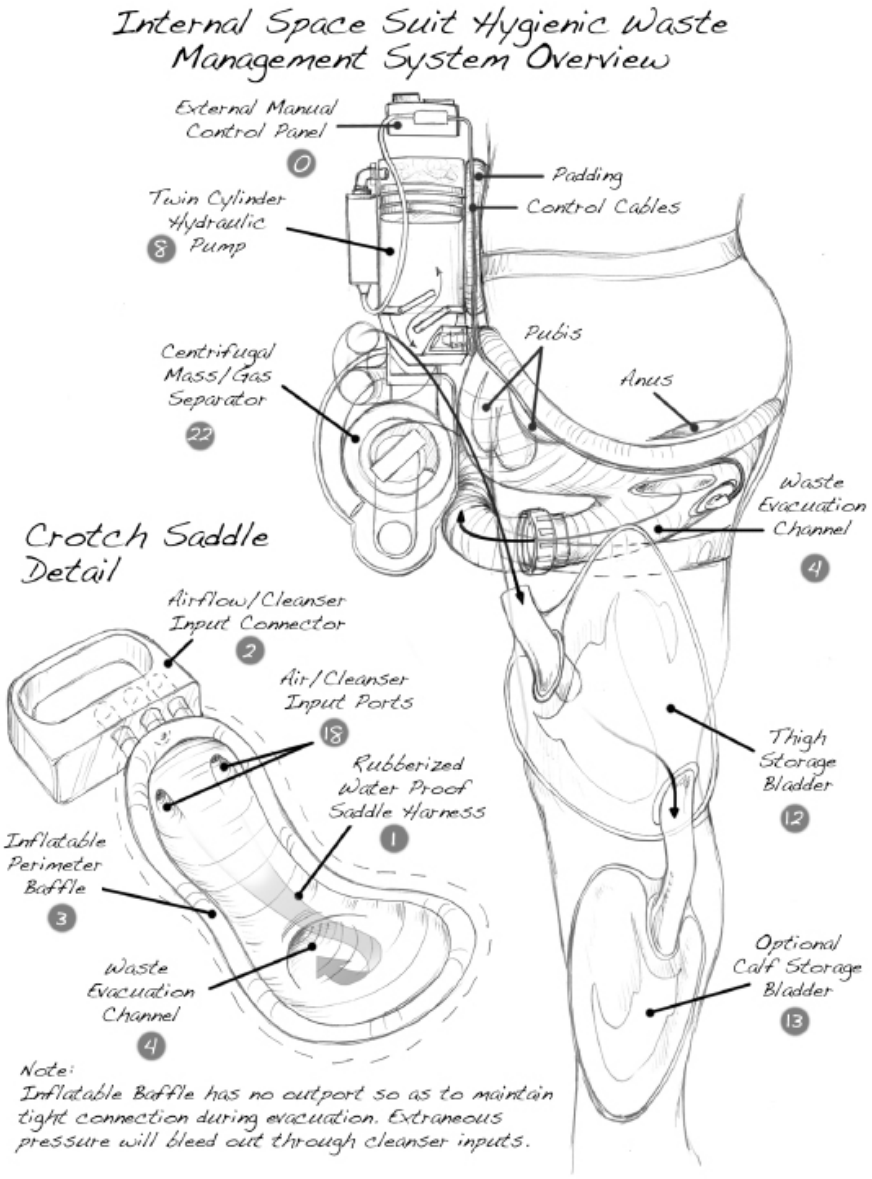
Air/Cleanser Input Connector (2): Air is pushed from the pump (8) to this connector where the pressure splits in two directions: the rubber inflatable seal (3) around the saddle perimeter and the air/cleanser input ports (18).

Rubber Inflatable Seal (3): The outer rim of the saddle (1) is an inflatable rubber baffle that tightens the saddle against the crotch area to make the suction/airflow most effective. Inflated by the center tube of the three shown (2), the rubber inflatable tube inflates and maintains a tight seal around the saddle until the pump stops, at which point it deflates.

Air/Cleanser Input Channels (18): The saddle has two small ports that push air/cleanser from the hydraulic pump (8) into the saddle (1) and evac chamber (4). The two exterior tubes of the three shown (2) provide continuous pushed airflow to help waste move in the correct direction. When there is no waste, this airflow continues, serving as drying fans until a moisture sensor or the astronaut indicate target dryness.

Evacuation Channel (4): In the anus area of the saddle there is a cylindrical channel that connects to the hydraulic pump (8). Suction occurs from the evacuation channel drawing waste to exit.

Note: When the hydraulic pump (8) is on, air is pushed and pulled from the saddle (1) at an equal rate, creating a single direction of air flow out the evac channel (4).

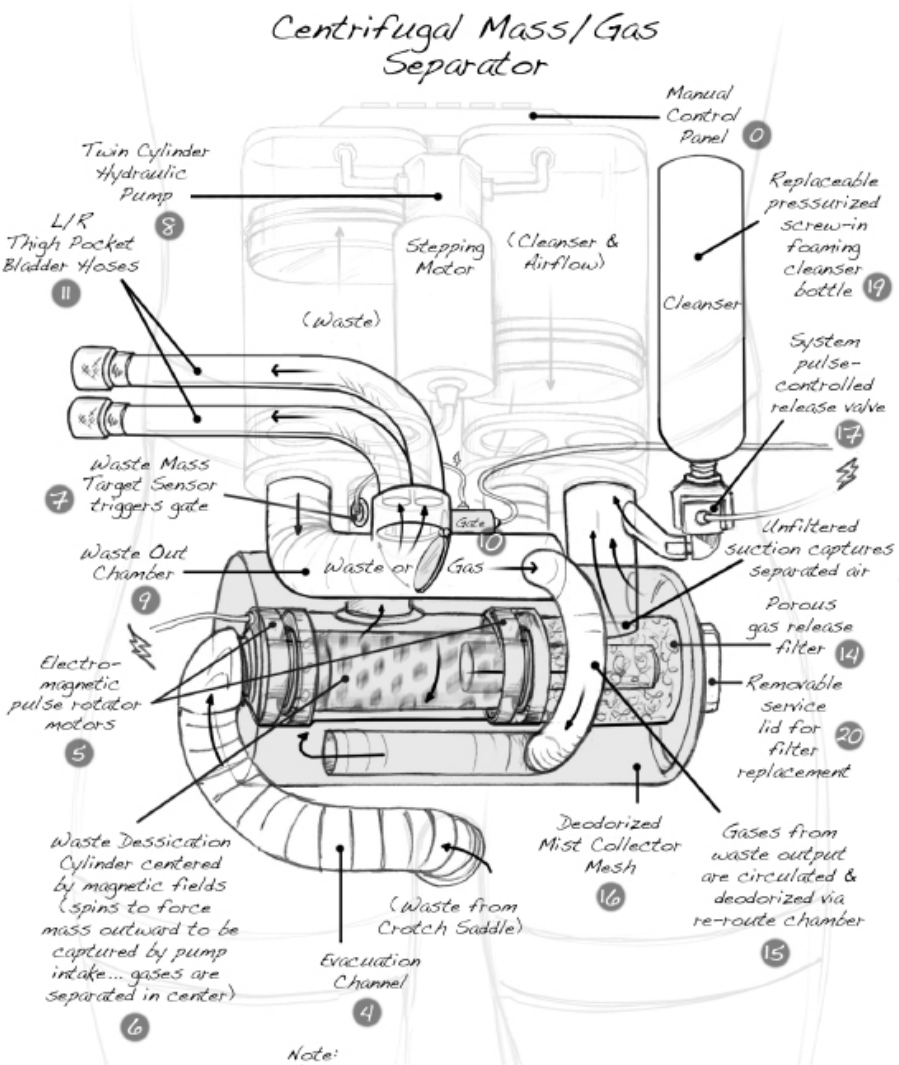


Centrifugal Gas/Mass Separator (When Gas & Mass are Present)

To maximize storage and recycle gasses, air needs to be removed before waste is moved to the Waste Storage Bags (11).

This process is for when mass is present. The process for when only gas is present is explained on the next page.

Note: Centrifugal Gas/Mass Separators are not new. Most existing centrifugal separator designs include spinning mesh, which would work for our purposes. We designed our own because it's fun and helps explain our solution.



Waste Dessication Cylinder (6)

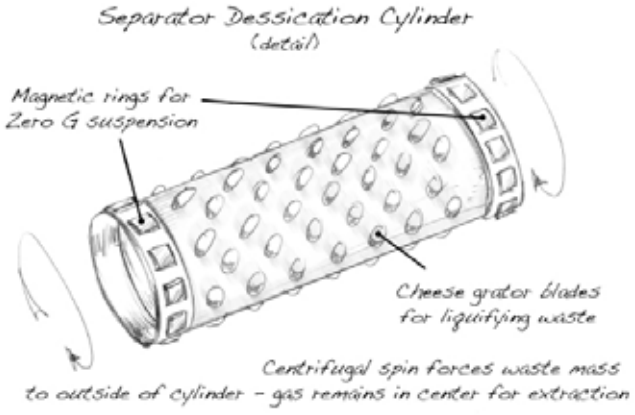
Similar to a cheese grater, this cylindar has grooved holes to facilitate the liquidation of any mass. Spun by pulsing electromagnets (5), when waste is present, it is dessicated and flung through the holes of the cylinader to the outside chamber, unable to enter back into the spinning chamber thanks to centrifugal force.

Porous Gas Release Filter (16)

Now that liquid is unable to pass back into the spinning Waste Dessication Cylinder (6), gas is forced into the center, and sucked through a porous filter (to ensure no mass gets through.) The gas continues its journey via suction out of the centrigual mass/gas separator and into the pump (8) to be pushed back towards the saddle. The gas has been recycled.

Waste Out Chamber (9)

With gas removed via the porous gas release filter (16), the liquid waste is sucked out of the chamber into the pump (8). A waste mass target sensor (7) notices mass and opens a gate valve (10). The pump(8) pushes waste out the waste out chamber (9) against the valve, and it is pushed into the waste storage bins (11). With waste removed, the mass target sensor (7) signals the gate valve (10) close and air-flow resumes as normal.



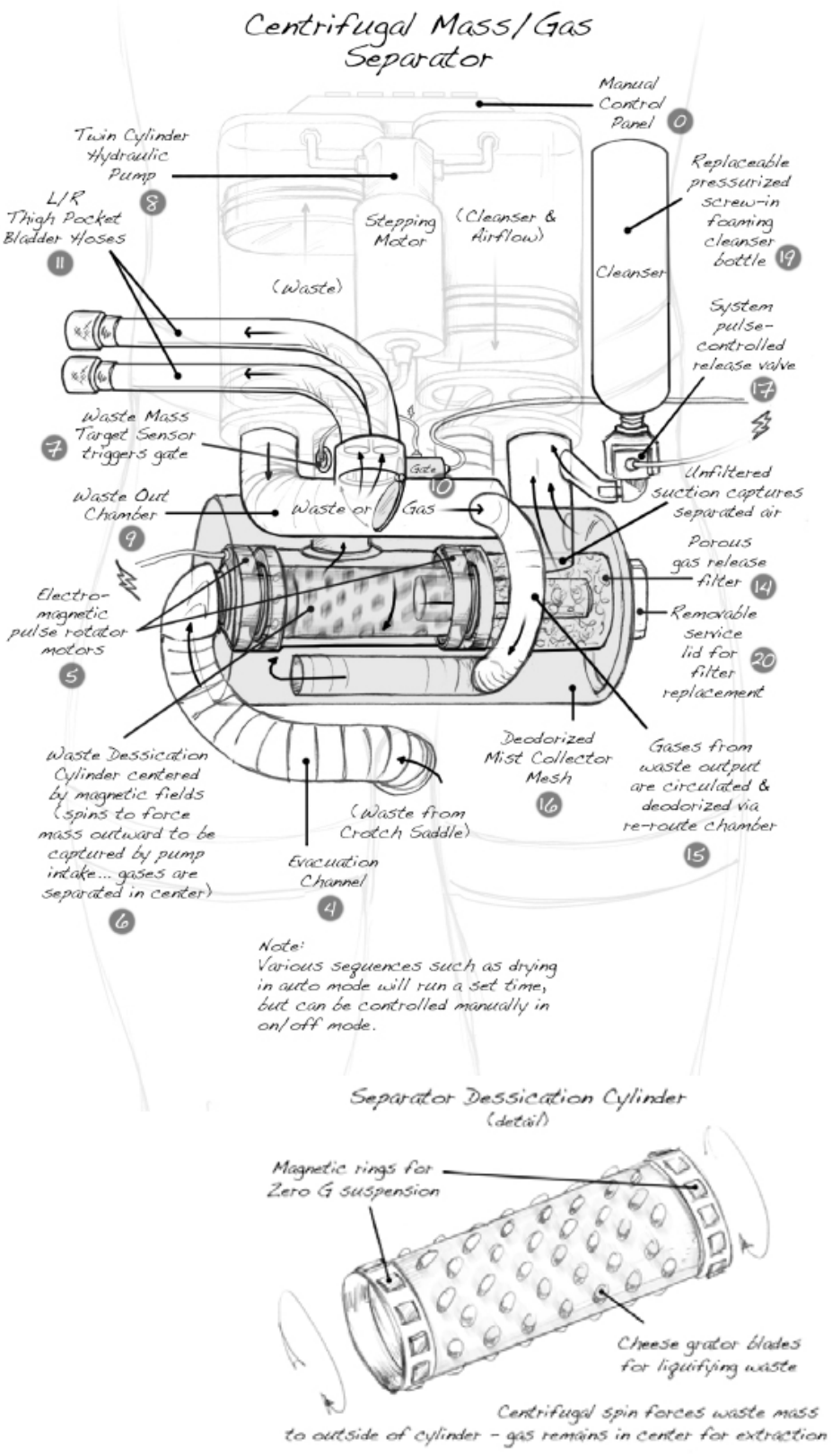
Centrifugal Gas/Mass Separator (When Only Gas is Present)

Waste Dessication Cylinder (6)

When only gas is present, mass being flung to the outside is not forcing gas into the center. So gas sucks up the first exit directly into the pump (8) without passing through a filter. Without mass, the waste mass sensor (7) does not trigger the gate valve (10) to open, so it remains closed.

Deodorized Chamber (16)

Gas is pushed out of the pump (8) through the waste out chamber (9), which is not rerouted to the waste storage bags. Instead it enters into the Deodorized Chamber (16) full of charcoal or some other stench removing filter. The gas is sucked through the deodorizer up into the second pump (8), and has been both deodorized and recycled.



CORE EQUIPMENT CONTINUED

Waste Storage Bags (12 & 13)

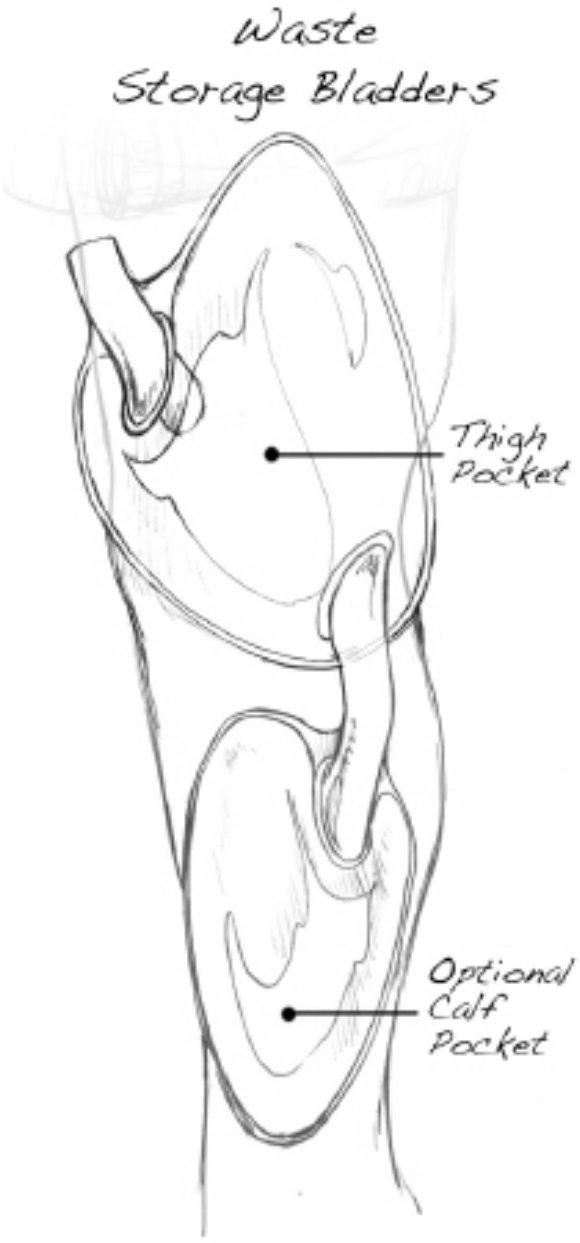
Twin plastic thigh bags capable of holding the required six days of liquid waste: 3.5 liters each for urine, liquified solid waste, menstrual blood, liquified cleanser foam, and minimal air.

These vacuum sealed disposable plastic bags have one entry and are safety-snap connected to the waste management system between uses.

Empty bags fit into thigh pockets on the outside of the cooling system layer of the suit.

If it is found more space is necessary, more bags could be designed to fit around calves (13) or in cargo pockets at the knees. Bags connected via small tubes at body joints to allow for maneuverability since all waste is liquefied at this point.

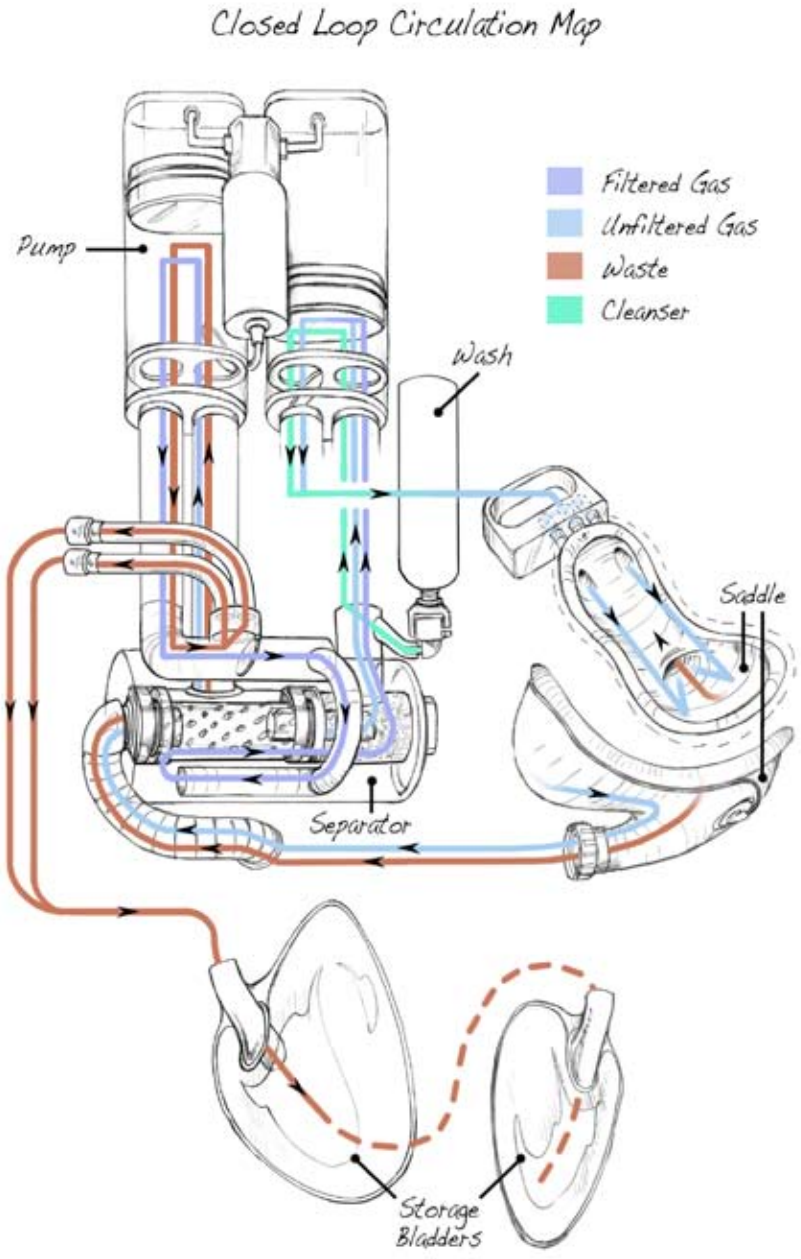
Note: Optionally, collection bags could be held in EXTERNAL pockets, connected by no-loss snap compression fittings to enable replacement of bags and extend the stay in the suit almost indefinitely. This option does bear a breach risk and depends on the integrity of the compression fittings (not addressed in our solution), hence the option-only status noted here.



CLOSED LOOP EXPLANATION

Path of recycled airflow through equipment

1. Air is sucked into the pump, then pushed from pump to saddle.
2. Push inflates the inflatable rubber seal on the perimeter of the saddle.
3. Pushed air enters into the saddle effectively helping to pushing waste but also drying dampness.
4. Suction pulls air and/or waste from the saddle out the evac channel.
5. Suction pulls air and waste through tube and into the centrifugal gas/ mass separator.
6. Electromagnets are spinning the centrifuge/desiccator.
7. When waste **is** present, gas is forced to the center of the centrifuge, and is pulled through the filter into the right side of the pump. It is now recycled. Liquified waste is moved up into the left side of the pump, then pushed into waste storage.
8. When waste **is not** present, gas sucks up into the left pump because it's the first available exit. Gas is then pumped into the deodorizer (outter shell of the centrifugal gas/mass seperator.) The gas is then sucked through the deodorizor material and up into the right pump. Gas is now deodorized and recycled.



AUTOMATIC SEQUENCES

Voice Command Sequences

Going #1

1. User says “Space Suit, I need to go #1” (or manual button push).
2. Air flows into rubber seal of saddle. The seal is tightened against skin. Suction from evac channel begins.
3. User urinates (urine is evacuated) for 4 pump cycles (20 secs).
4. Foaming cleanser automatically fills saddle, while the system pauses to let the foam dissipate and the dessicator to dessicate.
5. After 5 seconds of bubble action, foam is evacuated.
6. Airflow continues in saddle until moisture sensor or astronaut indicates target dryness.

Going #2

1. User says “Space Suit, I need to go #2” (or manual button push)
2. Same sequence as #1 except all timers are extended appropriately.

Dry/Auto Mode (sweat, menstrual flow, etc)

1. Astronaut says “Space Suit, dry me” (or manual button push).
2. -or- moisture collects in saddle and triggers moisture sensor.
3. Same sequence as #1 except without cleanse.
4. Astronaut asks for a cleanse as needed.

Manual Cleanse

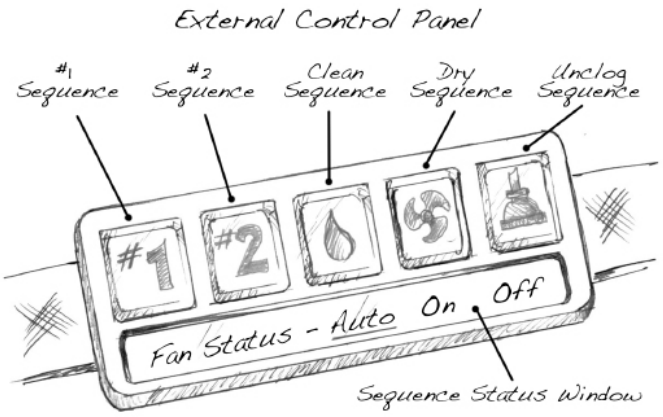
1. Astronaut says “Space Suit, clean me.”
2. Air flows into rubber seal of saddle, seal is tightened against skin.
3. Foaming cleanser automatically fills saddle, while the system pauses to let the foam dissipate and let the dessicator dessicate.
4. After 5 seconds of bubble action, foam is evacuated.
5. Airflow continues in saddle until moisture sensor or astronaut indicates target dryness.

Plunge a Clog

1. Astronaut says “Space Suit, I need a plunger.” (or manual button push).
2. Dual Plunger Pump stutters back and forth for 5 seconds (so pump valves don’t fully close) sending airflow backwards and forwards (loosening any clogs.)
3. Dual Plunger Pump resumes normal air flow.

Canceling a Sequence

1. Astronaut says “Space Suit, cancel [#1, #2, clean, or dry] (or manual button push).
2. Depending on where cancel is entered in the sequence:
3. Canceled before moisture enters saddle the rubber tube deflates.
4. Canceled during #1, #2, or clean removal the suit will continue airflow until waste/cleanser is secured away from body, then rubber tube deflates.
5. Canceled during dry the suit will stop air flow if waste/cleanser is secured away, then the rubber tube deflates.



SUIT-UP PROTOCOL

Putting on the Spacesuit with the Waste Management System

Pre Suit-up:

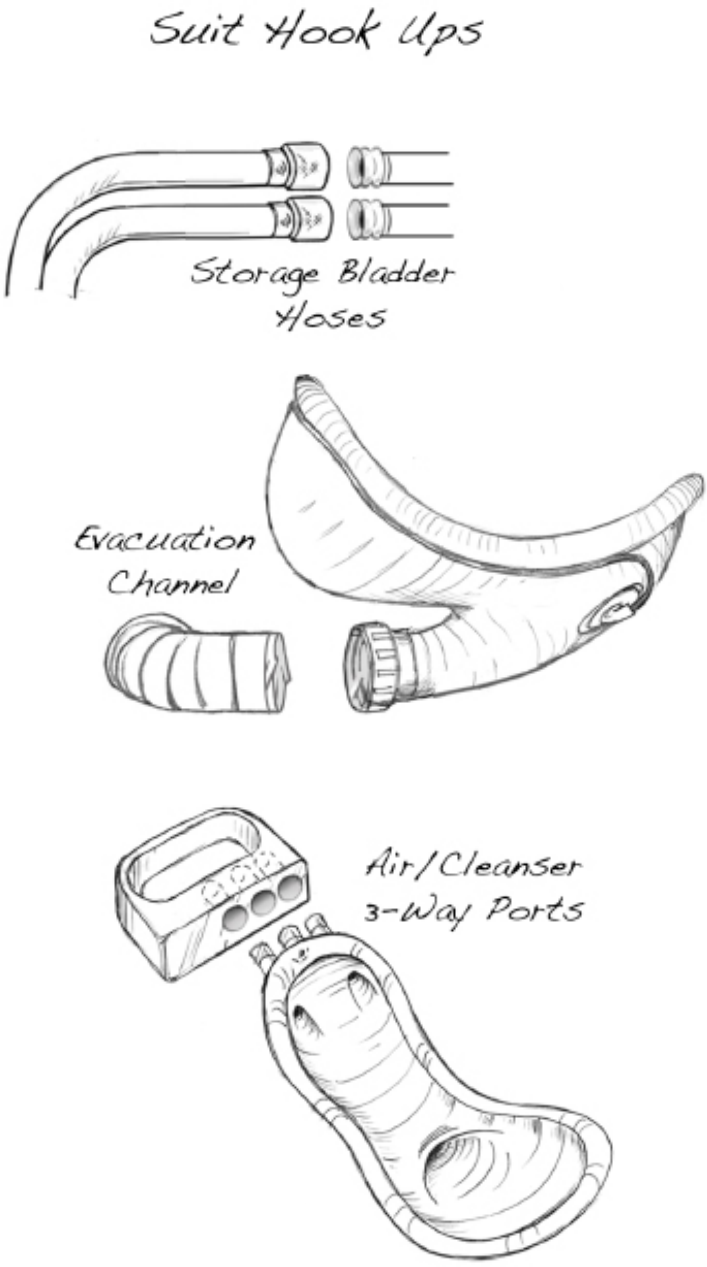
1. All of the waste management equipment is attached to the Spacesuit except the boxer-brief underwear.
2. The plunger and centrifuge are connected as a unit in a single bag with an evacuation channel, a 3-port hose and two bladder hoses protruding from the bottom of the bag. The bag is velcroed into it's spot on the internal belly area of the outermost layer of the suit.
3. New vacuum sealed bags are stored in thigh pockets sewn into the suit on the outside of the coolant layer. Connectors tubes protruding from the top of the pockets are left unconnected. (New vacuum sealed empty bags are replaced between uses.)

During Emergency Suit-up:

1. The astronaut slips on stretch briefs first before thermals.
2. Puts the thermal and coolant layers of the suit on as normal.
3. As the outermost layer of the suit is coming on, the evacuation channel hose is connected to the evacuation channel through a hole in the thermal and coolant layers.
4. The Air/Cleanser 3-way port is safe-click connected to the top of the saddle.
5. The storage bladder hoses from the waste collectors safe-click to the hoses from waste management system.

During Non-Emergency Suit-up:

Optionally, the crew could un-velcro the waste management bag from it's place and remove the waste management storage bags from their pockets. They could insert a super absorbant maxi-pad style diaper into their boxer-brief underwear for short non-long-term missions that require the suit. This option could increase maneuverability while still having the option to connect the suit if an emergency did occur.



SCORECARD EVALUATION

Category & Description	Our Evaluation	Points
Soundness and Technical Readiness of the Design Likelihood that the Solution will work as described to satisfy the minimum requirements with a minimum of risk. This includes the technical readiness level (TLR) of the design.	We purposefully modified tried-and-tested existing technology to build our solution so there wouldn't be any surprises on functionality. The components will need to be customized to fit into the suit. Some aspects such as suction power, sequence timing, and deodorizer levels will need to be tested and tweaked for optimal satisfaction.	20 Points
Gas Conservation Effectiveness at ensuring the conservation of gas in the crew member's suit.	We use a closed system that recycles the gasses required to move waste. Minimum 02 will be used or even exposed to the waste. A closed system also significantly reduces odor.	10 Points
Health and Safety Level of health and safety the Solution will provide to the crew member including dryness and prevention of pain, infection and permanent injury.	The system removes and stores waste away from the body. It disinfects, cleans, and dries the astronaut through automatic sequences and/or specific voice-activated procedures. The solution is 100% internal to the suit and works independently of other life support systems. No risk of breach, and no risk of failure affecting any other life support system in the suit or ship.	15 Points
Suit Integrity Effectiveness ensuring the integrity of the crew member's suit, including the number of entry/exit points required.	Zero suit entry/exit points means zero potential for suit breach. The system itself is a closed loop with a single valve to direct gas back into the closed loop or send waste to storage bags. It has minimal joints that exist for speedy suit-up. A remote possibility of filter or tube blockage does exist. This is why there is a hands-free "Plunger" solution to temporarily reverse airflow, stutter airflow back and forth, and resume normal airflow direction.	15 Points
Speed Category Description: Ease and feasibility of integrating the Solution with the body and the suit within 5 minutes.	The solution is self contained and mobile. It has only 3 unique connection points - 2 of which (storage bladder hoses and air/cleaner connection) are snap connectors and 1 (evacuation channel) utilizes a half twist compression fitting.	10 Points
Ease of Use/ Constraints Category Description: Ease of use given the constraints required for using (e.g., clean shaven, limitations on timing of waste elimination, requirement to be near a specific technology, etc.	Our Evaluation: The system is primarily voice activated then automatically completed fairly quickly through simple voice commands. A back-up controller with buttons could be added to the arm of the suit if it is needed. The system works the same for both men and women, it does not require special grooming, and is currently designed to fit in unused space. If it is found necessary to deviate from the current placement design for, as long as the closed system can remain connected via tubes it should still work perfectly fine.	10 Points

SCORECARD EVALUATION CONTINUED

Category & Description	Our Evaluation	Points
Comfort Level of physical, emotional, and psychological comfort the crew member will experience using the Solution, including while donning, moving around, and seated and strapped in.	Voice activated set-it-and-forget-it system keeps the astronaut's body waste free, sanitized, and dry. If the automatic system doesn't fully satisfy the astronaut, specific sequences can be efficiently repeated until comfortable. If the system clogs, there is a handsfree plunger system to remedy the problem. The current layout can be adjusted from its current placement based on astronaut testing and feedback.	10 Points
Ease of Incorporation Ease of incorporating into existing suits and vehicle.	Minimal suit adjustments include: • Thigh pockets added to the outside of coolant layer to hold waste collection bags • Thermals and coolant layer need to allow for the evacuation tube to pass through them. • Fit of pressurized suit might need to be adjusted to account for the pump and centrifuge.	5 Points
Other Benefits Other benefits that the judges identify or the competitor points out that do not fall into the above categories. Could also include judge preferences, such as for simplicity.	We believe the Judge looks particularly wise today.	5 points