DANIEL ON THE MOON

TECHNICAL ASPECTS PART 3

EMU (SPACE SUIT) MAINTENANCE KIT

Looking back, as I often do, I'm as much in awe of Apollo program achievements now as I was 50 years ago. This, despite the fact that I was so intimately involved in the "nuts and bolts" details and logistics essential for mission success.

There was so much creative thinking that lead to so many problem solutions that no one but those intimately involved are aware of.

I was recently looking at a photo of myself (below) where I appeared to be reading or as my wife said it looked like I was praying. No, in fact, I was evaluating, commenting on, and proposing changes to procedures for using the astronaut EMU maintenance kit. The maintenance kit was one of those "unsung" unused Apollo EMU components that, in my opinion, was one the of the most "creative packaging concepts" and an excellent example of the creative thinking that helped us achieve mission goals.

I want to share with you the functional details and creative packaging of this amazing EMU component that I was fortunate enough to have worked with as follows:

The EMU maintenance kit contained cleaning, replacement and repair parts including supplies for in flight maintenance of the Apollo Pressure Garment Assembly (PGA) and the Extra-Vehicular Visor Assembly (EVVA).

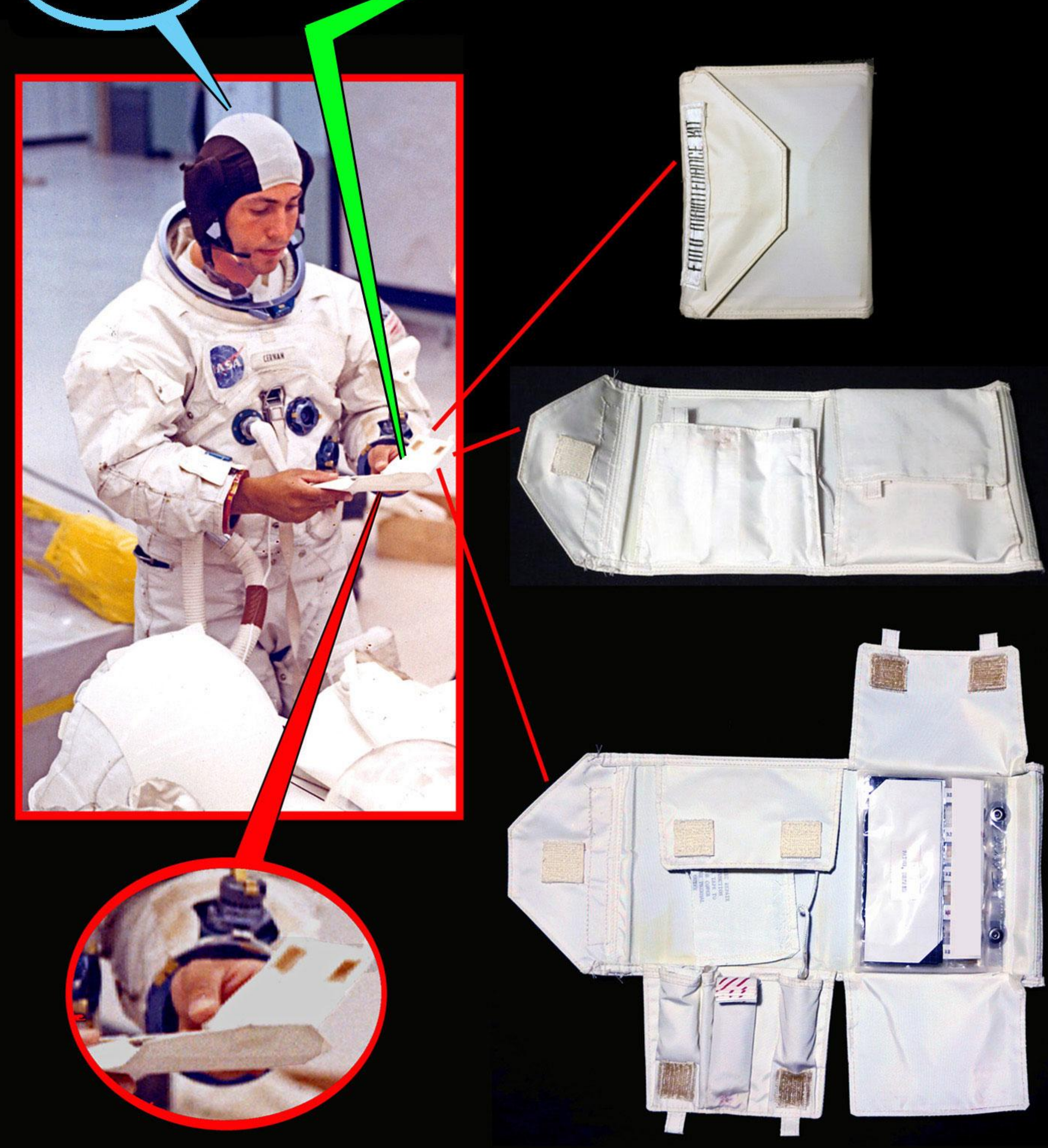
The EMU maintenance kit graphic below illustrates three photos of the maintenance kit, i.e. closed, partially open and fully open.

The photo in the graphic is me (Dan) evaluating procedural use changes that were made to the kit based on previous astronaut feedback. After my evaluation and consensus approval, the changes were ready for the astronauts to re-evaluate and comment on.

EMU MAINTENANCE KIT

EVALUATING RECENT CHANGES TO MAINTENANCE KIT

DAN



The EMU maintenance kit consisted of two primary sections. First is the pocket assembly (Figure A below). The pocket assembly, held closed by hook and pile fastener strips, folded out to reveal four pockets containing items labeled 8, 9, 10 and 11 as follows:

- FABRIC REPAIR TAPE (8)
  The Fabric Repair Tape was made of fiber glass and was cut in two lengths (1"x 36") wrapped individually to a nylon rod. A Beta cord lanyard connected a strip of Velcro (hook) to the rod. The tape was stowed in the pocket seen in Figure A.The Fabric Repair Tape was intended to be used to complete small repairs to layers of the Integrated Thermal Micro-Meteoroid Garment (ITMG) and Cover Layer Assembly (CLA) or used in conjunction with a Teflon coated Beta cloth patch (9 in Figure A) when repairs to abraded, cut, or torn areas of the ITMG or CLA were required.

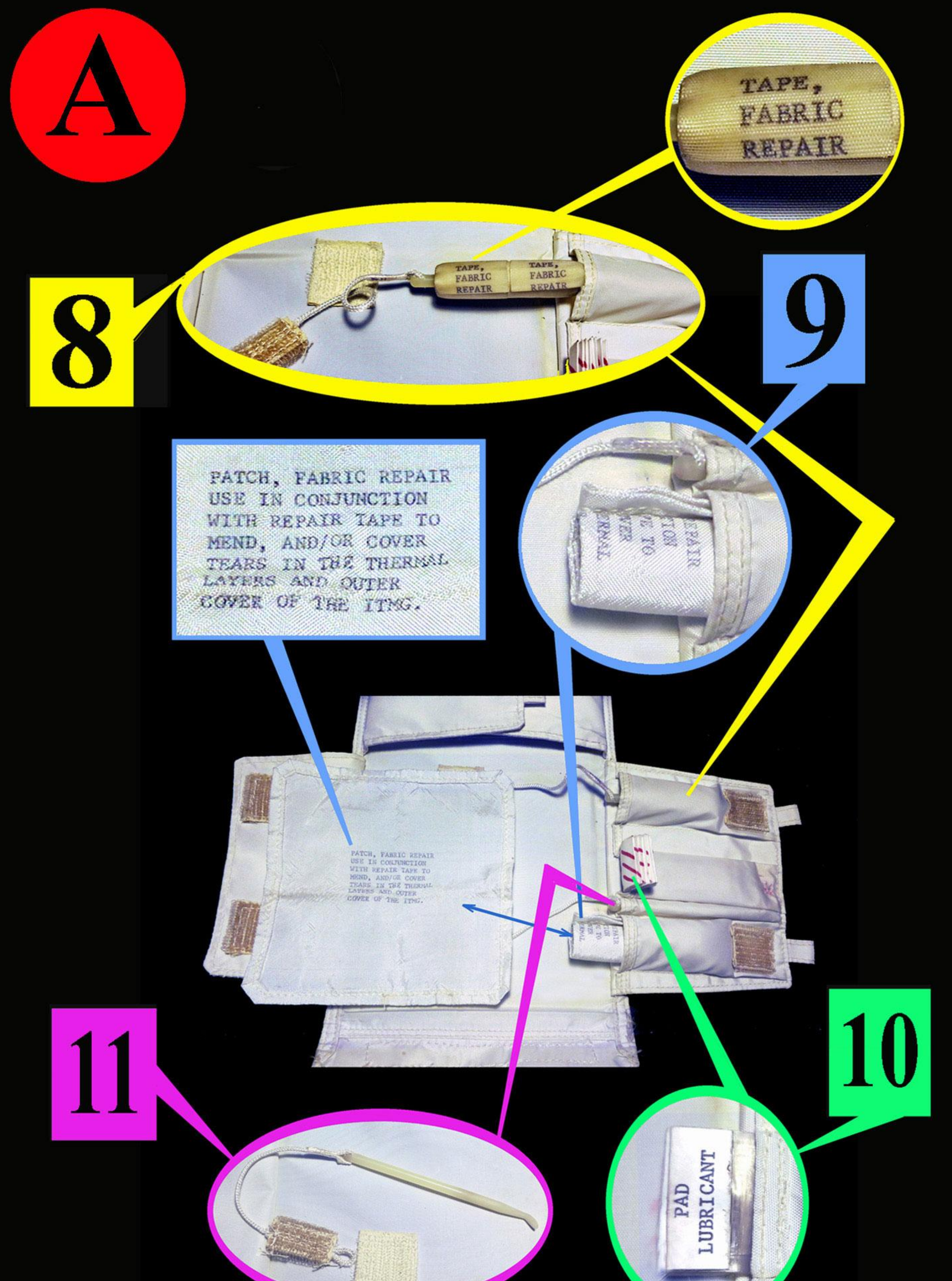
- BETA CLOTH REPAIR PATCHES (9)
  Two 5" x 5" squares of Beta cloth were available to be used to repair abraded, cut, or torn areas of the ITMG or CLA. The two patches were "rolled up" and stowed in the pocket seen in Figure A.

- LUBRICANT PADS (10)
  Eight oil saturated pads were included to be used to lubricate pressure sealing slide fasteners, seals and "O" rings.The pads were stowed in the pocket seen in Figure A.

- SEAL REMOVAL TOOL (11)
  The Seal Removal Tool is a nylon rod with an angled preformed tip which facilitates the removal of "O" ring seals for replacement in the PGA Wrist Disconnect, Pressure Relief Valve, Helmet Feed Port, Oxygen connectors and LCG water connector.

A lanyard with a Velcro (pile) fastener strip is attached to the tool. Temporary stowage is accomplished by engaging the pile strip with any Velcro (hook) strip. The tool was stowed in the pocket seen in Figure A.

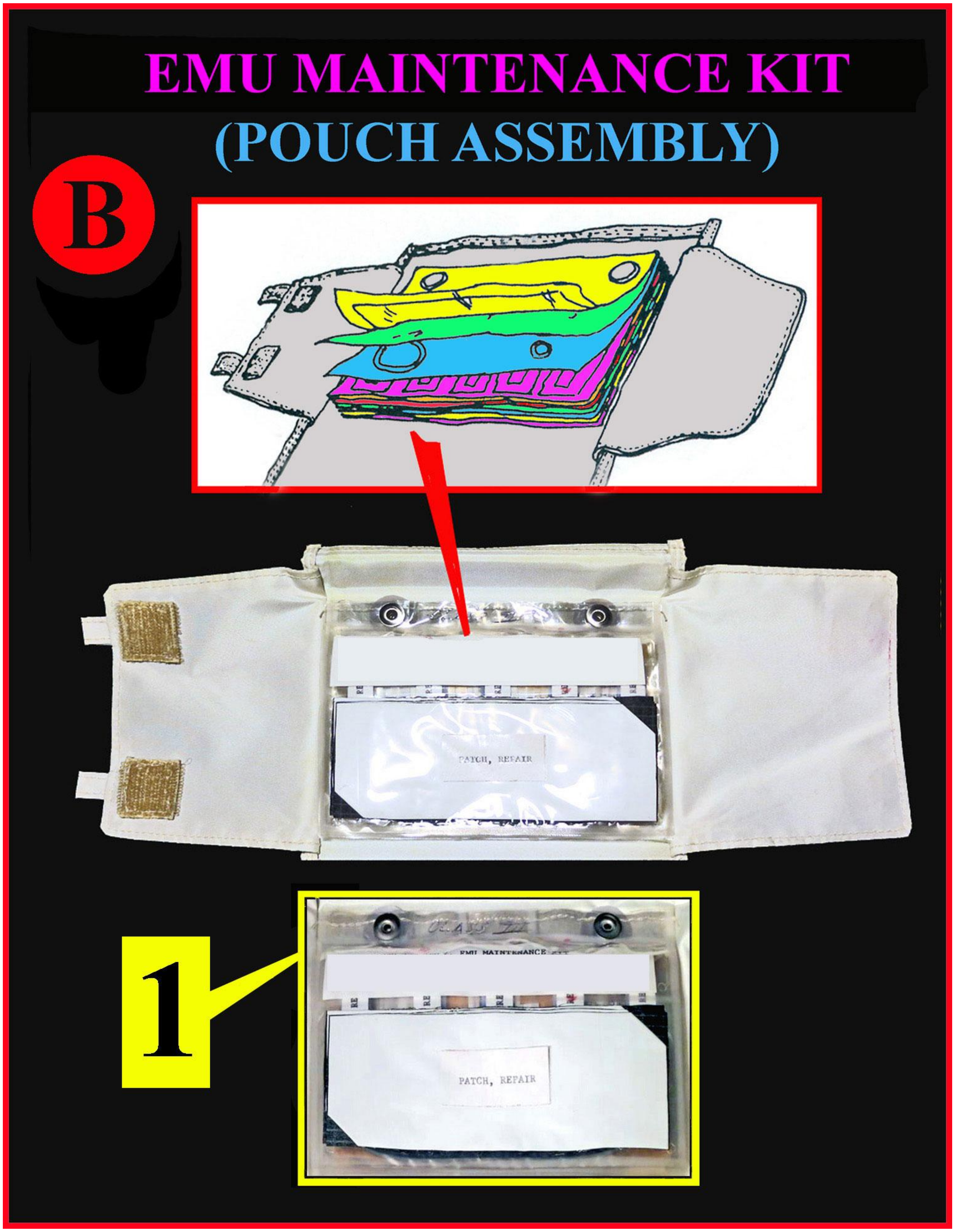
EMU MAINTENANCE KIT
(POCKET ASSEMBLY)



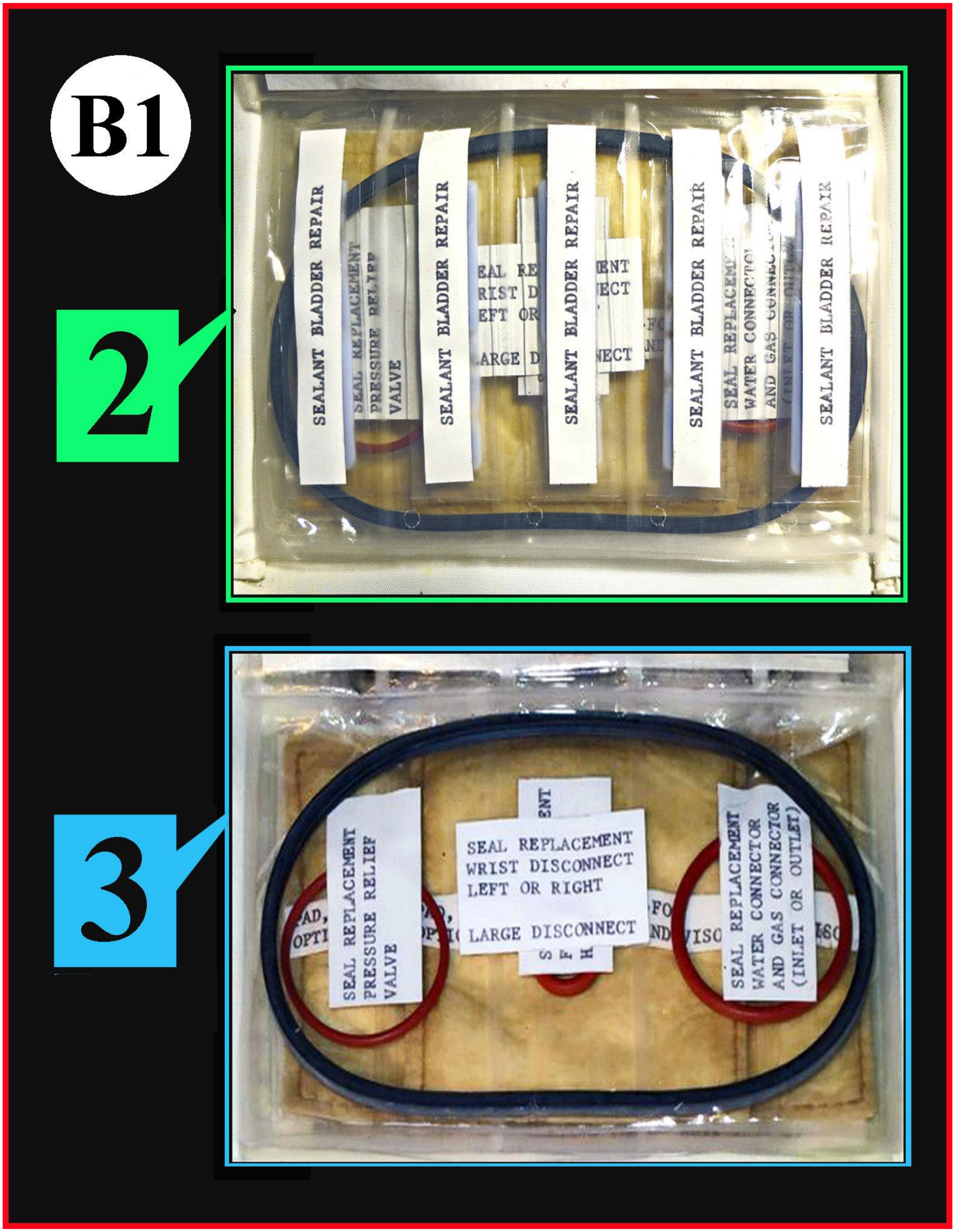
The second primary section of the EMU maintenance kit is the pouch assembly (Figure B below). The pouch assembly consisted of six transparent, heat-sealed pouches. The contents of each pouch were clearly labeled. The six pouches were attached using snap fasteners.

The six pouches and their contents are as follows:

- REPAIR PATCHES (POUCH 1)
  Contained three repair patches to be used in conjunction with sealant in pouch 2 (Figure B-2). The patches were to be used to seal accidental punctures in the Neoprene coated Nylon fabric of the Pressure Containing Bladder (PCB) portion of the Torso Limb Suit Assembly (TLSA).



- BLADDER REPAIR SEALANT (POUCH 2)
  Contained five measured portions of Sealant to be used in conjunction with the repair patches (pouch 1) to seal accidental punctures in the primary bladder of the Pressure Containing Bladder (PCG).
- REPLACEMENT RUBBER SEAL (POUCH 3)
  Contained a large replacement seal for either the right or left Suit Glove Wrist Disconnect.



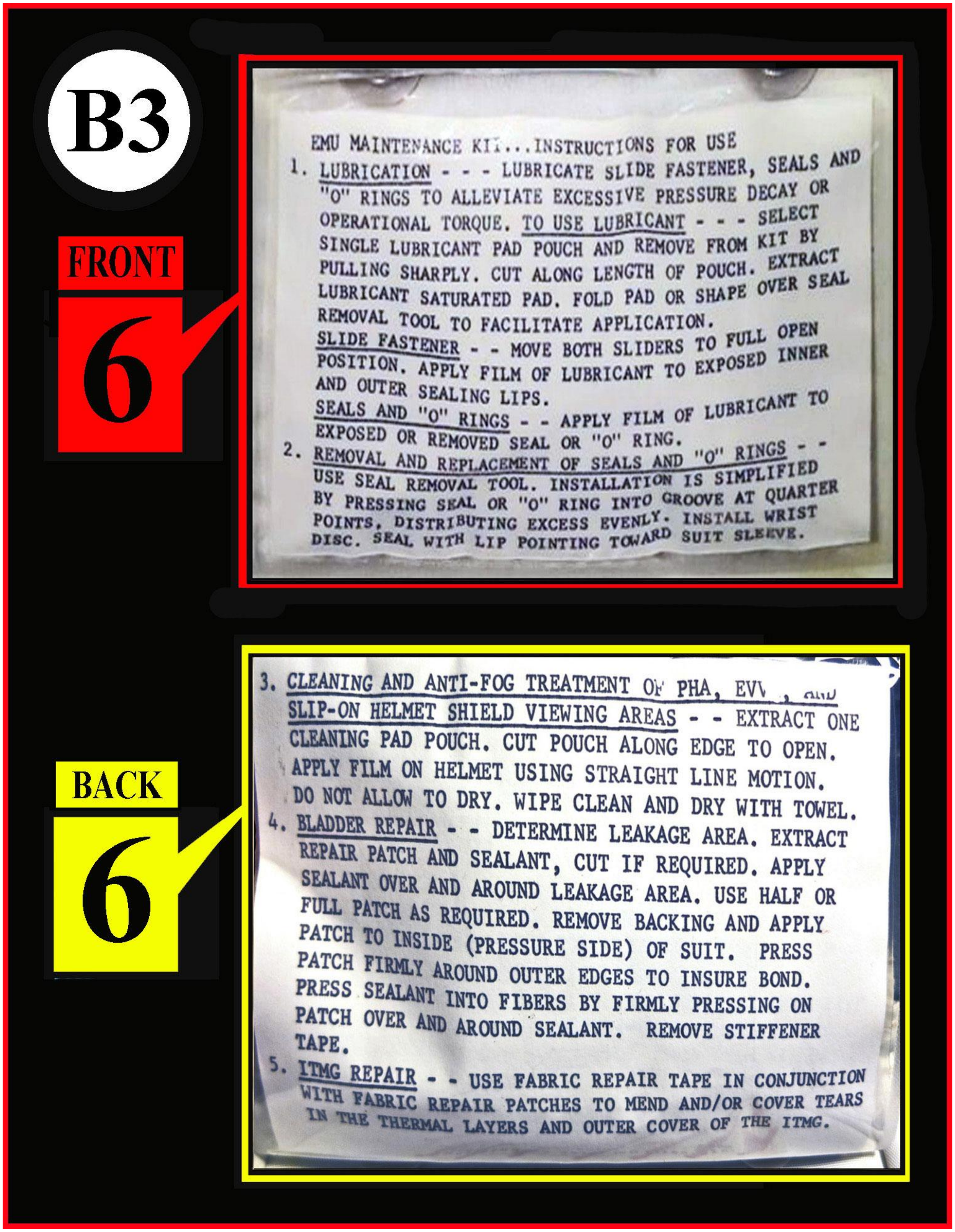
- REPLACEMENT SEALS (POUCH 4)
  Contained three Spare Replacement "O" Rings for the suit Pressure Relief Valve (PRV), Helmet Feed Port and the third for any of the suit Oxygen Connectors or the suit Liquid Cooling Garment (LCG) Multiple Water Connector.

- CLEANING AND ANTI-FOG PADS (POUCH 5)
  Contained six Treated Pads (two in each of three sealed pouch pockets) to be used to clean and provide anti-fog treatment to the optical surfaces of the Primary Helmet Assembly (PHA), Extra-Vehicular Visor Assembly (EVVA) and the Slip On Helmet Shield.

MAINTENANCE KIT INSTRUCTIONS (POUCH 6)

Instructions on the Front Side (Front 6 below) of the pouch, address Lubrication of Seals, "O" Rings and Slide Fasteners.

Instructions on the Back Side (Back 6 below) of the pouch address ITMG Repair, Pressure Control Bladder Repair, Helmet viewing area Cleaning and Anti-Fog treatment.



EMU MAINTENANCE KIT...INSTRUCTIONS FOR USE

1. LUBRICATION - - - LUBRICATE SLIDE FASTENER, SEALS AND "O" RINGS TO ALLEVIATE EXCESSIVE PRESSURE DECAY OR OPERATIONAL TORQUE. TO USE LUBRICANT - - - SELECT SINGLE LUBRICANT PAD POUCH AND REMOVE FROM KIT BY PULLING SHARPLY. CUT ALONG LENGTH OF POUCH. EXTRACT LUBRICANT SATURATED PAD. FOLD PAD OR SHAPE OVER SEAL REMOVAL TOOL TO FACILITATE APPLICATION.
SLIDE FASTENER - - MOVE BOTH SLIDERS TO FULL OPEN POSITION. APPLY FILM OF LUBRICANT TO EXPOSED INNER AND OUTER SEALING LIPS.
SEALS AND "O" RINGS - - APPLY FILM OF LUBRICANT TO EXPOSED OR REMOVED SEAL OR "O" RING.
2. REMOVAL AND REPLACEMENT OF SEALS AND "O" RINGS - - USE SEAL REMOVAL TOOL. INSTALLATION IS SIMPLIFIED BY PRESSING SEAL OR "O" RING INTO GROOVE AT QUARTER POINTS, DISTRIBUTING EXCESS EVENLY. INSTALL WRIST DISC. SEAL WITH LIP POINTING TOWARD SUIT SLEEVE.

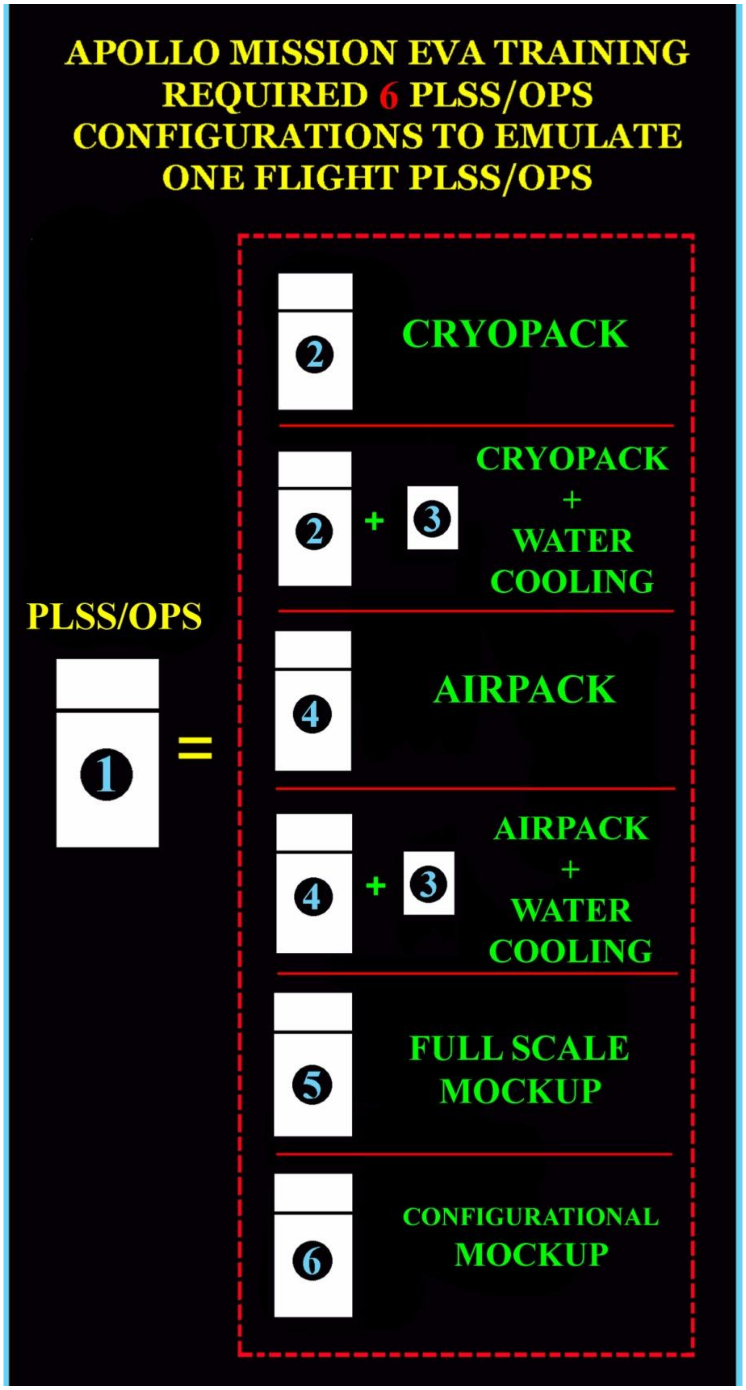
3. CLEANING AND ANTI-FOG TREATMENT OF PHA, EVV, AND SLIP-ON HELMET SHIELD VIEWING AREAS - - EXTRACT ONE CLEANING PAD POUCH. CUT POUCH ALONG EDGE TO OPEN. APPLY FILM ON HELMET USING STRAIGHT LINE MOTION. DO NOT ALLOW TO DRY. WIPE CLEAN AND DRY WITH TOWEL.
4. BLADDER REPAIR - - DETERMINE LEAKAGE AREA. EXTRACT REPAIR PATCH AND SEALANT, CUT IF REQUIRED. APPLY SEALANT OVER AND AROUND LEAKAGE AREA. USE HALF OR FULL PATCH AS REQUIRED. REMOVE BACKING AND APPLY PATCH TO INSIDE (PRESSURE SIDE) OF SUIT. PRESS PATCH FIRMLY AROUND OUTER EDGES TO INSURE BOND. PRESS SEALANT INTO FIBERS BY FIRMLY PRESSING ON PATCH OVER AND AROUND SEALANT. REMOVE STIFFENER TAPE.
5. ITMG REPAIR - - USE FABRIC REPAIR TAPE IN CONJUNCTION WITH FABRIC REPAIR PATCHES TO MEND AND/OR COVER TEARS IN THE THERMAL LAYERS AND OUTER COVER OF THE ITMG.

CREW TRAINING HARDWARE REQUIRED TO EMULATE THE FUNCTIONS OF THE FLIGHT PLSS

The PLSS/OPS was, of course, designed to be functionally operational on the moon. However, as I've discussed previously, using the lunar designed PLSS/OPS for Apollo KSC EVA crew training was a "non-starter."

As a result of not being able to use a lunar designed PLSS/OPS, we developed several pieces of hardware to emulate all the functional aspects of the PLSS/OPS in order to successfully carry out the Apollo mission EVA crew training requirements.

The key component hardware required were the cryopack, the airpack, the addition of a water cooling device for both the cryopack and airpack (when conditions necessitated water cooling), the full scale mockup and the configurational mockup as seen in the below graphic.



APOLLO 11 AND APOLLO 12 CRYOPACK PROBLEMS AND SOLUTIONS

The Apollo EVA Crew Training Cryopacks were designed to operate under a nominal heat input of about 1200 BTU/hr. When the heat input dropped below this level the Cryopacks began to accumulate ice in the injector and freeze up, ceasing breathable air flow to the astronaut. This situation limited the external environment the Cryopacks could be used in.

Not until we began using the Cryopacks at KSC did we determine the correlation between the designed 1200 BTU/hr heat input, the ambient temperature and the crewman's metabolic work load and more specifically these criteria related to the functional limitations of the Cryopack related to KSC EVA training.

With an ambient temperature of below 55°F and a nominal wind velocity, the Cryopack would freeze up. On the other hand, if the ambient temperature was above 80° F, the astronaut metabolic load that the Cryopack was able to dissipate was lower, causing the crewman to sweat profusely during strenuous EVA training exercises on the simulated outside KSC lunar surface.

Solving both the Cryopack freeze up problem and the crewman sweating problem resulted in both temporary patchwork solutions and semi - permanent solutions.

Both Apollo 11 and Apollo 12 lunar surface EVA Crew Training at KSC was 100% conducted in the KSC Crew Training Building using the Cryopacks. The major problems associated with both Apollo 11 and 12 EVA training exercises was CRYOPACK FREEZE UP AND AIR LEAKAGE.

Based on the previously discussed Cryopack design criteria, the Cryopack injectors froze when astronaut metabolic work loads were low (below 1200BTU/hr) and/or when the crew training building temperature was in the low 60's.

- CRYOPACK FREEZEUP PROBLEM:
  When a Cryopack "froze up" we had TWO OPTIONS. Option one involved using a heat gun to melt the ice in the injector requiring the crewman to be seated until air flow resumed. The nominal Cryopack design use time was 1.5 hr. My decision as PLSS/OPS EVA Crew Training Mission Manager to use or not to use the heat gun was based on the amount of remaining Cryopack functional operational time combined with remaining scheduled training exercise time.

- OPTION ONE:
  Decision to use the heat gun:
  As an example, if the total scheduled exercise time was 2.5 hrs and the Cryopack froze at the 30 minute mark with 1 hr remaining on the Cryopack, we used the heat gun to utilize the remaining 1 hour. At the 1.5 hr mark, with no time left on the pack, we switched to a fully charged cryopack to complete the 2.5 hr exercise. As I discussed previously, I had six Cryopacks charged and ready for every crew training exercise (theoretically three for each crew member).

- OPTION TWO:
  Decision not to use the heat gun:
  Option two was to replace the disabled Cryopack with another standby pack. As an example, if the Cryopack injector froze at the 1hr mark with only 30 minutes operational use remaining, it did not make sense to stop the training exercise 30 minutes after the previous change. In this case, we changed to a fully charged pack and completed the 2.5 hr exercise.

- CRYOPACK AIR LEAKAGE:
  As discussed previously, we continually monitored both the Cryopack System Pressure Gauge and the Suit Pressure Gauge. When the system pressure gauge decreased before the Cryopack nominal

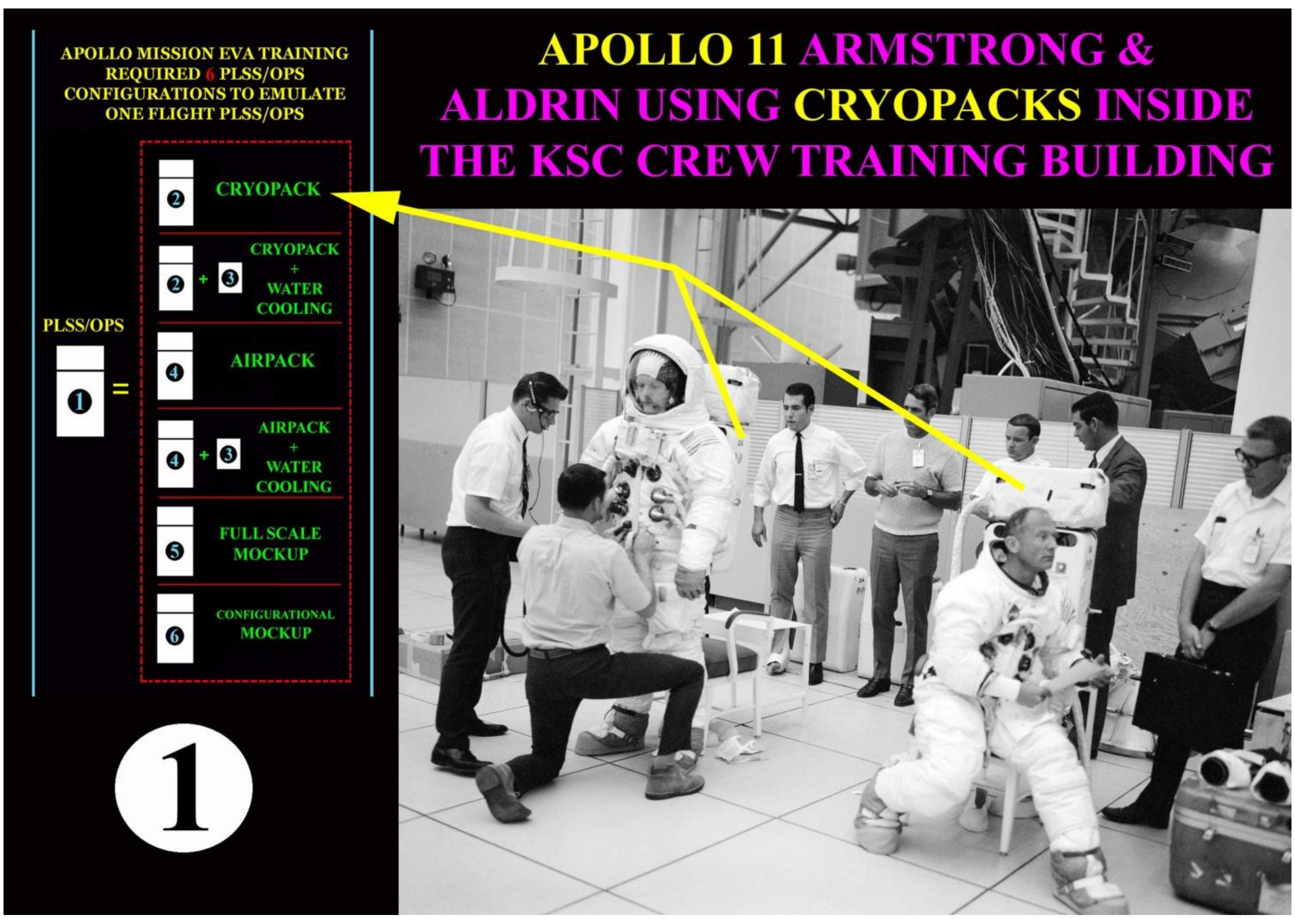
1.5 hr operating time, we recognized that we probably had air leakage and immediately notified the test conductor to alert the affected crew member. The affected Cryopack was removed and replaced with a standby pack.

By no means were we providing permanent solutions for both the FREEZE UP and AIR LEAKAGE problems. The objective was to successfully accomplish the crew training exercise objectives without having to cancel, potentially compromising the astronaut training schedule which, as we know, had very little or for that matter no time to reschedule, possibly delaying a scheduled launch.

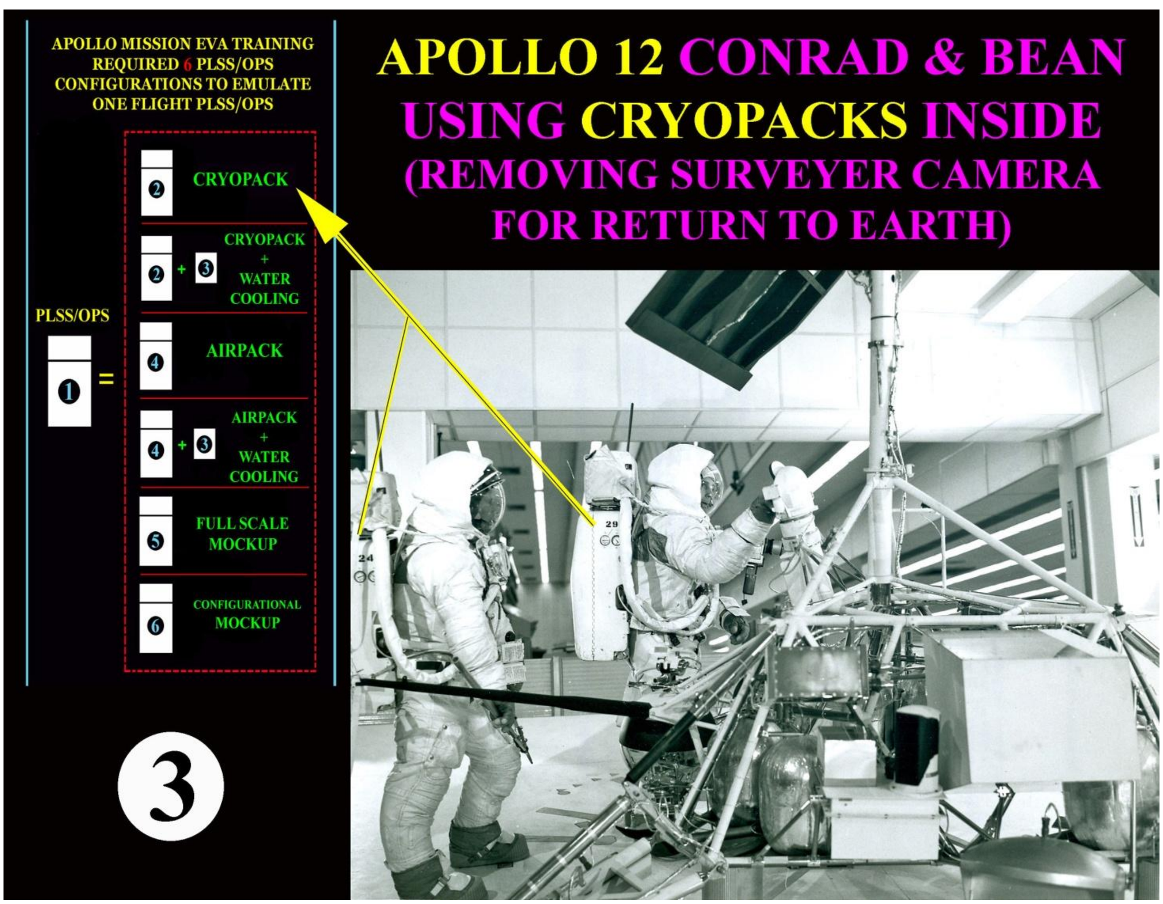
As I pointed out in previous posts, it is a "shame" that the training backpacks were not designed with the same quality criteria as was the flight hardware!

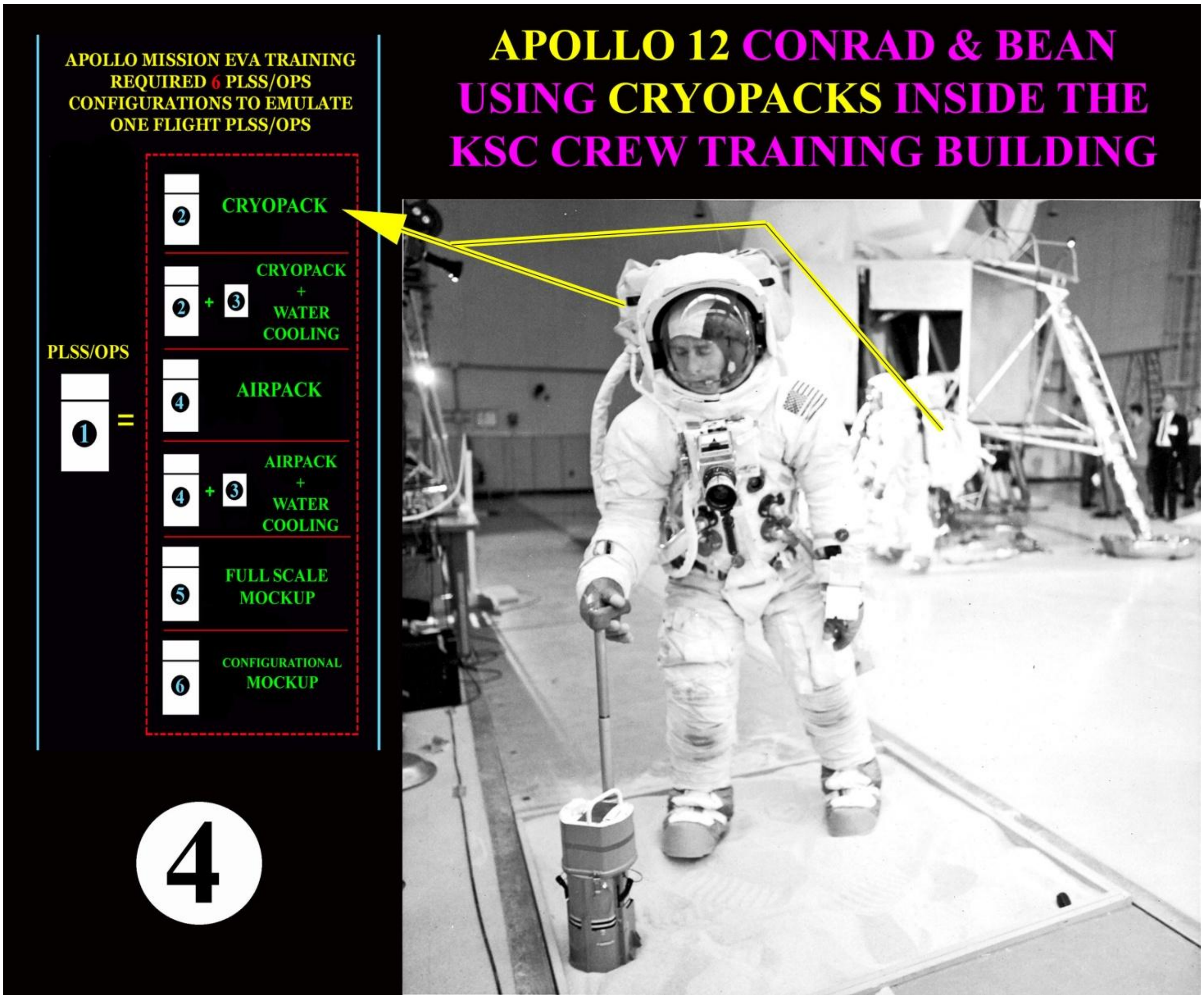
The following four graphic presentations show both Apollo 11 and Apollo 12 astronauts using cryopacks inside the crew training building.

As I also previously indicated, all Apollo 11 and Apollo 12 EVA crew training was accomplished using cryopacks.




APOLLO MISSION EVA TRAINING
REQUIRED 6 PLSS/OPS
CONFIGURATIONS TO EMULATE
ONE FLIGHT PLSS/OPS
PLSS/OPS
1 =
2 CRYOPACK
2 + 3 CRYOPACK + WATER COOLING
4 AIRPACK
4 + 3 AIRPACK + WATER COOLING
5 FULL SCALE MOCKUP
6 CONFIGURATIONAL MOCKUP
2
APOLLO 11 ARMSTRONG & ALDRIN
USING CRYOPACKS INSIDE THE
CREW TRAINING BUILDING


APOLLO MISSION EVA TRAINING
REQUIRED 6 PLSS/OPS
CONFIGURATIONS TO EMULATE
ONE FLIGHT PLSS/OPS
PLSS/OPS
1 =
2 CRYOPACK
2 + 3 CRYOPACK + WATER COOLING
4 AIRPACK
4 + 3 AIRPACK + WATER COOLING
5 FULL SCALE MOCKUP
6 CONFIGURATIONAL MOCKUP
3
APOLLO 12 CONRAD & BEAN
USING CRYOPACKS INSIDE
(REMOVING SURVEYER CAMERA
FOR RETURN TO EARTH)



FIRST USE OF CRYOPACKS OUTSIDE THE CREW TRAINING BUILDING FOR APOLLO 13 ON THE SIMULATED LUNAR SURFACE AND THE PROCEDURES USED

The first use of the training PLSS cryopacks outside on the KSC simulated lunar surface was during Apollo 13 EVA training.

From a logistics standpoint, we came up with a procedure to transfer the astronauts and equipment to the specific location on the KSC lunar surface that the KSC Crew Systems Division (CSD) test conductor specified for the training run.

After we (test conductor, suit techs, cryopack techs and myself) proposed a transfer procedure, I had the opportunity to logistically confirm the procedure.

First, we went through the normal suit up procedure that included EMU functional checks and EMU donning (Photo 1). The fully suited crewman stood up and walked out through the back vertical sliding door of the Crew Training Building to a waiting transfer van. The crewmen were each accompanied by both a suit tech and Cryopack tech.

While the crewman walked to the van, we transferred the donning chairs and all other equipment for the training exercise to the van and loaded everything through the side doors of the van (Photo 2).

Suit pressure was then lowered from 3.7 psi to 1 psi to make it easier for the crewman to sit, legs hanging over the rear bumper (Photo 3),for the ride to the designated lunar surface site (Photo 4).

It should be noted that there was enough space for both crewman to ride together on the back of the van as seen in Photo 5.

As an aside, after an incident where Al (Shepard) almost slipped off the back of the van, he, in a seemingly angry tone said blaring through the speaker of the hand held communications receiver, "I want to know who's driving and I want to speak with him!" We all knew Al loved to kid around, but being the van driver, I was the target of his fake anger and did not realize he was kidding with me till we stopped and I saw him grinning through his helmet.

Dan in space suit:

TRAINING EQUIPMENT INSIDE TRANSFER VAN

Dan in Space Suit:

Dan in Space Suit:

ASTRONAUTS BEING TRANSFERRED FROM CREW TRAINING BUILDING TO KSC SIMULATED LUNAR SURFACE EXERCISE SITE.

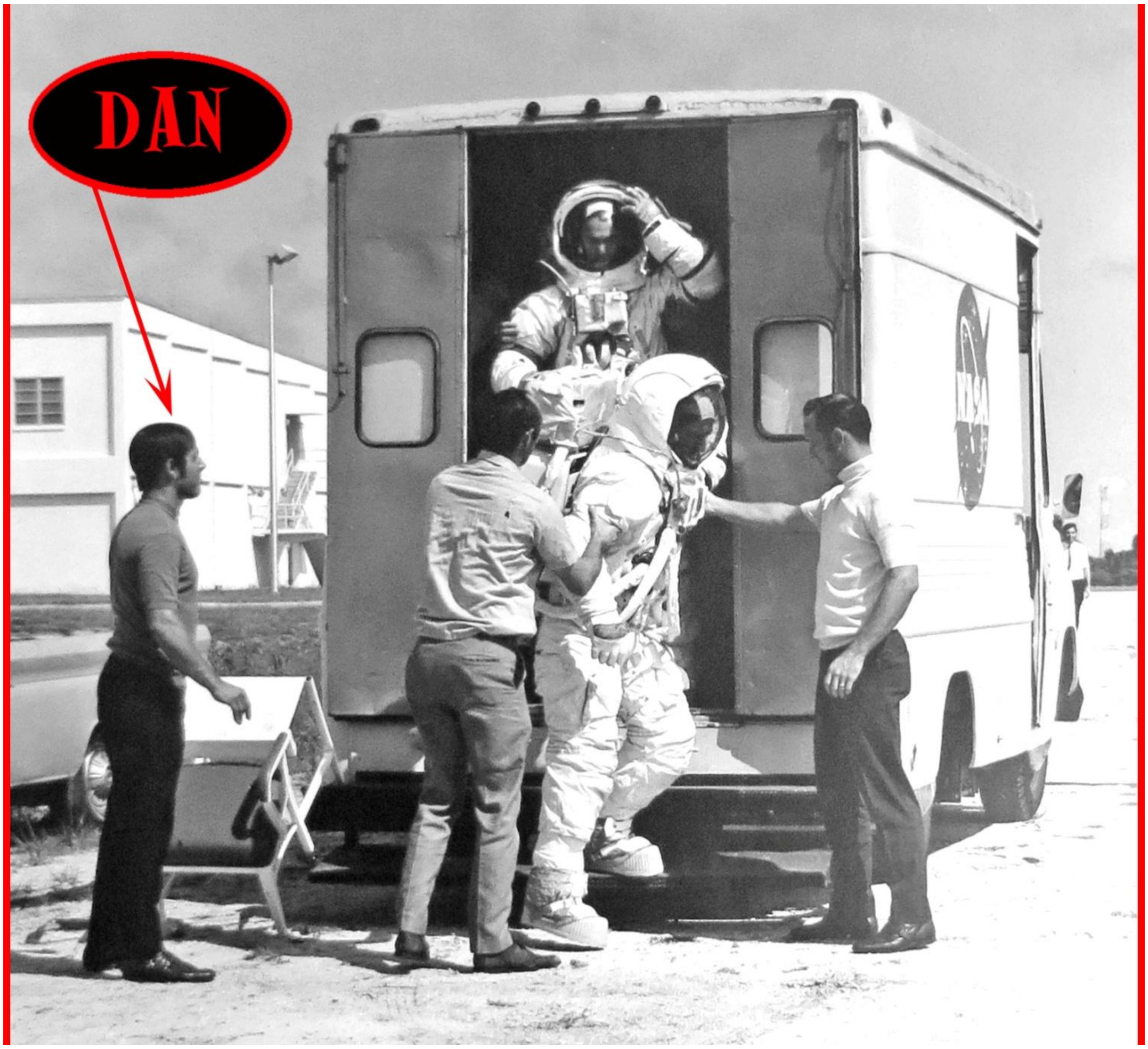
The "more familiar" transfer van was used with flight hardware, including flight suits. The van we used was the Hamilton Standard government issued van that did not require a quality control "paper work trail," which was consistent with all our training equipment.

For all morning EVA crew training exercises I and my two techs arrived at our HSD building at 6AM to drive our van and pick up the cryopacks at the Bendix facility where the packs were charged with cryogenic air (liquid air).

One morning I arrived to find our van had a flat tire. I called and woke up the CSD test conductor (fortunately I had his home phone number) and let him know the situation we were in.

He called back about an hour later and said an old NASA van was available and would be driven to our facility for our use. He mentioned that the driver would have to be driven back.

Following is a photo of the replacement van and the crew exiting. That's me on the left.



PROBLEMS AND SOLUTIONS WITH EVA CREW TRAINING AFTER APOLLO 13

Up to this point I talked about Apollo 11, 12 and 13 EVA crew training using the PLSS training cryopacks and the cryopack problems we had, namely, cryopack freeze up, cryopack air leakage and uncomfortable high suit temperatures.

After completion of Apollo 13 crew training, we sent the cryopacks to the Manned Spacecraft Center (MSC) in Houston for evaluation and "repair" of both the freeze up and air leakage problem.

With repair "modifications" completed the cryopacks were returned to KSC in time for the beginning of Apollo 14 EVA training.

Unfortunately, to say the least, we began experiencing the same problems as before with the addition of a new problem, that being unexplained possibly dangerous pressure increases in the cryopack dewar (the cryogenic air reservoir tank) during Apollo 14 crew training runs. This increased pressure climbed higher than the relief valve set at 180psig. The nominal cryopack system operating pressure was 150 psig to 160 psig with the relief valve set at 180 psig.

The system pressure was elevating higher than the relief set point resulting in considerable leakage reducing the 1.5 hr nominal cryopack operating time to between 45 minutes and about an hour.

My immediate thought was to increase the relief valve pressure and see how high we needed to go on the relief valve set point to compensate for the pressure buildup anomaly. The unknown, of course, was how high would the pressure actually increase.

We ran a test on all cryopacks with the relief valves removed to see if the pressure buildup stopped increasing beyond 80% of the 300 psig designed proof pressure of the Dewar (240 psig).

We found that the maximum pressure, with the relief valve removed, of eight cryopacks tested was 205 psig. We repeated the tests and got similar results.

I decided to raise the relief valve pressure to 220 psig. We then tested the cryopacks with the relief valve in the loop and no leakage occurred. I discussed our test results with the dewar manufacturer from a safety standpoint and they agreed that it was reasonable to increase the relief valve setting to 220 psig.

We continued with Apollo 14 crew training using cryopacks for both inside and outside exercises. We continued to have the freeze up, air leakage and uncomfortable high suit temperatures. We implemented the same Apollo 11, 12 and 13 solutions. Fortunately we were able to work around the pressure buildup problem with the increased relief valve set point.

This was all very disconcerting for me as I felt it was my responsibility to successfully support all EVA crew training exercises. At the same time I was disappointed with MSC sending us "supposed" repaired cryopacks!

We continued with Apollo 15 crew training using cryopacks for both inside and outside exercises. We continued to have the "freeze up," "air leakage" and "uncomfortable high suit temperature" problems and we implemented the same Apollo 11, 12, 13 and 14 solutions.

As I previously stated, my objective as PLSS/OPS EVA Crew Training Mission Manager was to successfully accomplish crew training exercise objectives without having to cancel, potentially compromising the astronaut training schedule which, as we know, had very little or for that matter no time to reschedule, possibly delaying a scheduled launch.

Additional cryopack problems were encountered during Apollo 15 Crew Training both inside the Crew Training Building and outside on the simulated lunar surface. Fortunately these additional problems did not affect Crew Training exercises as we always had additional spare charged cryopacks to successfully complete all scheduled exercises. However, more and more time between training exercises had to be devoted to cryopack repair and makeshift modifications.

There came a point during Apollo 15 training, when I realized that we had to come up with an alternate PLSS Backpack for training runs to replace the cryopacks, specifically, to eliminate the "freeze up" and "air leakage" problems.

After just one problem solving meeting, we agreed that we could modify existing Shell (empty inside) PLSS mockups used for occasions when only an outside dimensionally equivalent flight PLSS envelope was needed. The idea was to utilize the existing Crew Training Building Regulated Air Supply that we were already using to pressurize Astronaut suits and provide breathable air flow during LM suit donning and doffing exercises. During these exercises, the Astronaut wore dimensionally and component correct Hi Fi PLSS/OPS mockups with suit pressurization and breathable air flow supplied from the regulated air supply console directly to the suit inlet oxygen connector and out the suit purge valve. With an unlimited air supply to the crewman, there was no need for re-circulated oxygen and carbon dioxide removal as with the flight PLSS.

Modifications to the PLSS shell mockups included adding a regulator, an inlet air hose connector to the back of the shell mockup connected to the regulator. The regulator outlet was a retrofitted PLSS outlet oxygen hose and suit inlet connector. Lastly, we added regulator inlet and outlet (suit pressure) pressure gauges that could be easily visually monitored by any of the support crew. From this point on I will refer to the air regulated shell mockup as the AIR PACK.

After fabricating and testing four Air Packs, the next challenge was to figure out how to provide the limited mobility needed inside the Crew Training Building with the crewman's Air Pack air supply hose connected to the stationary air console. The logical answer was to use a long hose.

The challenge with a long hose was, how do you walk around the LM conducting EVA tasks without the hose(s) (two crewman) getting snagged on LM projections along the way and preventing the two crewman hoses tangling with each other?

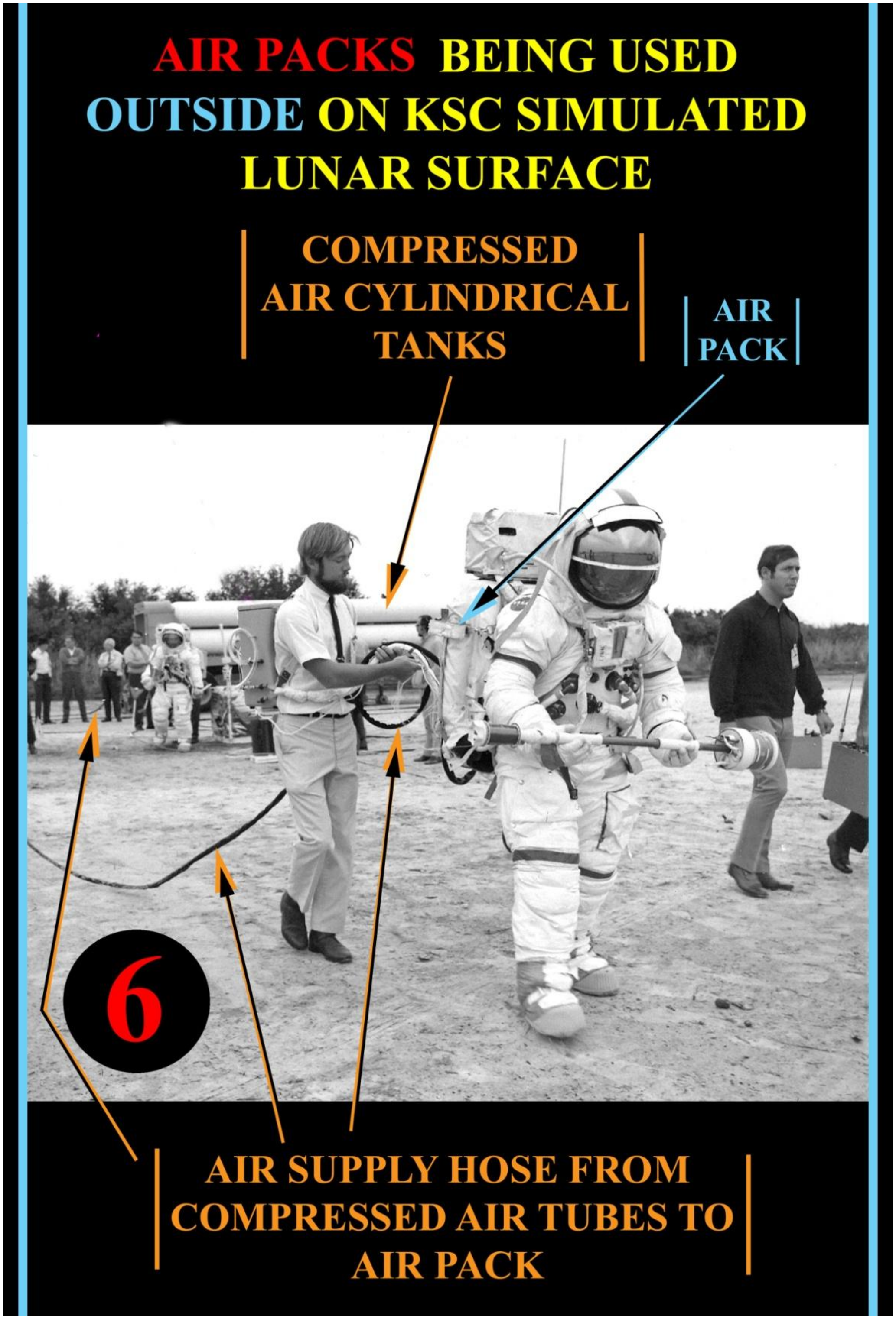
The solution we came up with was to construct a "rotating spindle frame" on the top of the Crew Training Building LM Mockup with a radius longer than the furthest LM projection below. The air supply hose from the air regulated console was routed to the center of the rotating spindle frame to rotatable Air Pack hose connectors.

I'm providing Graphic 12 below to give you a visual depiction of my written descriptions.

The next challenge was to figure out a way of using the air packs outside on the KSC simulated lunar surface. I made some phone calls and found the availability of a flatbed truck with compressed air cylinders that could be moved to the outside training site.

Before celebrating, we asked the next logical question. Can we obtain hoses long enough to support the mobility needed for required training excursions away from the compressed air supply. We were able to coordinate the use of 200 and 300 foot hoses.

Graphic 6 below is a pictorial depiction of a crewman wearing an air pack and as can be seen is a considerable distance from the compressed air supply.



DESIGN AND FABRICATION OF SPACE SUIT WATER COOLING CAPABILITY FOR ASTRONAUT COMFORT DURING EVA LUNAR TRAINING EXERCISES

In the back of my mind through both Apollo 14 and Apollo 15 training cycles, I obsessed about the need for EVA "water cooling capability" for EVA training based on the Apollo 13 Final Report that reflected the concerns of Apollo 13 astronauts Lovell and Haise about the uncomfortable high suit temperatures during arduous training exercises both inside and outside the crew training building.

My concerned obsession led to a "water cooling pack" depicted in Graphic 7 below. The primary objective was to provide cool water flowing through the crewman's Liquid cooling garment (LCG). As I previously discussed, the cryopack was only capable of supplying breathable air and inadequate crewman air cooling as the cooled cryogenic air flowed from the helmet through the suit and out the open suit purge valve. The flight PLSS as I also previously discussed, had LCG water cooling capability using the process of sublimation only achievable in the vacuum of space.

The "Prototype Test Unit" body (A) in graphic 7 was fabricated from molded plastic. It was designed to be carried on the back of tech who became the astronaut's "shadow" as he was connected to the crewman. The hollow interior of the pack (B) was insulated and functioned as a reservoir holding ice and water. The pack had an insulated hinged cover (C) that was opened to add ice (before and during a training exercise) replacing previously added ice that had melted.

Different in line water pumps (D) were evaluated for their functional capability of providing a water flow rate of 4lbs/hr through the LCG. When we found an acceptable pump, it was mounted inside the water pack reservoir and connected to the water cooling pack inlet (G) (LCG outlet) and the outlet (H) (LCG inlet). The hose (F) was a lengthened PLSS multiple flow hose (contained both inlet and out flow tubes) including the identical PLSS flight multiple water connector that connected to the suit multiple water connector.

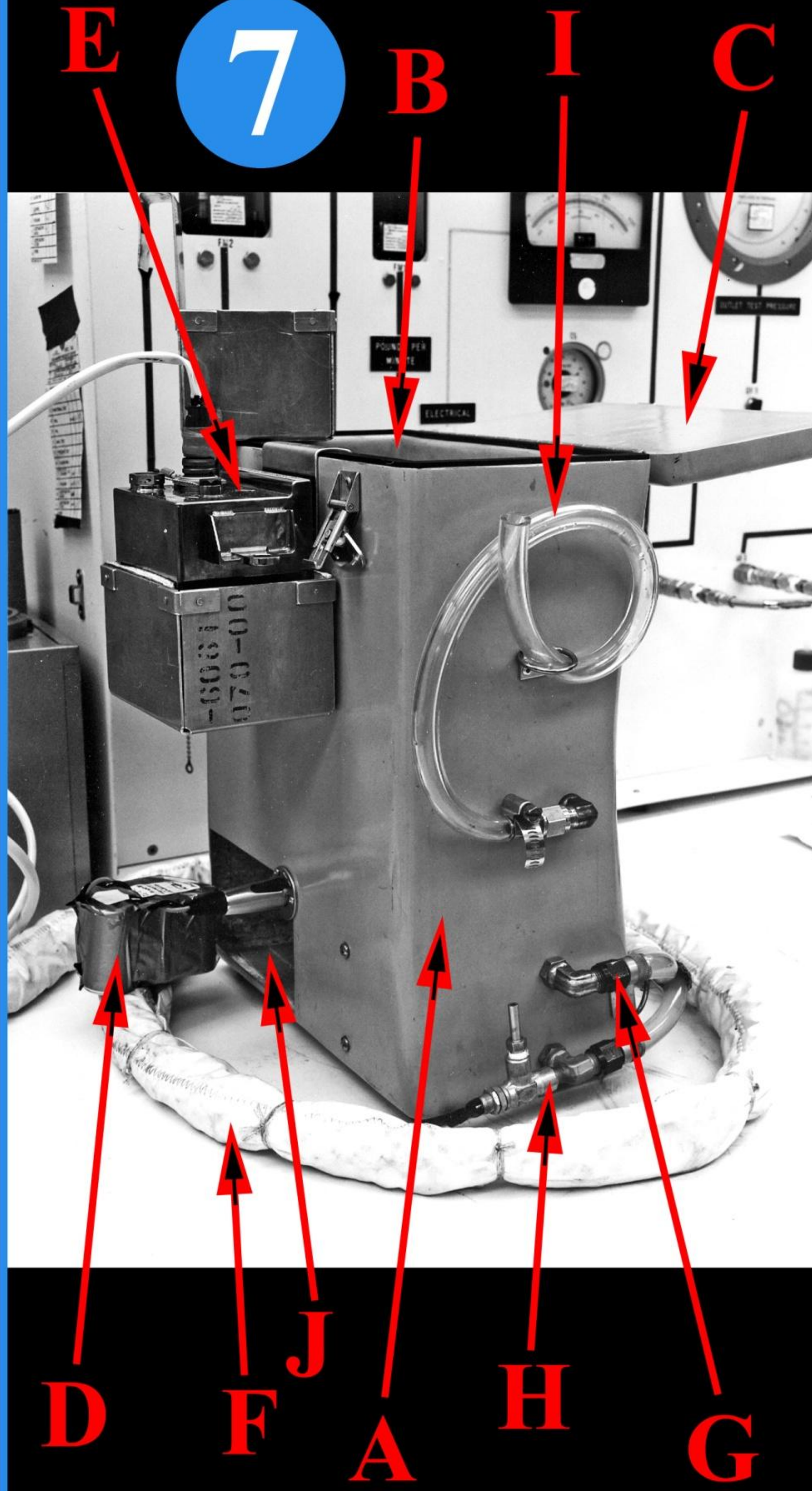
The battery (E) hanging off the top rear of the water cooling pack was not the battery that powered the cooling pack pump (D). It was, in fact, the battery that powered the Extravehicular Communications System (EVCS) located inside the training OPS mockup mounted on top of the air pack or cryopack.

With the cryopack, the EVCS battery was mounted inside the cryopack but instead of modifying the Air Pack by cutting a hole in the back of the pack and fabricating a battery mounting bracket inside the air pack, I decided it made more sense to mount the EVCS battery on the back of the cooling pack (as depicted in graphic 7) with the battery power cable long enough to reach the EVCS. We found, however, after a number of crew training exercises that the combination weight of the water and ice filled pack plus the weight of the battery was too much to carry during a two to four hour training run. We found it much easier to carry the battery by hooking it on the front or side of the support person's belt.

Now that I finished rambling on about the battery (E) that had nothing to do with the water cooling pack, let's get back to the remaining cooling pack features. The space (J) was used to hold the battery that powered the pump (D). The last component was a drain tube (I) that was used to drain melted ice water to make room for additional ice during a training run.

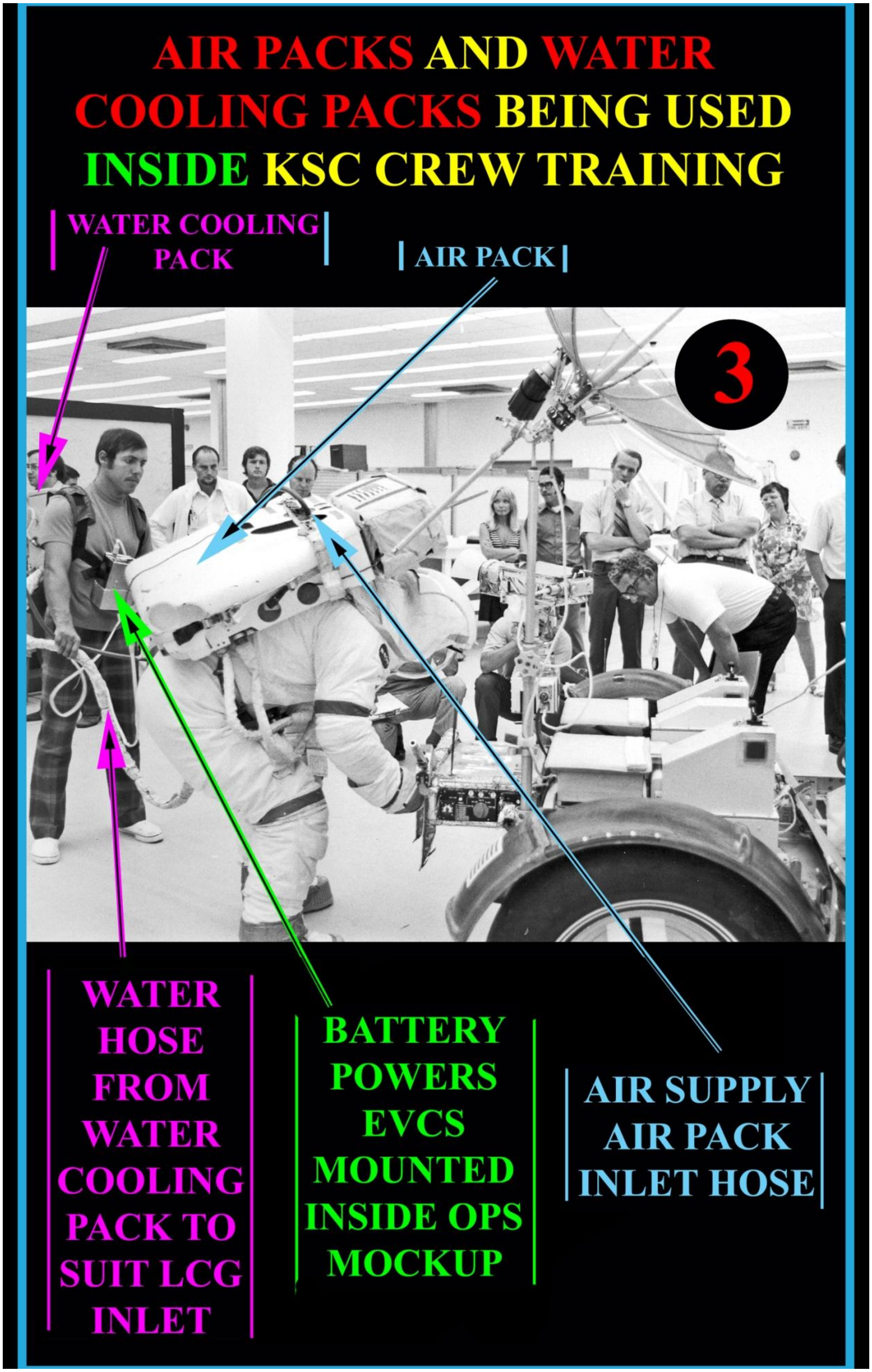
WATER COOLING PACK

(PROTOTYPE TEST UNIT)



We began using the aforementioned "water cooling packs" at the start of Apollo 16 EVA training.

Following are three graphic representations showing the water cooling packs and also the previously discussed "Air Packs" being used during both inside and outside crew training exercises:

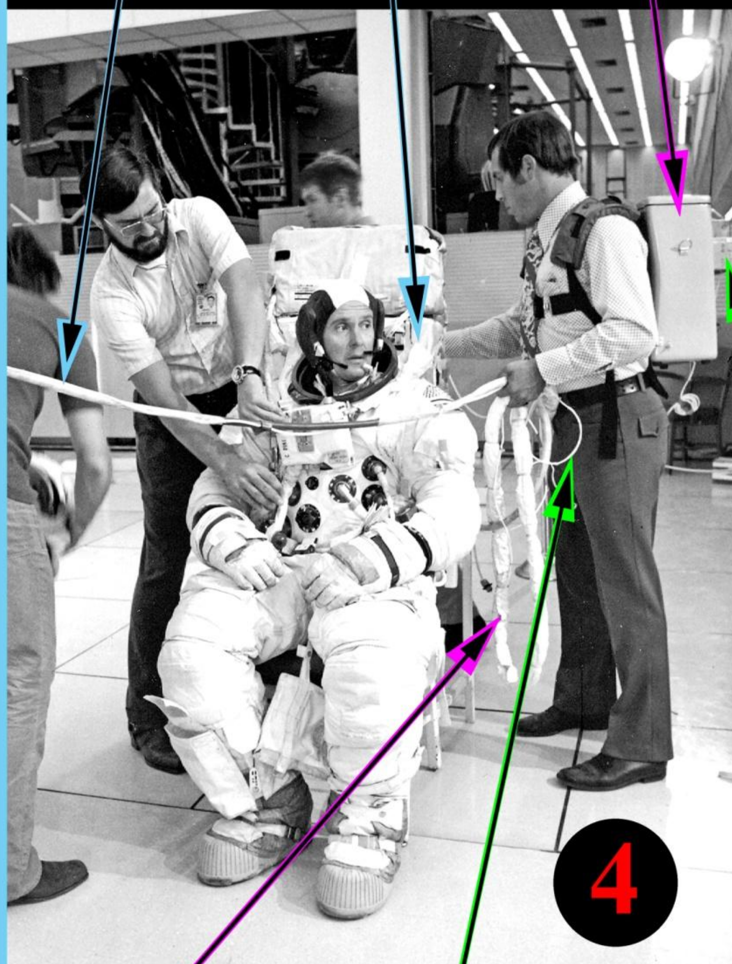


AIR PACKS AND WATER COOLING PACKS BEING USED INSIDE KSC CREW TRAINING BUILDING

AIR PACK AIR SUPPLY HOSE

AIR PACK

WATER COOLING PACK



WATER HOSE FROM WATER COOLING PACK TO SUIT LCG INLET

EVCS BATTERY CABLE

BATTERY POWERS EVCS MOUNTED INSIDE OPS MOCKUP

AIR PACKS AND WATER COOLING PACKS BEING USED OUTSIDE ON KSC SIMULATED LUNAR SURFACE

WATER COOLING PACK

BATTERY POWERS EVCS MOUNTED INSIDE OPS MOCKUP

AIR PACK

AIR PACK AIR SUPPLY HOSE

WATER HOSE FROM WATER COOLING PACK TO SUIT LCG INLET

EVCS BATTERY CABLE

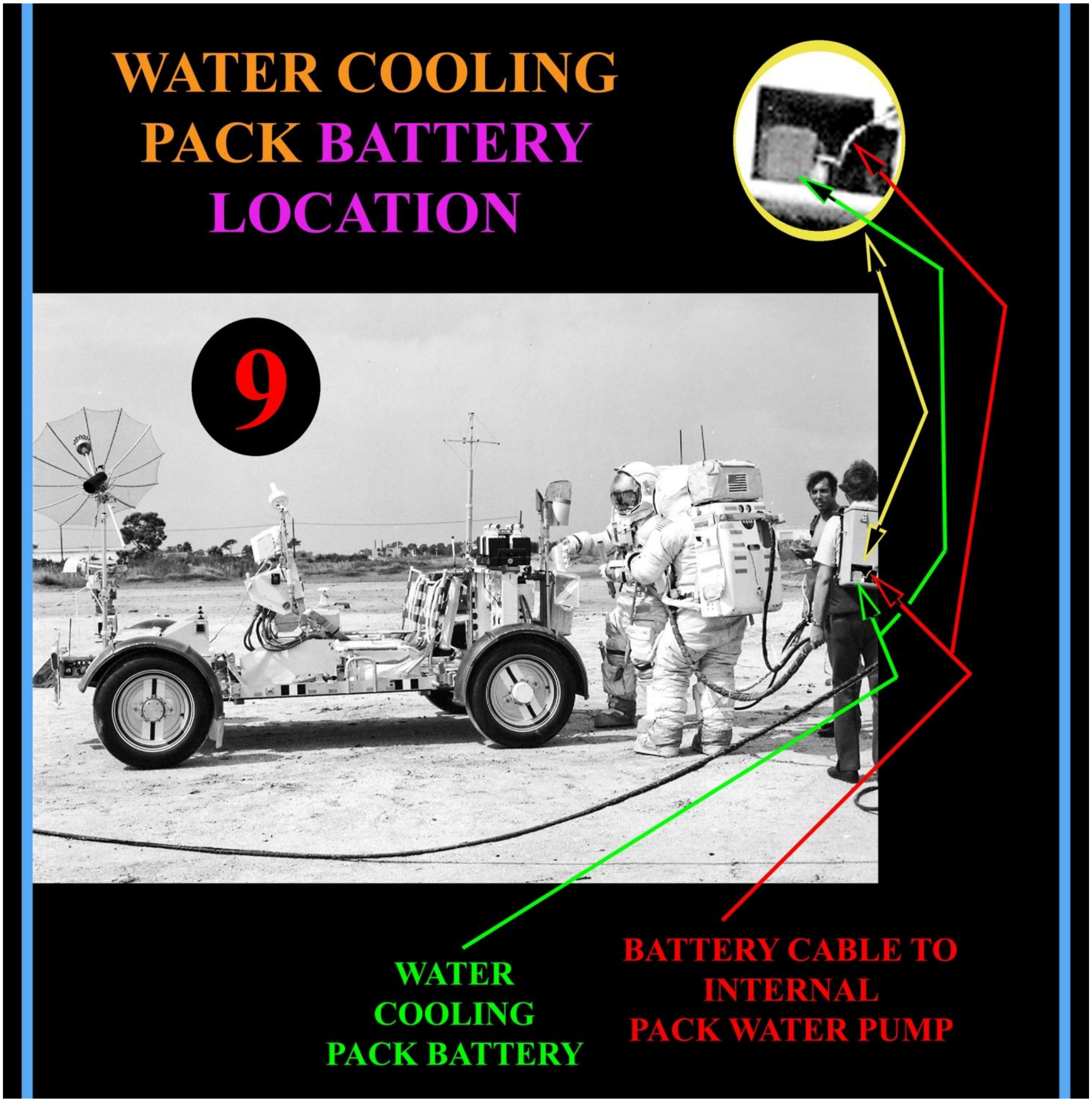
In Graphic 8 below, one of my techs is preparing a "water cooling pack" for use.

The hinged cover of the water cooling pack (A) is about to be opened by a technician so that he can add water from the bucket (C) to about 1/3 volume of the cooling pack reservoir. The tech will then fill the bucket with ice cubes from one of the two Styrofoam ice chests (B). The tech will then add ice to the cooling pack to a level about 1" from the top of the pack.

Prior to the crewman standing, the tech, with the help of another support crew member, will mount the water cooling pack on his back. Note the cooling pack has cushioned support harness straps (D). When the crewman is completely suited with helmet on and pressurized, the tech will connect the Cooling Pack water hose (E) to the crewman's multiple water connector.

Lastly, someone other than the tech carrying the cooling pack will turn the cooling pack pump toggle to the on position. The location of the pump toggle switch is hidden in graphic 8 below.

In my previous post, Graphic 8 did allow me to point out the water cooling pack pump on/off toggle switch. In the below Graphic 9 I've identified the location of the cooling pack pump battery in the rear lower left open compartment. You can also see the battery power cable routed to the pump inside through the rear wall of the cooling pack reservoir. The pump on/off toggle switch cannot be clearly seen, however, it is in line with the battery cable.

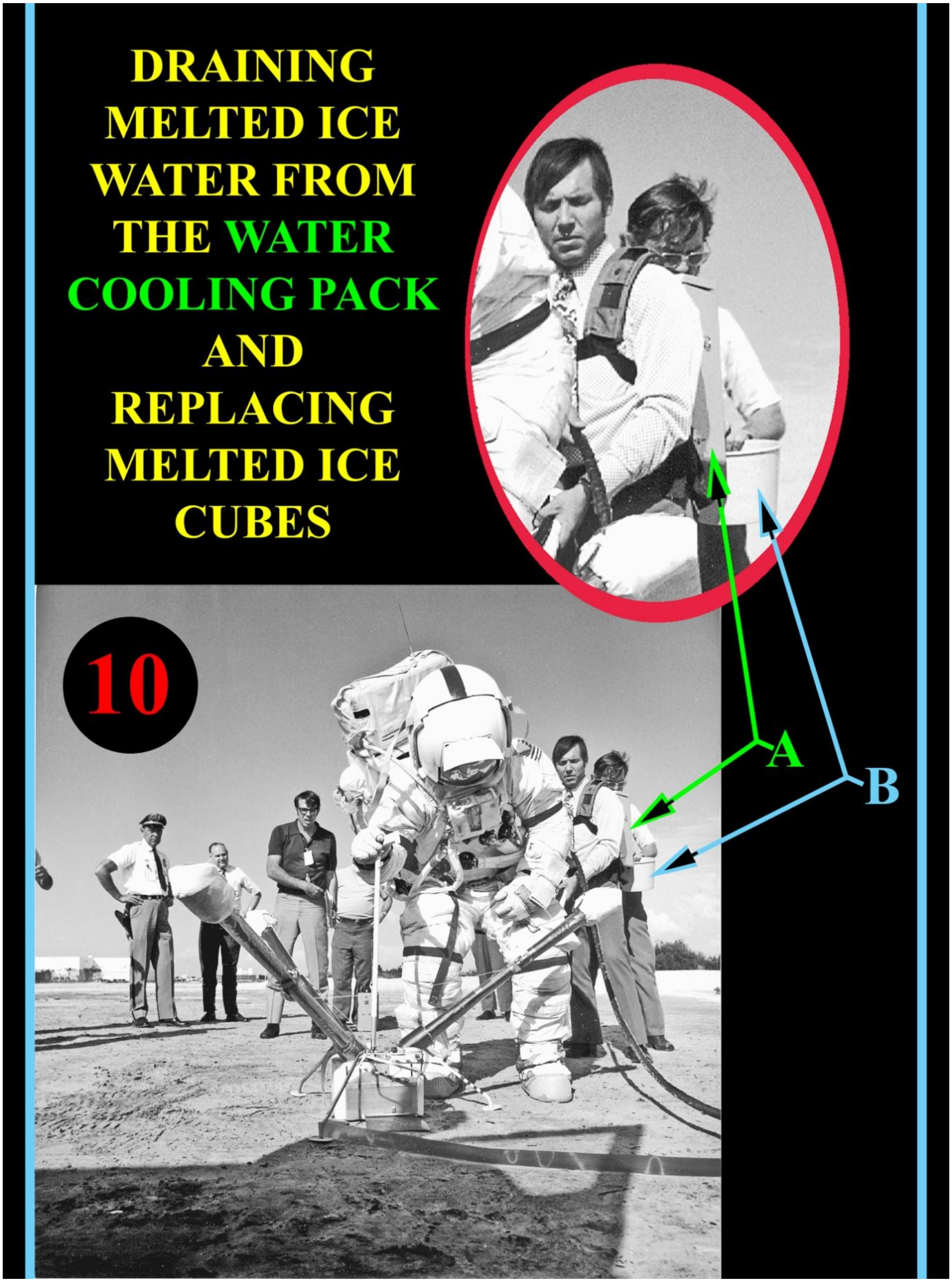


The "water cooling pack" was a solution to the uncomfortable high temperatures that the astronauts experienced during Apollo 11, 12, 13, 14 and 15 EVA training.

Granted, it was a "makeshift" solution, but the bottom line is that it worked, i.e. it keep the crewman cool by circulating cooled water through the crewman's Liquid Cooled Garment (LCG) rather than the non-existent cooling capability of the cryopack.

Referring to Graphic 10 below, the water cooling pack had to monitored and "serviced" during the EVA run, runs that sometimes lasted more than four hours. In Graphic 10, a tech is draining melted ice water from the cooling pack (A) into the bucket (B) without interrupting the training exercise. The water was then emptied to one-third pack volume level. The tech spilled the water out of the bucket and filled the bucket with ice cubes from one of the two ice chests waiting nearby. The ice was then added to the pack reservoir.

Draining cooling pack water and adding ice cubes continued for the duration of the training run. The number of times necessary to "service" the cooling pack was, of course, determined by both the ambient temperature and the crewman's metabolic work load.



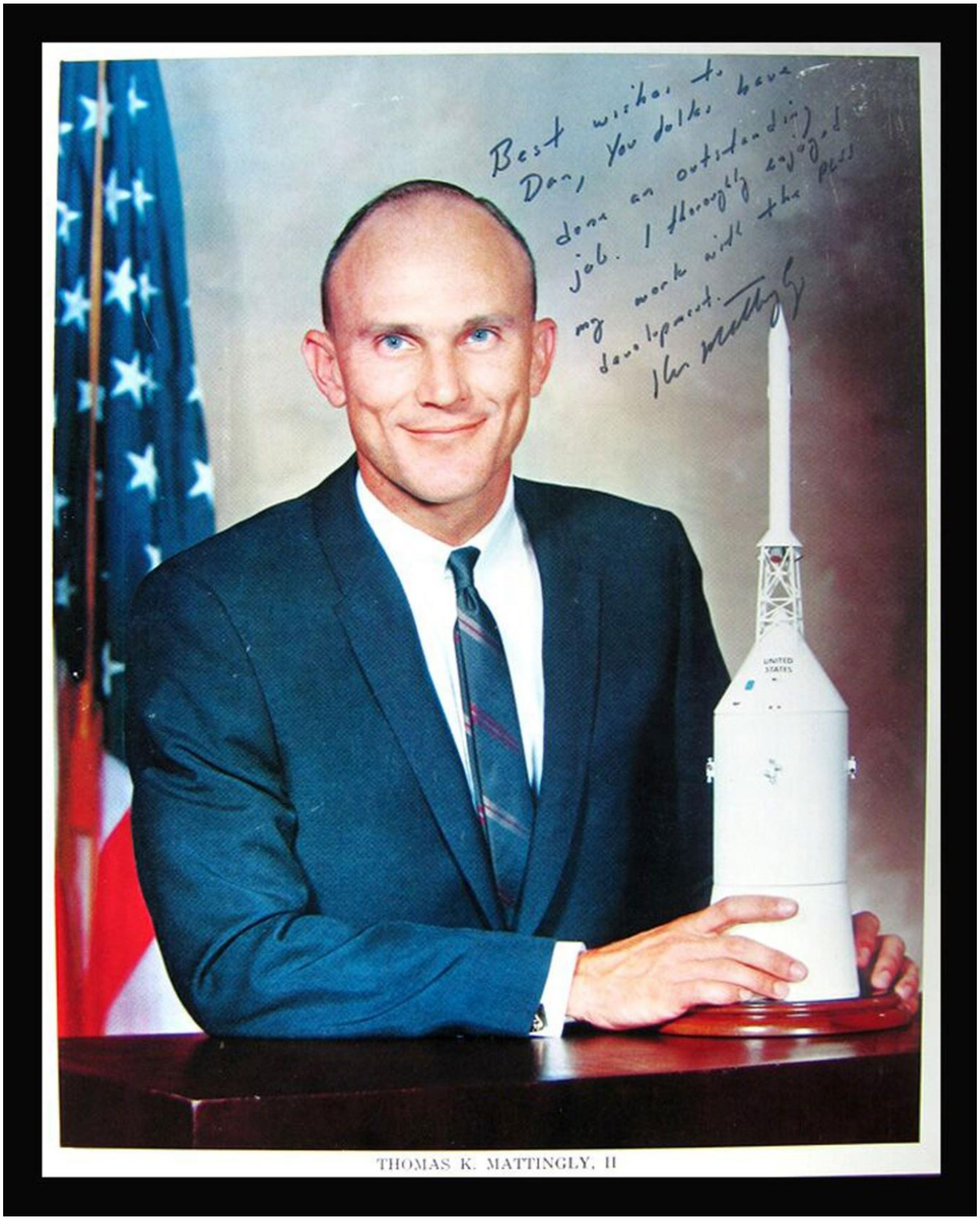
I bet you thought we were finally able to "deep six" the cryopacks. No such luck! As logic would have it, EVA training for Apollo 16 and 17, when the airpacks and water cooling packs were available, could not be used when lunar rover excursions on the simulated lunar surface were necessary, as tethering anything (airpack and/or water pack hose) to the crewman riding on the rover was not an option (Graphic 11 below).

MY WORKING RELATIONSHIP WITH ASTRONAUT KEN MATTINGLY

My contact with Astronaut Ken Mattingly was more extensive from a working relationship than my "brief" working time with Worden as Ken Mattingly was assigned to follow EMU development and implementation. In that role, he was responsible for proposing and evaluating PLSS/OPS and suit modifications. Ken's responsibility included being the liaison between EMU contractors, NASA Crew Systems Division (CSD) and his fellow astronauts.

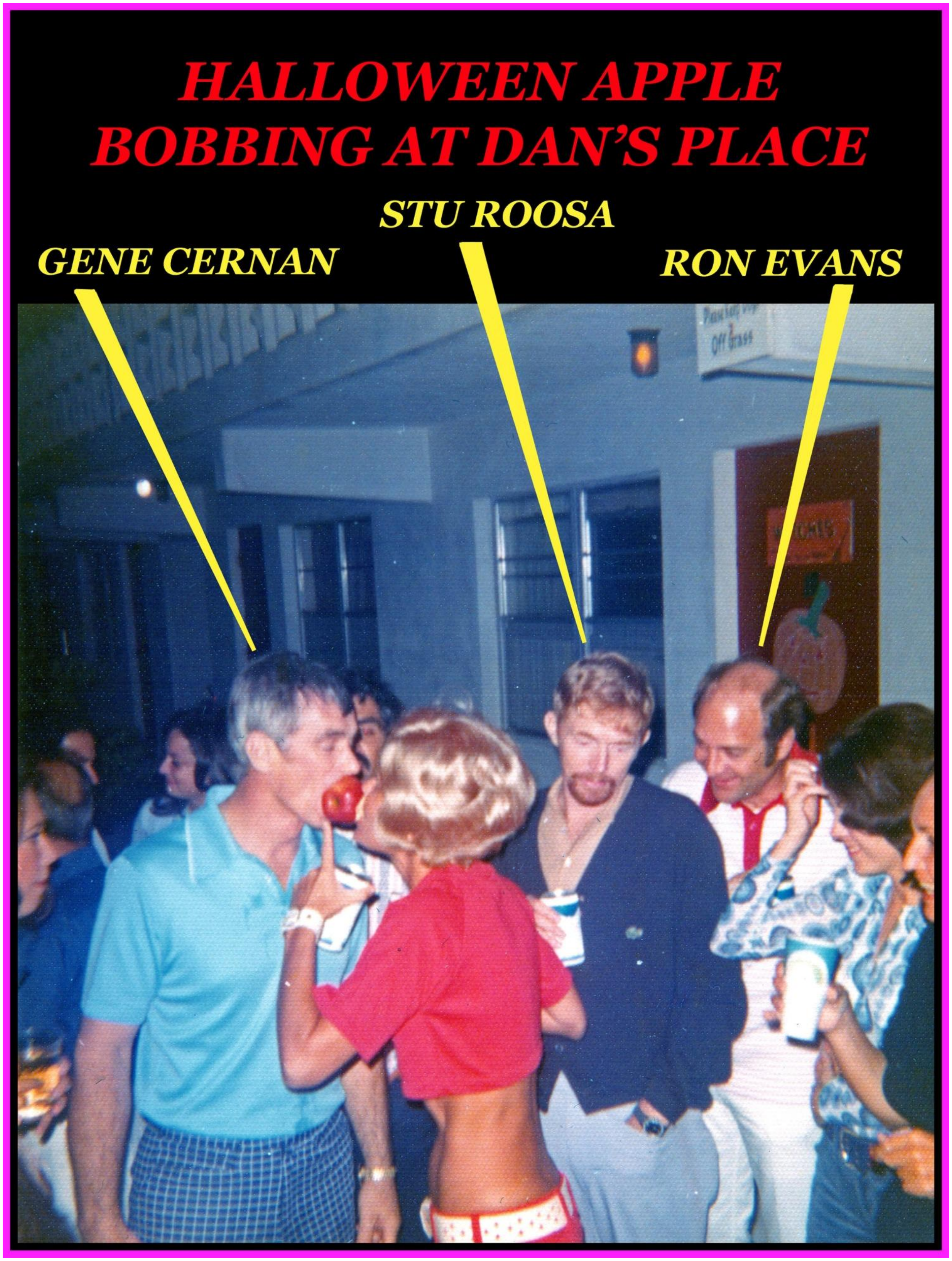
I worked with Ken coordinating his comments and proposed changes related to the PLSS/OPS. Ken was dedicated and a very important and influential voice during PLSS/OPS development.

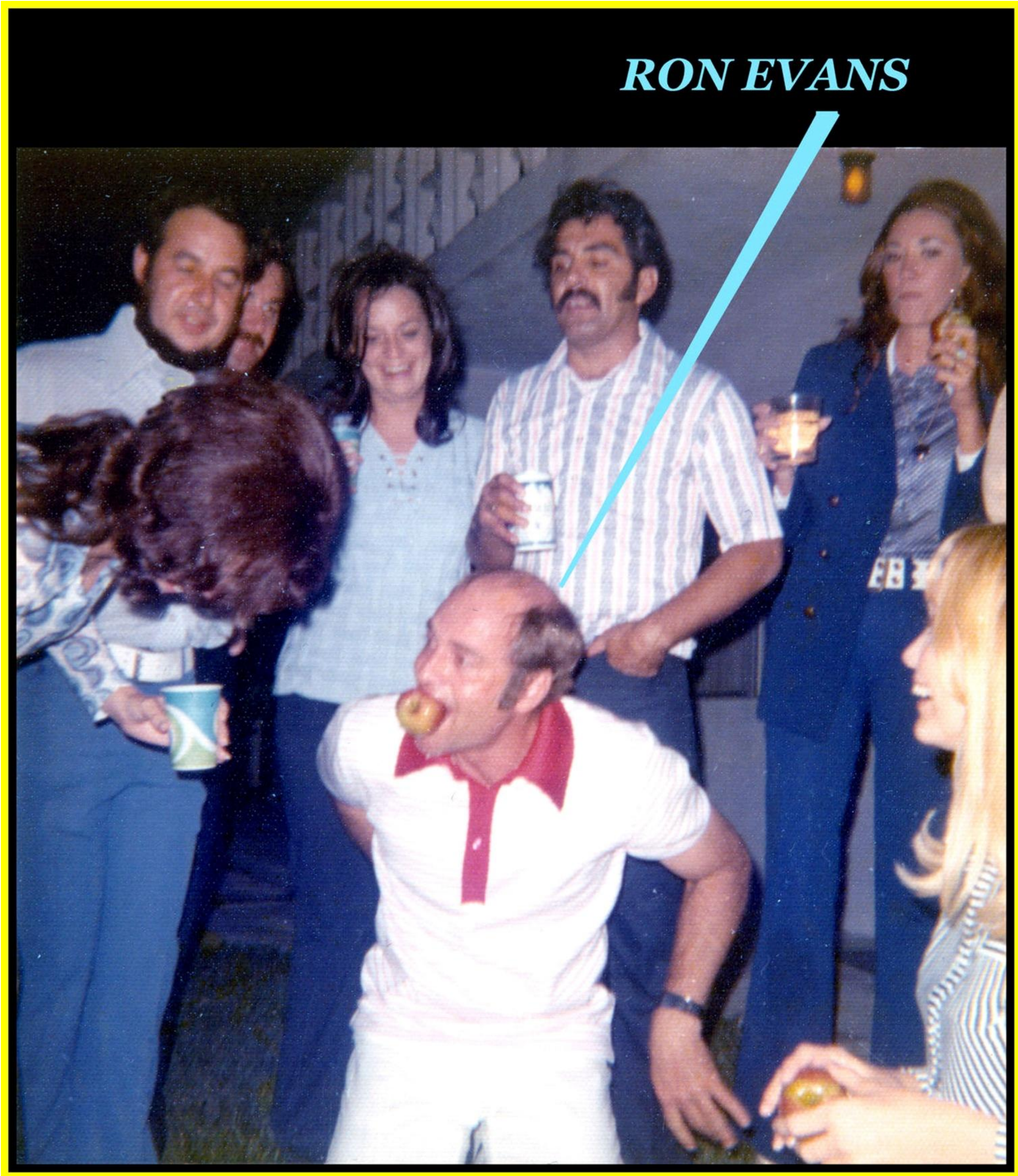
He apparently enjoyed his work with PLSS development as evidenced in his comments to me in the below photo, i.e. "Best wishes to Dan, you folks have done an outstanding job. I thoroughly enjoyed my work with the PLSS development."



MY RELATIONSHIP WITH APOLLO 17 CMP RON EVANS

My contact with astronaut Ron Evans with respect to work with the PLSS/OPS was similarly as brief as that with Al Wordon. However, contact with Ron was quite extensive from a social standpoint as evidenced from the party photos at my apartment. He was a "fun loving guy!"





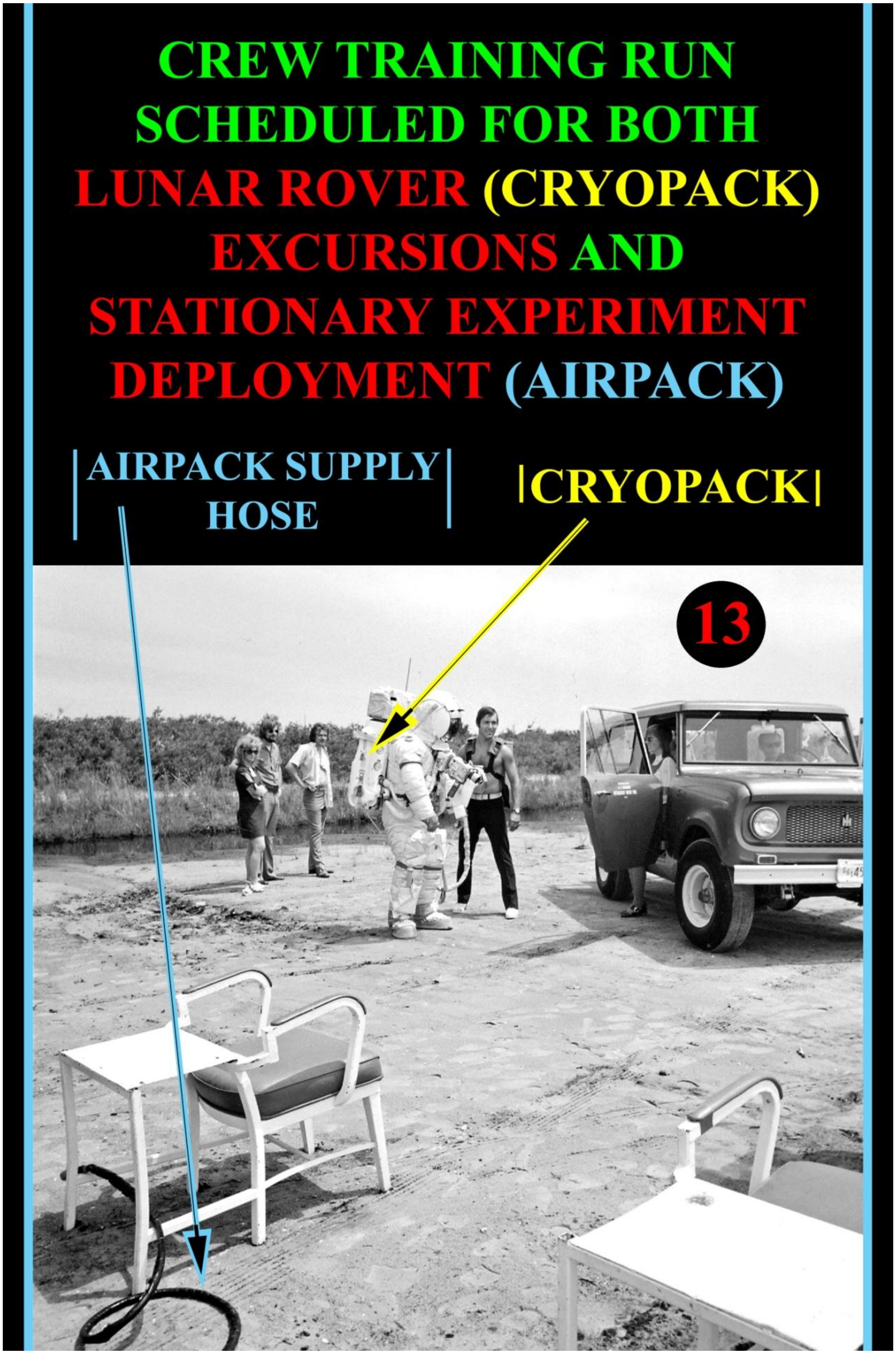
USE OF CRYOPACKS, AIRPACKS AND WATER COOLING PACKS DURING A SINGLE EVA CREW TRAINING EXERCISE

There were a considerable number of Apollo 16 and 17 EVA crew training runs that required the use of cryopacks, airpacks and water cooling packs.

Referring to the below Graphic 13, as can be seen in the photo, the crew training run was scheduled for both lunar rover excursions and stationary experiment deployment and/or rock sampling. In the photo, the suited crewman is wearing a cryopack and is going to walk over to and "board" the lunar rover for un-tethered rover excursions (if and when he stops flirting with the young lady sitting in the passenger seat of the jeep!).

After completing the scheduled rover tasks, the crewman will exit the rover and walk to the cryopack/airpack donning/doffing chair(s). The cryopack will be removed, the crewman will drink Gatorade, he will don the airpack and connect to the airpack supply hose seen in the photo. With the airpack supply hose connected, he will execute the scheduled EVA timeline "stationary" objectives.

I should mention that, on a very hot day as it was on the day the below photo was taken, I connected the water cooling pack to the crewman during his walk and standup tasks around the rover before boarding the rover.



SAMPLE CREW TRAINING EVA "MENU" AND MAP OF AN EVA TRAINING EXERCISE ON THE KSC SIMULATED LUNAR SURFACE

Graphic 14 below includes a description of an Apollo 16 EVA training exercise and a map of the simulated KSC lunar surface.

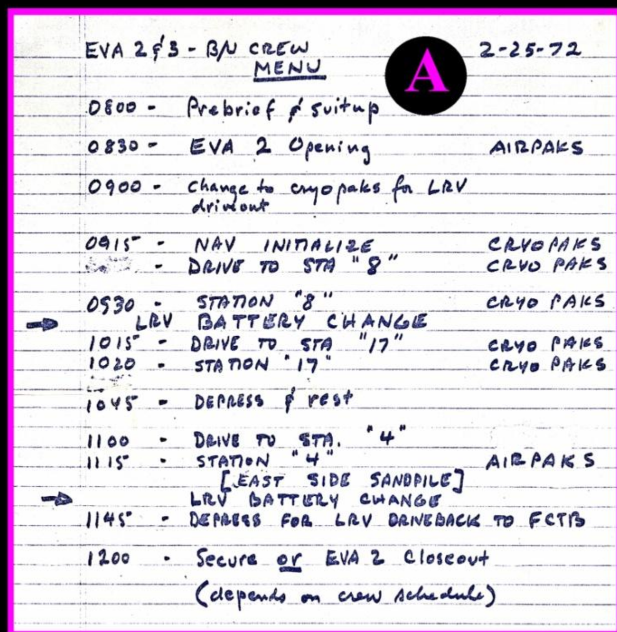
A day before each EVA training exercise, I was given both a "menu" (A) defining for me what equipment we would have to prepare to support the exercise. Along with the "menu", a map (B) was included if the exercise involved mobility utilizing the lunar rover.

Referencing menu (A), at 08:00 we attended a pre-brief meeting and then crew suit up. At 08:30, an EVA 2 exercise was initiated inside the crew training building utilizing airpacks. At 09:00 airpacks were removed and cryopacks were donned for a lunar rover (LRV) drive from the crew training building to Station 8 identified on Map (B). Next was an LRV drive to Station 17 (Map B). Next was an LRV drive to Station 4. Each time the crew arrived at a station, water cooling packs were connected while the crewman practiced defined stationary station procedures.

As you can see in Menu (A), training time was 3.5 hrs. The last item on the menu, i.e. "Secure or EVA 2 Closeout" was dependent on the crew schedule that day. What it usually meant was whether or not the crewmen were "up for" changing back to airpacks and going through the EVA 2 closeout procedures which added another 1.5 hours!

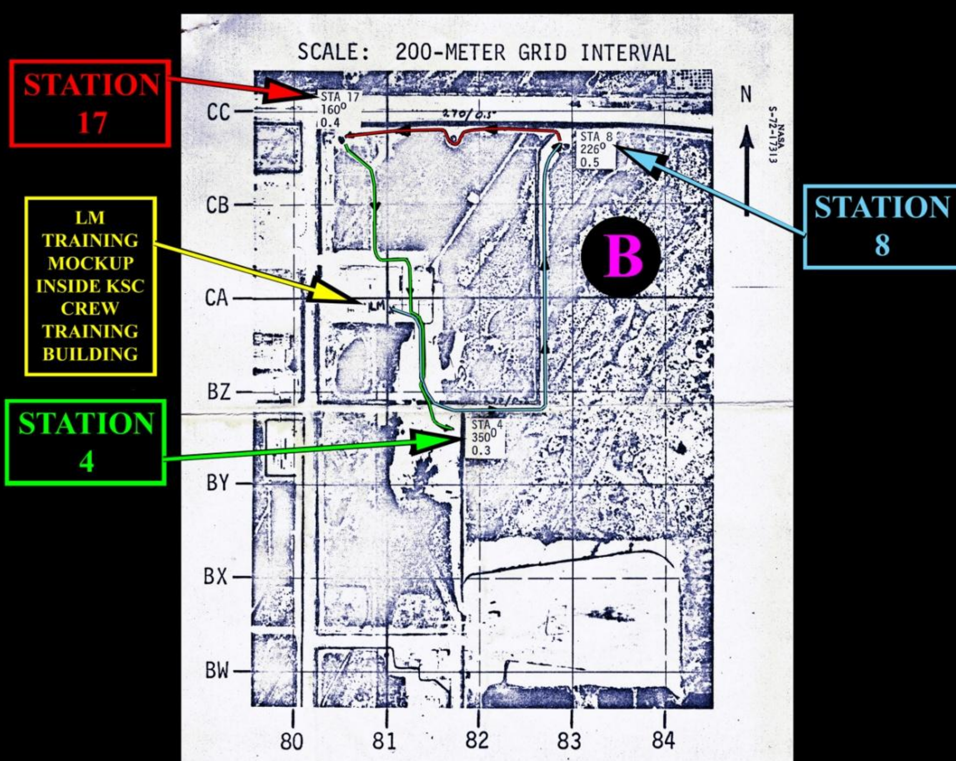
EXAMPLE OF AN EVA TRAINING RUN "MENU" INVOLVING BOTH CRYOPACKS AND AIRPACKS.

14


A

EVA 2 & 3 - B/U CREW — 2-25-72
MENU

0800 - Prebrief & suitup
0830 - EVA 2 Opening — AIRPAKS
0900 - Change to cryopaks for LRV driveout
0915 - NAV INITIALIZE — CRYOPAKS
- DRIVE TO STA "8" — CRYO PAKS
0930 - STATION "8" — CRYO PAKS
LRV BATTERY CHANGE
1015 - DRIVE TO STA "17" — CRYO PAKS
1020 - STATION "17" — CRYO PAKS
1045 - DEPRESS & REST
1100 - DRIVE TO STA. "4"
1115 - STATION "4" — AIRPAKS
[EAST SIDE SANDPILE]
LRV BATTERY CHANGE
1145 - DEPRESS FOR LRV DRIVEBACK TO FCTB
1200 - Secure or EVA 2 Closeout
(depends on crew schedule)

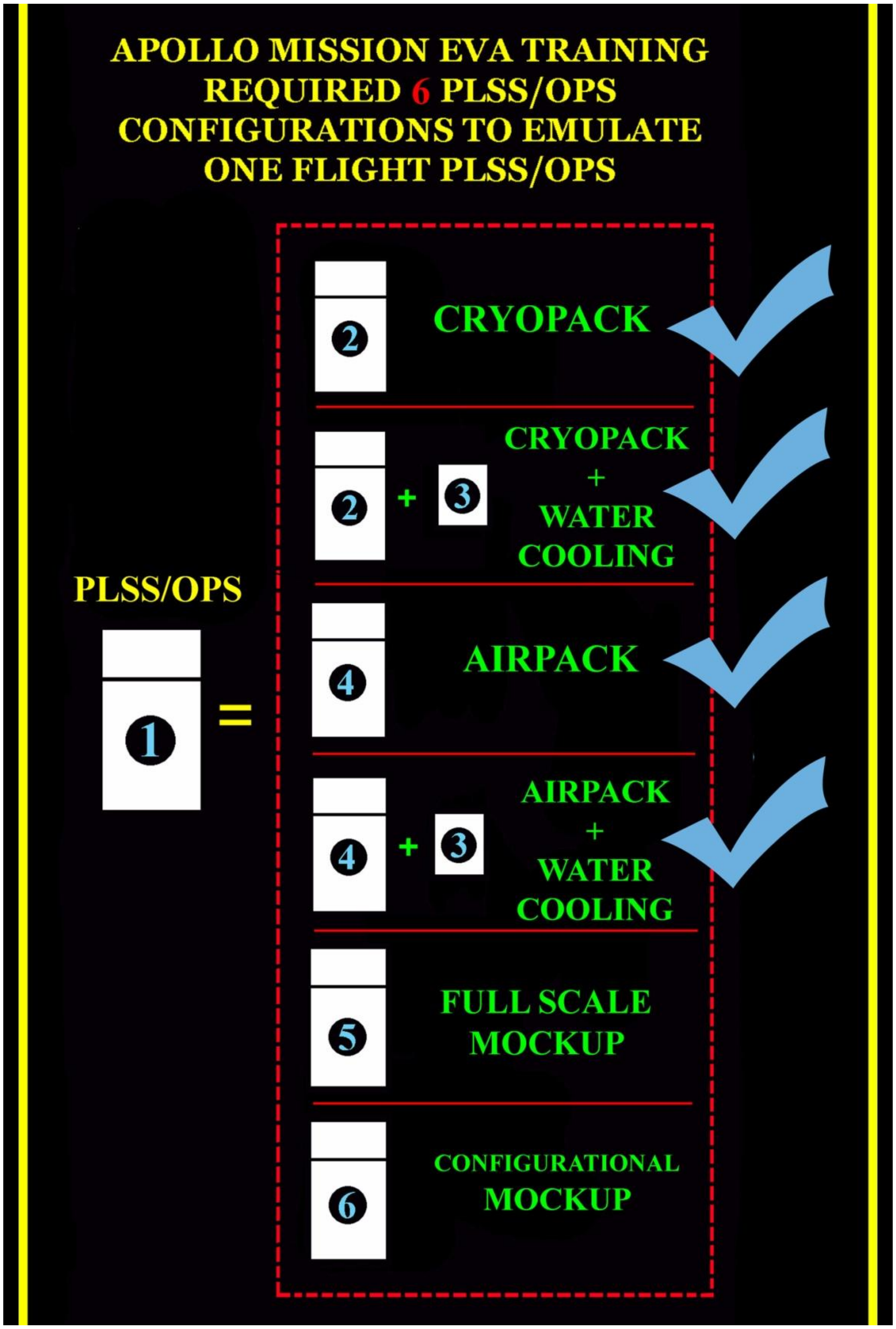


PLSS/OPS TRAINING HARDWARE CHART REVIEW

I've been discussing the different PLSS/OPS hardware configurations that were necessary to emulate the only "ONE" flight configuration PLSS/OPS necessary to support Apollo KSC EVA Crew Training.

The below graphic blue check marks represent hardware training configurations and combinations that I've discussed in previously, i.e. Cryopack, Cryopack + Water Cooling Pack, Airpack and the Airpack + Water Cooling Pack. When discussing the aforementioned configurations, I tried to give you enough detail to understand the story and rationale behind the need for these multiple training Life Support hardware.

I will later discuss the need and use of PLSS/OPS Full Scale Mockups and Configurational Mockups.



LM EVA PRE AND POST PROCEDURES PERFORMED INSIDE THE CREW TRAINING BUILDING AND HARDWARE USED TO IMPLEMENT THE PROCEDURES

The previously discussed cryopacks, airpacks and water cooling packs were all used for astronaut life support during lunar surface EVA training. They provided the suited crewman with breathable air, suit pressurization and eventually water cooling.

Not only did the Apollo CDR and LMP spend a great deal of training preparing for Lunar surface activities, they spent many hours training for donning (EVA Pre) and doffing (EVA Post) their EMU (Suit and PLSS/OPS) preparing for LM exit and LM return.

The procedures for LM EVA Pre and Post necessitated the use of full scale PLSS, OPS and remote control units (RCU) as these procedures specifically related to preparing the PLSS, OPS and RCU for donning and doffing.

The specific procedures were documented on EVA pre and post "cue cards" that were secured by a clip in a fixed visible vertical position in the LM so that the crewmen could read each procedural step as they worked their way through the procedures.

In the below Graphics A, B and C, I related examples of cue card written procedures to actual pictorial representations of crewman performing the procedures. When the crewman went through the EVA pre and post procedure, the objective was "practicing to learn."

I had the incredible opportunity to perform the same pre and post procedures with the following objectives:

- Verify written procedural steps successfully accomplished objectives.
- Determine if procedural steps should or could be modified from a "human factors" standpoint.
- Evaluate requested crew procedural changes and possible hardware modifications for evaluation.

One of my responsibilities at KSC was to make sure the crew training PLSS, OPS and RCU mockups were identical to the flight hardware. This involved keeping track of all changes made to the flight PLSS, OPS and RCU and updating the mockups when necessary.

Each time a change was made to the flight hardware that involved astronaut PLSS, OPS or RCU procedures, inspection, component change briefings, etc., I was responsible for implementing the change to the mockups keeping in mind that the astronauts use of the flight hardware was based on their training with the mockups.

Imagine, for instance, if a configuration change was made to the flight hardware and was not implemented in the mockups and subsequently not recognized by the crew on the moon, there might have been disastrous consequences.

CDR DON BOOTS

ATTACH OPS TO PLSS

7/14/71

EVA 1 PREP

EQUIPMENT PREP EVA 1

Stow PGA Gas Conn Plugs In Pu
Empty PGA Pockets Into Purse
PGA Relief Valve Cap In Pkt
Verify Watch On PGA

CDR Move To Aft Cabin A

Unstow CDR Boots, Purge Valve To Purse
CDR Don Boots
Unstow CDR OPS

Remove Pallet, Stow On Cabin Fan
Perform OPS Check
Restow OPS

LMP Move To Aft Cabin Area

Unstow LMP Boots, Purge Valve To Purse
Stow IV Gloves In Bot Boot Comp
LMP Don Boots

Unstow LMP OPS
Remove Pallet, Stow On Cabin Fan
Perform OPS Check

Stow LMP OPS & Ancillary Container On Eng Cover
Stow CSRC (Aft OPS) In LMP's PGA Pkt
Install ISS
Stow Pallets In Jett Bag

Apply Antifog (Purse), Wipe Dry With Tissue (LHSSC)
Stow EMU Maintenance Kit In Purse
Stow LEVA's & Helmets On ISS
Stow Helmet Bag

Move CDR's OPS Forward On Eng Cover
Stow ETB On Aft Eng Cover
Tie Jett Bag, Stow On Aft Engine Cover

Fwd Hatch Handle - UNLOCK

PLSS DONNING

* * * * LMP 1st: * * * *
Set PLSS On Mid-Step
Verify OPS Reg Decay
Unstow O2 Nozzle & Antenna Lead
Secure Flaps

Attach OPS To PLSS
Connect OPS Antenna Lead To PLSS
Verify Sublimator Exhausts Clear
Install PLSS Tool Harness

Unstow PLSS Straps & Hoses
Remove Elect Dust Cap, Stow In Purse
Verify AUX H2O, DIVERTER, O2, & PRIM H2O-OFF
Connect Battery Cable

Verify The Following Locked:
- PLSS Battery Connection
- OPS Antenna Lead To PLSS
- OPS To PLSS

Don PLSS/OPS, Lift PLSS Hoses Above Lower Straps

Connect PLSS O2 Hoses To PGA
Verify AUX H2O, DIVERTER, O2, & PRIM H2O-OFF

Connect RCU To PGA & Upper Straps
Verify RCU Controls:
- PUMP, FAN - OFF (Left) MODE SEL-O
Connect RCU To PLSS

Unstow OPS O2 Hose & Actuator, Route Hose Behind PGA
Connect Actuator To RCU

CDR Repeat PLSS DONNING * *

PLSS COMM CHECK

HOU & CDR

Verify Powerdown CB Configuration (White Dots Out)
COMM: MODULATE - FM
PWR AMP - PRIM
Verify Voice Comm With Hou

Audio (LMP)
- S-BAND - T/R
- ICS - T/R
- RELAY - ON
- MODE - VOX
- VOX SENS MAX
- VHF A - T/R
- B - RCV

HOU & LMP

COMM:
- VHF A XMTR - VOICE
- A RCVR - ON
- B XMTR - OFF
- B RCVR - ON
- TLM BIOMED - OFF
- SQUELCH VHF A&B - Noise Thres + 1 1/2
- DER - ON

VHF An - EVA
UPLINK SQU ENABLE

CDR

Audio (CDR)
- S-BAND - T/R
- ICS - T/R
- RELAY - OFF
- MODE - VOX
- VOX SENS MAX
- VHF A - T/R
- B - RCV

CB(16) COMM: SE AU - Open
LMP Connect To PL Comm

HOU

A

CONNECT RCU TO PGA & UPPER STRAPS

CONNECT BATTERY CABLE

UNSTOW PLSS ANTENNA

DON HELMETS WITH LEVA'S

```
CB(16) COMM: SE AUDIO - Close
PLSS PTT (LMP) - MAIN (Rt), Verify
PLSS Mode(LMP) - A, Wheel-CCW
  (Tone-On, Vent Flag - P,
  Press Flag - 0, O2 Mom)
PLSS O2 Press Gage > 85%
LMP Comm Check With CDR And Hou

NOTE: Unstow PLSS Antenna If It
  Transmits Garbled And/Or Loses TM

CB(11) COMM:  CDR AUDIO - Open
CDR Connect To PLSS Comm

CB(11) COMM:  CDR AUDIO - Close
Audio (CDR)
  VHF A - OFF
  VHF B - OFF

PLSS PTT (CDR) - MAIN (Rt), Verify
PLSS Mode(CDR) - B, Blade-CCW
  (Tone-On, Vent Flag - P,
  Press Flag - 0, O2 Mom)
PLSS O2 Press Gage > 85%

NOTE: Crewman In Mode B Cannot
  Hear Hou

LMP Comm Check With CDR And Hou

PLSS Mode(LMP)-B, Blade-CCW(Tone-On)
PLSS Mode(CDR)-A, Wheel-CCW(Tone-On)
CDR Comm Check With LMP And Hou

PLSS Mode (Both) - AR (Tone-On)

NOTE: (AR) Wheel-Hou, Blade-EVA

Perform Comm & TM Check With Hou &
  Comm Check With Each Other
Read PLSS O2 Qty to Hou

NOTE: If Comm Is NO GO With Hou,
  S-BAND MOD - PM
  Verify Comm & TM

FINAL SYSTEMS PREP

CB(16) ECS: LCG PUMP - Close
LCG - Cold, As Reqd
CB(16) ECS: CABIN REPRESS - Close (Ver)
  SUIT FAN ΔP - Open
  SUIT FAN 2 - Open
SUIT FAN Sel - 2
Verify ECS Caution & H2O SEP COMP
  Lts - On (~ 1 Min)

SUIT GAS DIVERTER - PULL-EGRESS(Verify)
CABIN GAS RETURN - EGRESS (Verify)
SUIT CIRCUIT RELIEF - AUTO (Verify)

OPS CONNECT

# # # # LMP 1st: # # # #
SUIT ISOL - SUIT DISC
Discon LM O2 Hoses, Secure About PGA

Connect OPS O2 Hose To PGA B/B
Retrieve Purge Valve (Purse)-
  Verify Closed, Lock Pin In & LO
Install Purge Valve In PGA R/R
PGA Diverter Valve - Vertical

CDR Repeat OPS CONNECT # # # #

Drink
DES H2O VLV - CLOSE

HELMET/GLOVE DONNING

Position Mikes (Both)
PLSS FAN - ON, Rt (Vent Flag - Clear)
Don Helmets With LEVA's  Check Drink
  Bag Position
Secure Tool Harness Self Doff Straps
  To LEVA's

LCG-Cold, As Reqd
CB(16) ECS: LCG PUMP - Open
Disconnect LM H2O Hose
Connect PLSS H2O Hose
Stow LM Hoses (CDR's To ECS Handhold)

Verify The Following:
  Helmet & Visor  (1) - Aligned &
                        Adjusted
  O2 Connectors   (3) - Locked
  Purge Valves    (1) - Locked
  H2O Connectors  (1) - Locked
  Comm Connectors (1) - Locked
  PGA Diverter Vlv(1) - Vertical

Verify EVA CB Configuration
  (White Dots Out + EVA Decals)
```

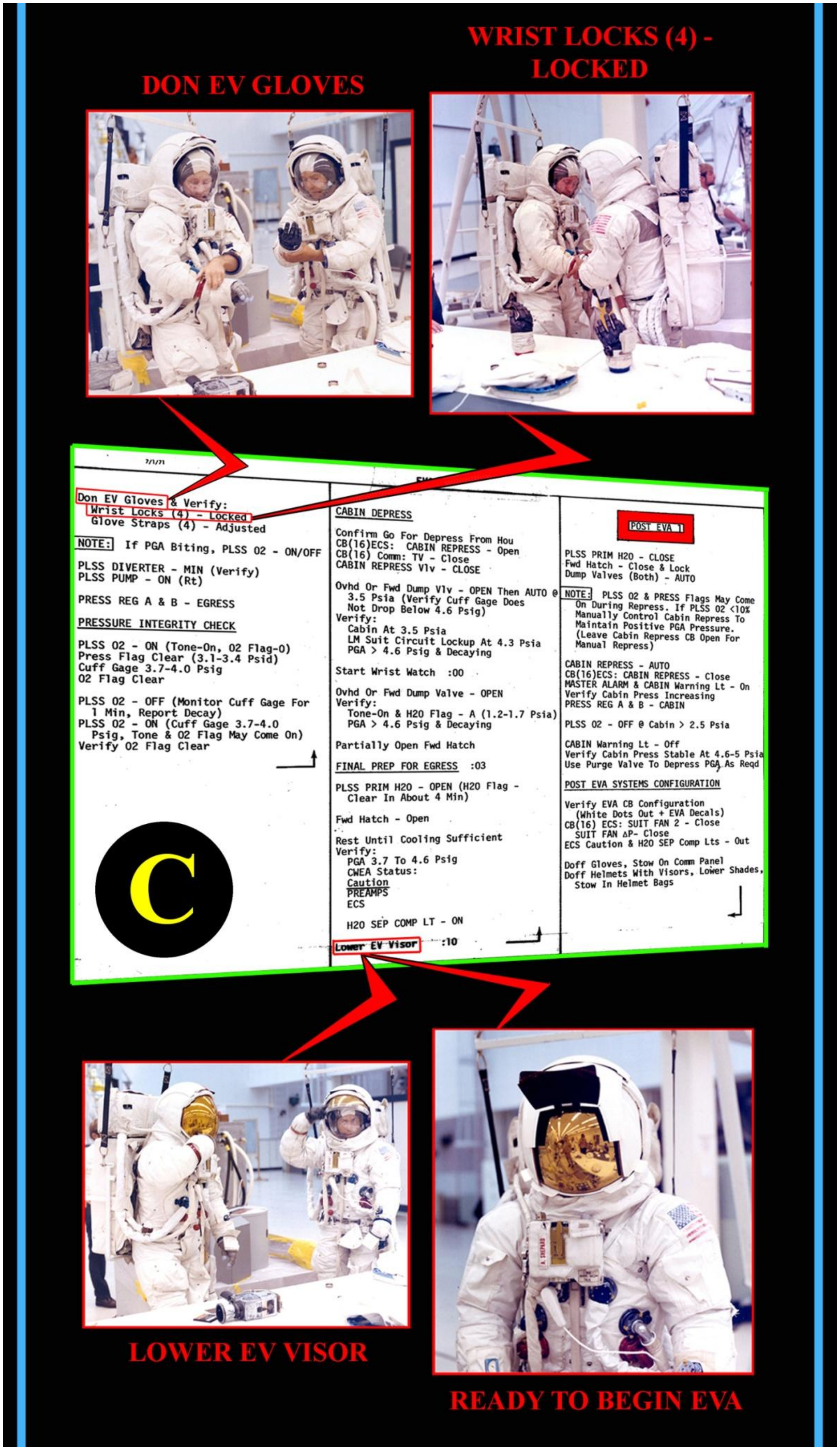
7/1/71

EVA 1

B

INSTALL PURGE VALVE

CONNECT O2 HOSE TO PGA



7/1/71

Don EV Gloves & Verify:
  Wrist Locks (4) - Locked
  Glove Straps (4) - Adjusted

NOTE: If PGA Biting, PLSS O2 - ON/OFF

PLSS DIVERTER - MIN (Verify)
PLSS PUMP - ON (Rt)

PRESS REG A & B - EGRESS

PRESSURE INTEGRITY CHECK

PLSS O2 - ON (Tone-On, O2 Flag-O)
Press Flag Clear (3.1-3.4 Psid)
Cuff Gage 3.7-4.0 Psig
O2 Flag Clear

PLSS O2 - OFF (Monitor Cuff Gage For 1 Min, Report Decay)
PLSS O2 - ON (Cuff Gage 3.7-4.0 Psig, Tone & O2 Flag May Come On)
Verify O2 Flag Clear

CABIN DEPRESS

Confirm Go For Depress From Hou
CB(16)ECS: CABIN REPRESS - Open
CB(16) Comm: TV - Close
CABIN REPRESS Vlv - CLOSE

Ovhd Or Fwd Dump Vlv - OPEN Then AUTO @ 3.5 Psia (Verify Cuff Gage Does Not Drop Below 4.6 Psig)
Verify:
  Cabin At 3.5 Psia
  LM Suit Circuit Lockup At 4.3 Psia
  PGA > 4.6 Psig & Decaying

Start Wrist Watch :00

Ovhd Or Fwd Dump Valve - OPEN
Verify:
  Tone-On & H2O Flag - A (1.2-1.7 Psia)
  PGA > 4.6 Psig & Decaying

Partially Open Fwd Hatch

FINAL PREP FOR EGRESS :03

PLSS PRIM H2O - OPEN (H2O Flag - Clear In About 4 Min)

Fwd Hatch - Open

Rest Until Cooling Sufficient
Verify:
  PGA 3.7 To 4.6 Psig
  CWEA Status:
  Caution
  PREAMPS
  ECS

  H2O SEP COMP LT - ON

Lower EV Visor :10

POST EVA 1

PLSS PRIM H2O - CLOSE
Fwd Hatch - Close & Lock
Dump Valves (Both) - AUTO

NOTE: PLSS O2 & PRESS Flags May Come On During Repress. If PLSS O2 <10% Manually Control Cabin Repress To Maintain Positive PGA Pressure. (Leave Cabin Repress CB Open For Manual Repress)

CABIN REPRESS - AUTO
CB(16)ECS: CABIN REPRESS - Close
MASTER ALARM & CABIN Warning Lt - On
Verify Cabin Press Increasing
PRESS REG A & B - CABIN

PLSS O2 - OFF @ Cabin > 2.5 Psia

CABIN Warning Lt - Off
Verify Cabin Press Stable At 4.6-5 Psia
Use Purge Valve To Depress PGA As Reqd

POST EVA SYSTEMS CONFIGURATION

Verify EVA CB Configuration (White Dots Out + EVA Decals)
CB(16) ECS: SUIT FAN 2 - Close
  SUIT FAN ΔP- Close
ECS Caution & H2O SEP Comp Lts - Out

Doff Gloves, Stow On Comm Panel
Doff Helmets With Visors, Lower Shades, Stow In Helmet Bags

HOW PLSS/OPS FLIGHT HARDWARE CHANGES WERE ADDED TO PLSS/OPS MOCKUPS

There were no formal procedures to communicate changes to me. We were dealing with a fully documented, regulated flight hardware program and a NON-documented NON-regulated training program with respect to Full Scale Mockups, Cryopacks, Airpacks, Water Cooling Packs and other training support hardware.

It was, in fact, my responsibility to know what modifications were made to the flight hardware and make sure those modifications were incorporated into the training mockups. Keep in mind that I worked with the flight PLSS/OPS/RCU on a daily basis so I attended meetings that involved flight hardware changes and procedures. All memos both internally at KSC and from our Hamilton Standard home office in Windsor Locks, Conn. were either directed to me or cc'd to me so it was a matter of being "diligently dedicated" while accomplishing my responsibility.

I'll present to you a few examples pertaining to maintaining identical flight and mockup configurations.

Graphic (A) below represents a page in one of my Apollo 11 notebooks. The pink highlighted section reads as follows:

Went through Apollo 11 EVA procedures using crew training mockups to determine the acceptability of the mockups for crew training usage. Found the following differences between the mockups and flight hardware.

a. *The mockup has a CO2 sensor and associated new upper conformal pad.*

b. *Mockup does not have gas separator*

c. *Mockup does not have relocated stowage plate.*

d. *J5 dust caps missing.*

e. *Jim lovell's upper left harness has snap on wrong side.*

f. *RCU dust covers missing.*

g. *Battery locking device different from flight hardware.*

Graphic (B) below represents a page from one of my Apollo 12 notebooks. The pink highlighted section reads as follows:

3. *I inspected and went through a functional check list of the mockup hardware to prepare for stowage in the LM mockup.*

4. *Made up a list of differences between mockup and flight hardware and malfunctions found during functional check of mockups.*

With respect to making sure Flight and Mockup hardware configurations were continually updated, I wrote "formal" QUICK LOOK REPORTS, Reference Graphic (C-1) and (C-2) below. As LM-5 PLSS/OPS Mission Manager, I wrote the below report titled: LM-5 Pre EVA Crew Training Procedure. This specific report related to a procedure on June 12, 1969.

Reference Report Page (2) below. It reads as follows: *On June 12, 1969, HSD/KSC supported a Pre EVA Crew Training procedure. The following mockup hardware was utilized:*

a. *Two PLSS hi-fi mockups*

b. *Two OPS mockups*

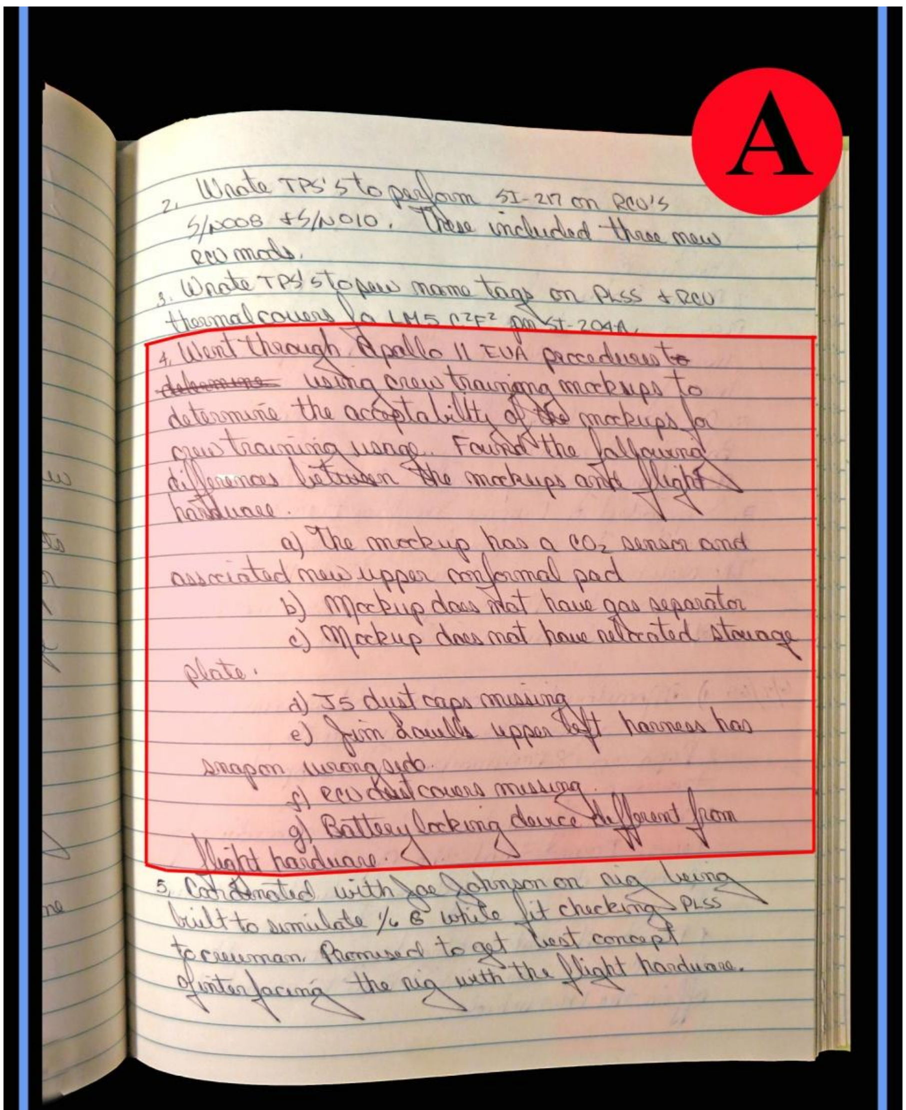
c. *Two RCU mockups*

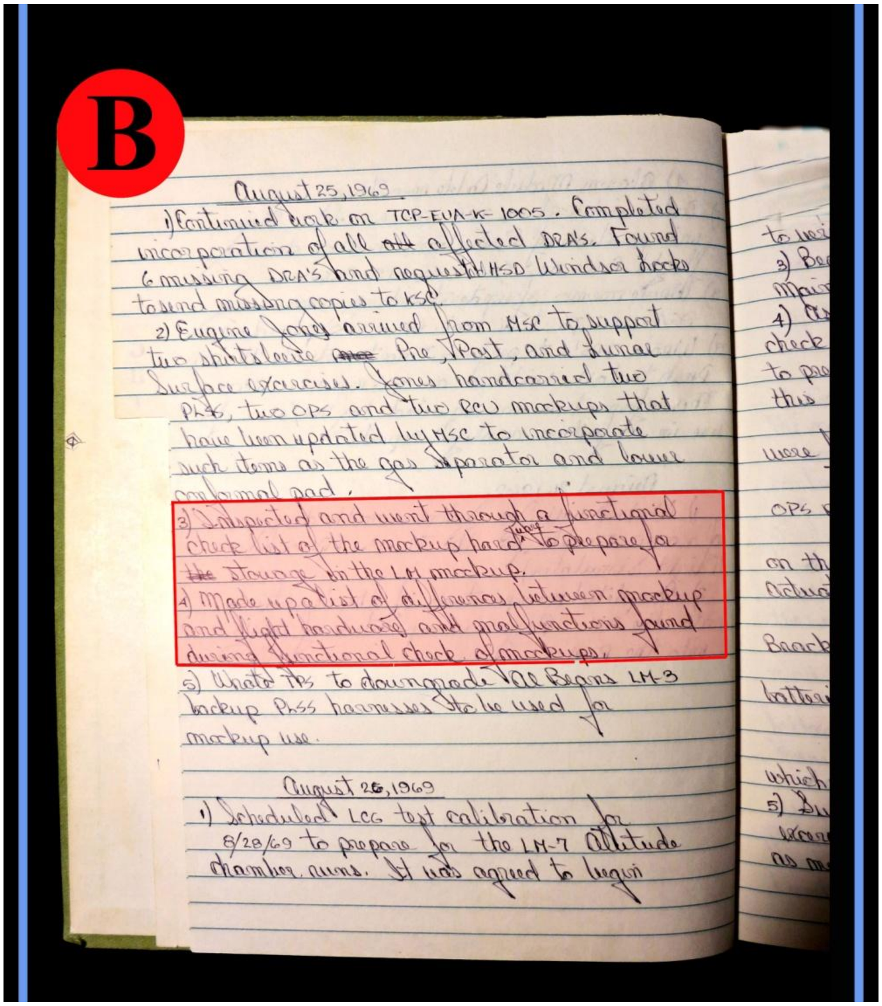
d. *Two PLSS light weight mockups*

Apollo 11 backup astronauts Fred Haise and James Lovell successfully performed the pre EVA procedures which involved unstowing, checking out and donning the EMU hardware in the lunar module cabin. The astronauts were pleased with the condition and operation of the PLSS, OPS and RCU mockups.

The astronauts were made aware of the following differences between the mockup and flight hardware:

- a. *The PLSS mockups incorporate a CO2 sensor and associated new upper conformal pad that will not be incorporated for the Apollo 11 flight.*
- b. *The PLSS mockups do not incorporate the recently added gas separator.*
- c. *The PLSS mockups do not have the relocated electrical umbilical stowage plate.*
- d. *The PLSS mockups do not have the new PLSS thermal garment which incorporates a flap to gain access to the gas separator and no longer interfaces with the lower conformal pad.*
- e. *The RCU mockup Camera Mount bracket can slide off the RCU Camera Mount plate if the bracket release lever is held in the dismount position.*
- f. *A new lower conformal pad without protruding snaps and screws will be incorporated on the flight hardware in the very near future.*





B

August 25, 1969

1) Continued work on TCP-EVA-K-1005. Completed incorporation of all ~~all~~ affected DRA's. Found 6 missing DRA's and requested HSD Windsor Locks to send missing copies to KSC.

2) Eugene Jones arrived from MSC to support two shirtsleeve ~~[illegible]~~ Pre, Post, and Lunar Surface exercises. Jones handcarried two PLSS, two OPS and two RCU mockups that have been updated by MSC to incorporate such items as the gas separator and lower conformal pad.

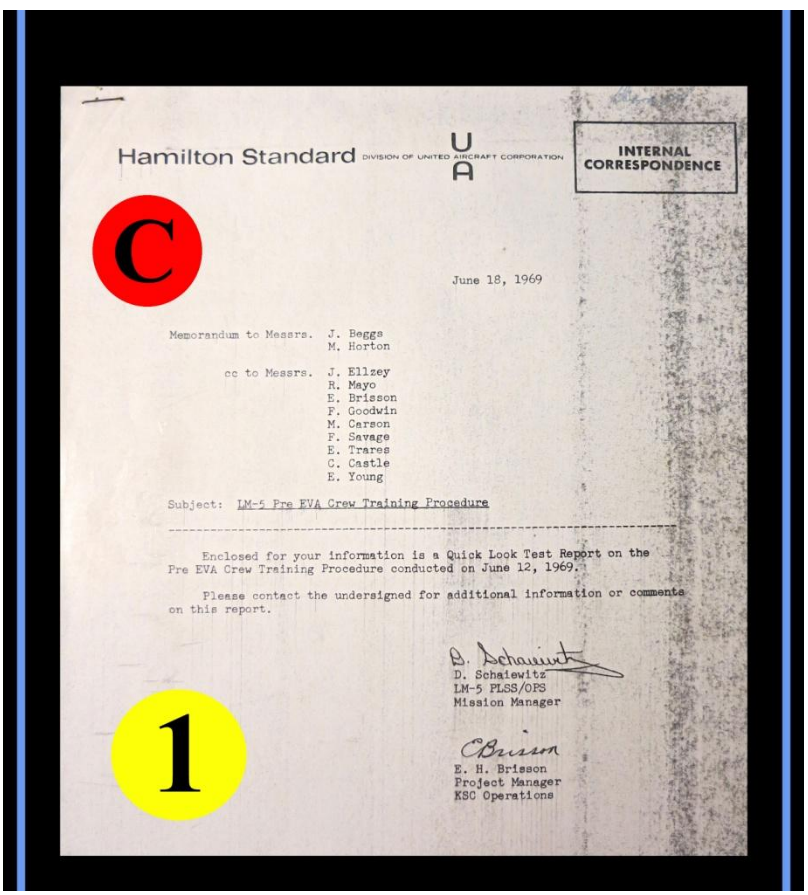
3) Inspected and went through a functional check list of the mockup hardware to prepare for ~~the~~ storage in the LM mockup.

4) Made up a list of differences between mockup and flight hardware and malfunctions found during functional check of mockups.

5) Wrote TPS to downgrade Al Bean's LM-3 backup PLSS harnesses to be used for mockup use.

August 26, 1969

1) Scheduled LCG test calibration for 8/28/69 to prepare for the LM-7 Altitude chamber runs. It was agreed to begin



Hamilton Standard DIVISION OF UNITED AIRCRAFT CORPORATION UA

INTERNAL CORRESPONDENCE

C

June 18, 1969

Memorandum to Messrs. J. Beggs
M. Horton

cc to Messrs. J. Ellzey
R. Mayo
E. Brisson
F. Goodwin
M. Carson
F. Savage
E. Trares
C. Castle
E. Young

Subject: LM-5 Pre EVA Crew Training Procedure

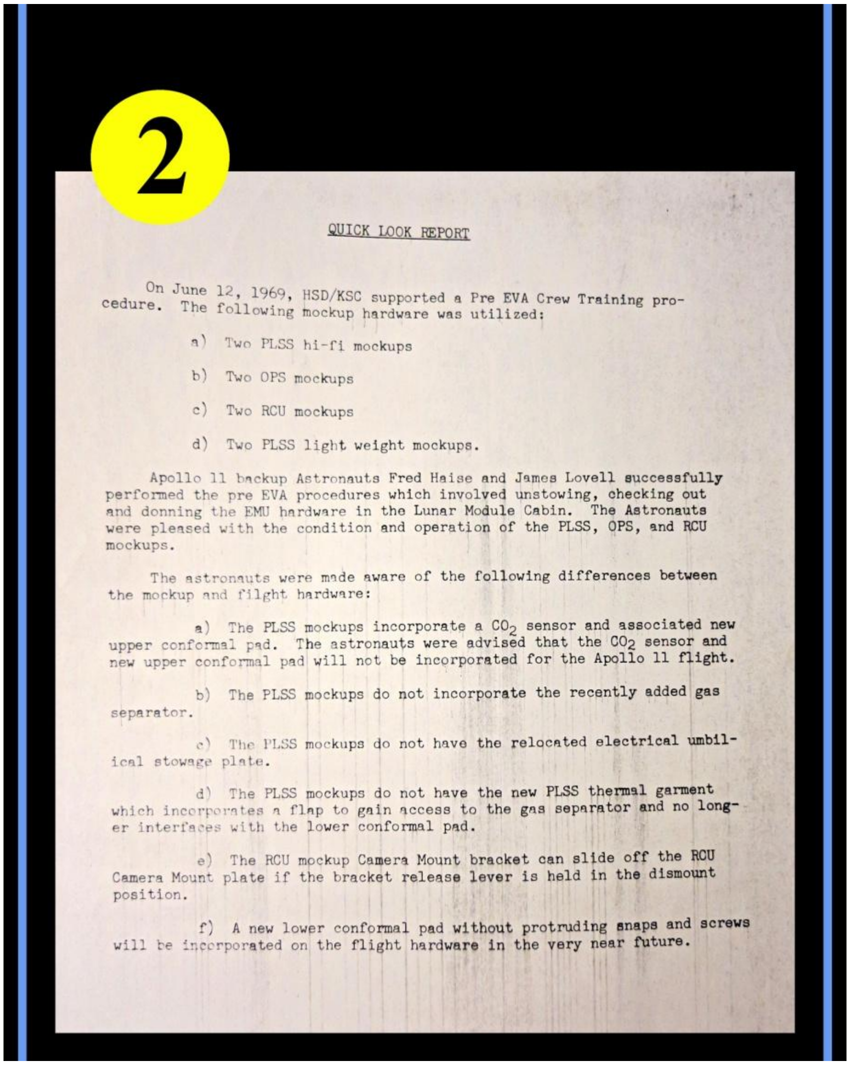
Enclosed for your information is a Quick Look Test Report on the Pre EVA Crew Training Procedure conducted on June 12, 1969.

Please contact the undersigned for additional information or comments on this report.

D. Schaiewitz
D. Schaiewitz
LM-5 PLSS/OPS
Mission Manager

EBrisson
E. H. Brisson
Project Manager
KSC Operations

1



QUICK LOOK REPORT

On June 12, 1969, HSD/KSC supported a Pre EVA Crew Training procedure. The following mockup hardware was utilized:

a) Two PLSS hi-fi mockups

b) Two OPS mockups

c) Two RCU mockups

d) Two PLSS light weight mockups.

Apollo 11 backup Astronauts Fred Haise and James Lovell successfully performed the pre EVA procedures which involved unstowing, checking out and donning the EMU hardware in the Lunar Module Cabin. The Astronauts were pleased with the condition and operation of the PLSS, OPS, and RCU mockups.

The astronauts were made aware of the following differences between the mockup and filght hardware:

a) The PLSS mockups incorporate a CO_2 sensor and associated new upper conformal pad. The astronauts were advised that the CO_2 sensor and new upper conformal pad will not be incorporated for the Apollo 11 flight.

b) The PLSS mockups do not incorporate the recently added gas separator.

c) The PLSS mockups do not have the relocated electrical umbilical stowage plate.

d) The PLSS mockups do not have the new PLSS thermal garment which incorporates a flap to gain access to the gas separator and no longer interfaces with the lower conformal pad.

e) The RCU mockup Camera Mount bracket can slide off the RCU Camera Mount plate if the bracket release lever is held in the dismount position.

f) A new lower conformal pad without protruding snaps and screws will be incorporated on the flight hardware in the very near future.

CONFIGURING THE LM MOCKUP BEFORE SPECIFIC PRE AND POST PROCEDURES

I previously referenced the use of PLSS/OPS full scale mockups in a Quick Look Report memo that I wrote discussing the results of a LM-5 Pre EVA crew training procedure. This procedure was conducted inside the LM mockup.

Before every pre or post-training exercise inside the mockup LM, the LM had to be configured for the specific exercise. This may sound like an easy task, but remember, missions had up to three EVAs and each pre and post procedure required different LM configurations.

The below three pages from a specific EVA-11 pre and post LM mockup configuration document was giving to me one to two days before the exercise. With the document in hand, I and one of my techs drove to the crew training building and along with a suit tech and CSD EVA prep and post test conductor configured the mockup as written in the referenced document.

I'm sure those of you intrigued by the detailed nuances of the Apollo program will appreciate examining the below pages.

LM MOCKUP CONFIGURATION

EVA II PREP AND POST

LM Mockup Configuration

Technician	GFE/CFE/Mockup	Configuration/Location
1. Mockup	SRC (1)	Lower SRC Compt
2. Mockup	16mm Camera	In Brkt over RH window, connected with mag installed
3. Mockup	CDR Utility Light and Brkt	Lower Boot Compt
4. Mockup	LMP Utility Light and Brkt (1)	Haise's special taped configuration
5. Mockup	Dark Slides (2) - Reseau Plate Covers (2)	RHSSC - Lower Hasselblad Compt
6. Mockup	COAS (1)	Fwd Window Mount
7. Mockup	Purse (1)	Installed on Panel 5
8. Mockup	RCU Camera Brkt Bag	ISA top pocket
9. Mockup	Interim Stowage Straps (2)	Snapped around horizontal handhold on ECS Panel
10. Mockup	EVA Antenna	"T" rotated so that "up" faces fwd
11. Mockup	CSRC Bag with Rocks	Top Boot Compt
12. Mockup	CSRC	Not stowed
13. Mockup	70mm Hasselblad Cameras (2) with Handles, Triggers, and RCU Camera Brkts installed	One camera has polarizing filter installed. Both have B&W mags installed and are inside ETB.
14. Mockup	70mm Mag (1) - HCEX	ETB
15. Mockup	Surface Sequence Camera (1)	Mag installed; in ETB
16. Mockup	16mm Mags (2)	ETB
17. Mockup	Lunar Surface Map (1)	ETB
18. Mockup	ETB	In Jettison Bag

* *

Technician	GFE/CFE/Mockup	Configuration/Location
19. Suit/Mockup	Cuff Checklist (CDR and LMP)	On CDR and LMP EV gloves
20. Suit/Mockup	EV Gloves (CDR and LMP)	Over Comm Panels
21. Suit/Mockup	IV Gloves (CDR and LMP)	At CDR's LH and LMP's RH Armrest location
22. Suit/Mockup	Helmet (CDR and LMP)	Helmet Bag
23. Suit/Mockup	LEVA (CDR and LMP)	Helmet Bag
24. Suit/Mockup	Maintenance Kit	CDR's Helmet Bag
25. Suit/Mockup	Helmet Bags (CDR and LMP)	RH Floor

Technician	GFE/CFE/Mockup	Configuration/Location
26. Suit/Mockup	Purge Valves (2)	Purse
27. Suit/Mockup	Lunar Boots (CDR and LMP)	LH Floor

* *

Technician	GFE/CFE/Mockup	Configuration/Location
28. HSD/Mockup	PLSS Bats No. 1 and No. 2	Fwd LHSSC
29. HSD/Mockup	PLSS LiOH Carts No. 1 and No. 2	PLSS Canisters No. 3 and No. 4
30. HSD/Mockup	PLSS Canisters No. 3 and No. 4	Fwd LHSSC
31. HSD/Mockup	PLSS Bats No. 3 and and No. 4	No. 3 - CDR's PLSS No. 4 - LMP's PLSS
32. HSD/Mockup	PLSS LiOH Carts No. 3 and No. 4	No. 3 - CDR's PLSS No. 4 - LMP's PLSS
33. HSD/Mockup	YO-YO (CDR and LMP)	PLSS lower LH strap - stitched
34. HSD/Mockup	RCU Camera Brkts (2)	70mm Hasselblad
35. HSD/Mockup	CDR's OPS	On SRC stowed in lower SRC Compt
36. HSD/Mockup	LMP's OPS	RH Floor
37. HSD/Mockup	CDR's PLSS	Recharge Station with: (a) Bat connected (b) Bat Dust Cover on cable stowage connector (c) RCU Dust Cover in aft LHSSC (any upper pocket) (d) Hoses and straps as crew might restow after EVA I
38. HSD/Mockup	LMP's PLSS	RH Floor: configured as CDR's
39. HSD/Mockup	Super Lightweight PLSS (2)	On platform at rear of mockup
40. HSD/Mockup	RCU (2)	Inside Aft LHSSC

* *

Technician	GFE/CFE/Mockup	Configuration/Location
41. Mockup	LMP's LM Restraint Cables	Unstowed and on floor
42. Mockup	CDR's LM Restraint Cables	Stowed for lunar surface activity
43. Mockup	ISA	Attached to RCU hammock attach points with the following inside: (a) Brush/scribe/lens (b) Personal items (c) Tote Bag with rocks
44. Mockup	CDR's Hammock	RCU end connected
45. Mockup	LMP's Hammock	LHSSC end connected

Mockup - (1) Mockup stowage and configuration should be as for earth launch, unless altered by the above "perturbations."

(2) One Jettison Bag (jettisoned during EVA I) should be outside mockup with the following inside:

(a) 2 OPS Pallets

(b) CDR's LH and LMP's LH and RH Armrest

(3) The following should be on mockup porch:

(a) 1 - SRC

(b) 1 - CSC Mag

(c) 1 - Tote Bag with rocks

Suit - (1) Crew fully suited with:

(a) Protective Plugs (2) in LH PGA connectors

(b) Watch (1) on PGA arm

(c) ~ 300 cc water in UCTA

EVA - (1) EVA Prep and Post cue cards for EVA 1 and 2 and One-Man EVA cue card in bag in Flight Data File.

(2) CB cards taped over panels.

(3) One-Man EVA transition card clipped to AOT.

(4) During EVA II:

(a) Crew passes out Surface Sequence Camera - stow mag in ETB.

(b) Stow CSC mag in ETB.

(c) Pass in SRC and Tote Bag.

DETERMINING OXYGEN WEIGHT IN THE OXYGEN PURGE SYSTEM (OPS)

As I've stated on more than one occasion, I am the "luckiest man in the world!"

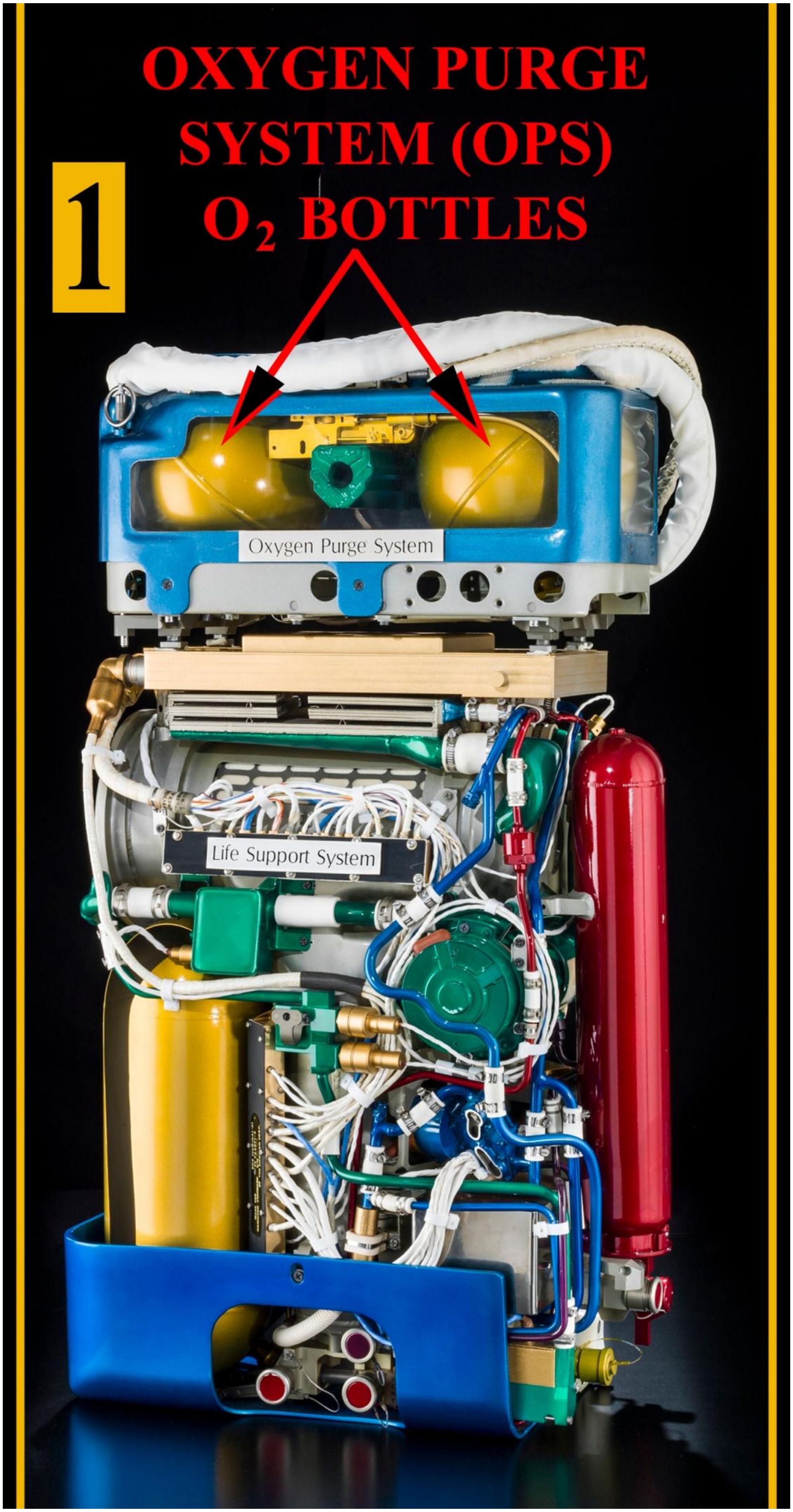
Being as intimately involved in the Apollo program as I was, there were so, so many fascinating details that I thoroughly enjoy sharing.

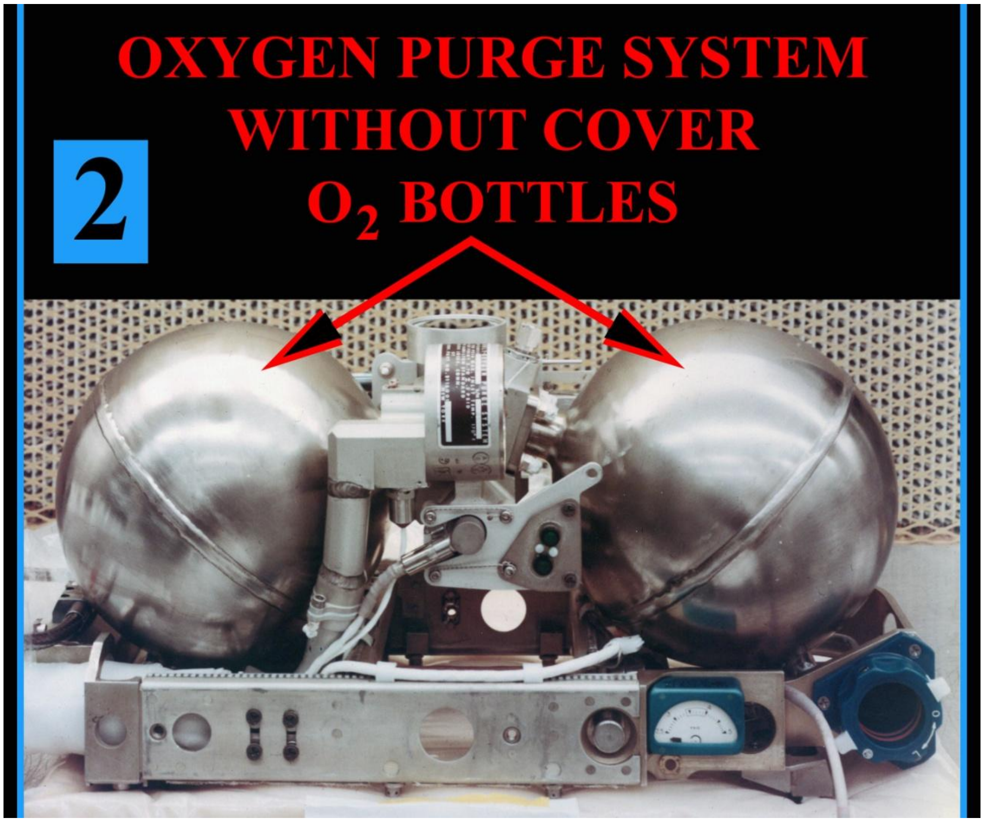
Following is a great example of a "detail" that when you think about it, you might say to yourself, "Wow, another Apollo fact that I never considered!"

Here it is: Before each and every Apollo mission an exact vehicle earth liftoff and lunar liftoff weight had to be established for obvious reasons. Going through my boxes and boxes of Apollo paperwork that I saved (I saved every document that related to my Apollo experience), I came across one of the many interesting memos that I wrote. In this case the attached "Quick Look Report" (Graphic 3 below) describing a test procedure and test results to determine the weight of the Oxygen in the Oxygen Purge System bottles (Graphics 1 and 2 below).

When you think about it, adding the weight of an intangible object to include in the total weight of the spacecraft is not something, quite honestly, one would have considered!

The referenced Quick Look Report (Graphic 3) is self explanatory. The results of the report establishing the weight of the Oxygen in the OPS bottles at 5.85 lbs is to me fascinating!


OXYGEN PURGE
SYSTEM (OPS)
O_2 BOTTLES
1
Oxygen Purge System
Life Support System



3

QUICK LOOK REPORT

PURPOSE:

To determine the total Oxygen weight capacity of S/N 026 OPS under flight charge conditions.

EQUIPMENT USED:

OPS S/N 026
OPS Test Stand S/N 001

PROCEDURE:

To establish an accurate Oxygen weight, the OPS Pad Pressure was depleted. The OPS was then weighed. The OPS fill valve cracking pressure was established. The OPS was then charged to the maximum flight charge tolerance limit taking into account the established fill valve cracking pressure. After stabilization the OPS was weighed.

TEST RESULTS:

OPS Empty Weight	30.45 lbs.
OPS Fill Valve Cracking Pressure	20 psig
OPS Oxygen Charge Pressure including fill valve crack pressure as indicated on OPS T/S G1 Gage	5980 psig
OPS Bottle Temperature after stabilization at 5980 psig	71° F
OPS Charged Weight	36.30 lbs.
OPS Oxygen Weight	5.85 lbs.

USING PLSS/OPS FULL SCALE MOCKUPS FOR LM PRE AND POST PROCEDURES

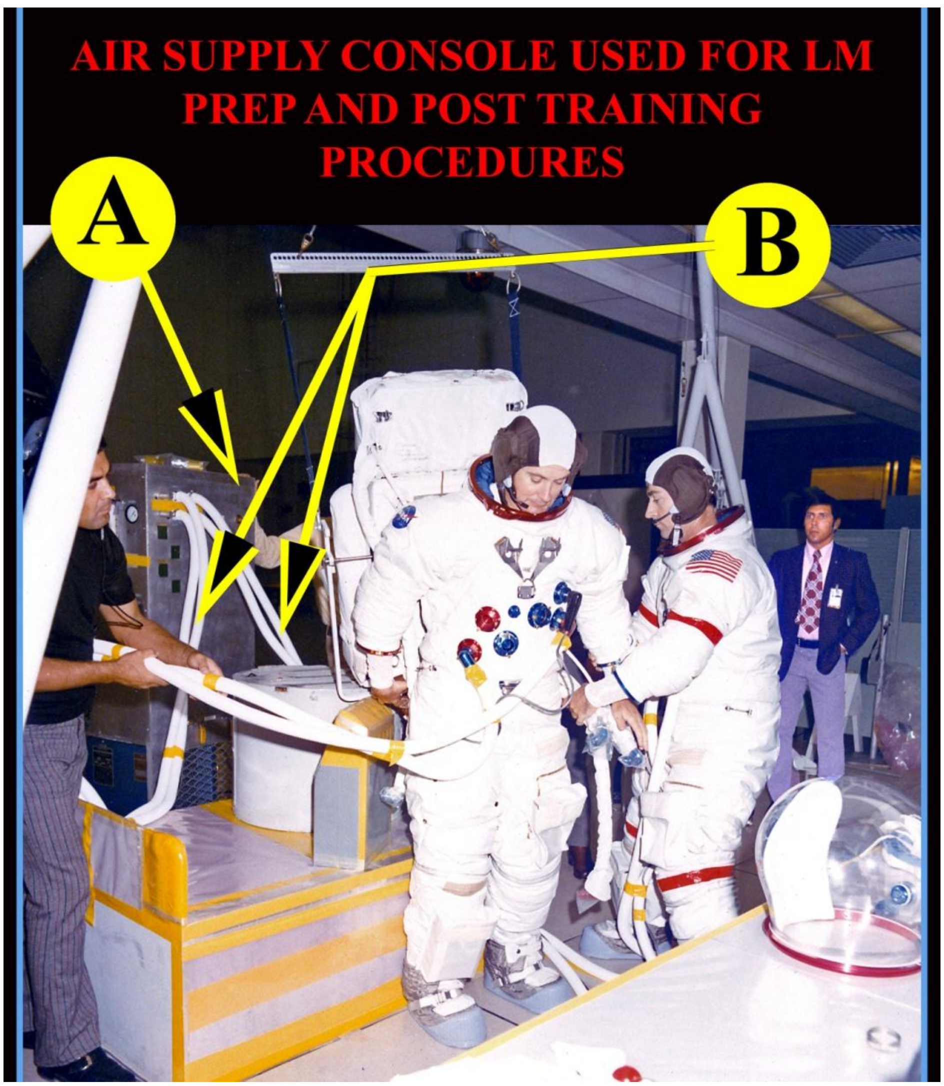
When I previously discussed the use of the PLSS/OPS full scale Mockups, I related how they were used inside the crew training LM. Performing LM prep and Post procedures inside the LM was the ideal scenario, however, the downside of working in the enclosed confines of the LM was that critical test conductor and tech observation was limited.

We therefore conducted the majority of LM prep and post procedures in an open area of the crew training building. As I discussed in a previous post, a LM engine cover and step to simulate the space in the LM used to don and doff the PLSS/OPS was fabricated.

You've seen many photos depicting LM pre and post procedures in the open space of the crew training building so that's nothing new. What is new is a reminder that the PLSS/OPS full scale mockups are one of four PLSS/OPS training configurations that were required to practice both lunar surface and LM procedures vs one flight PLSS/OPS.

Each PLSS/OPS training configuration required a source of breathable air, cooling and suit pressurization. When completely suited during LM prep and post procedures using the PLSS/OPS full scale mockups, breathable air was provided by using the air supply from the Air Console Unit (A) in the below photo.

With the mockup PLSS oxygen inlet and outlet hoses disconnected, hanging free, the air console inlet and outlet air supply hoses (B) were connected to the suit inlet and outlet oxygen connectors and provided air to the suited crewman. As you can see in the photo, there were two sets of inlet and outlet hoses for both the CDR and LMP.



HISTORY OF THE ASTRONAUT EVA WRIST CHECKLIST

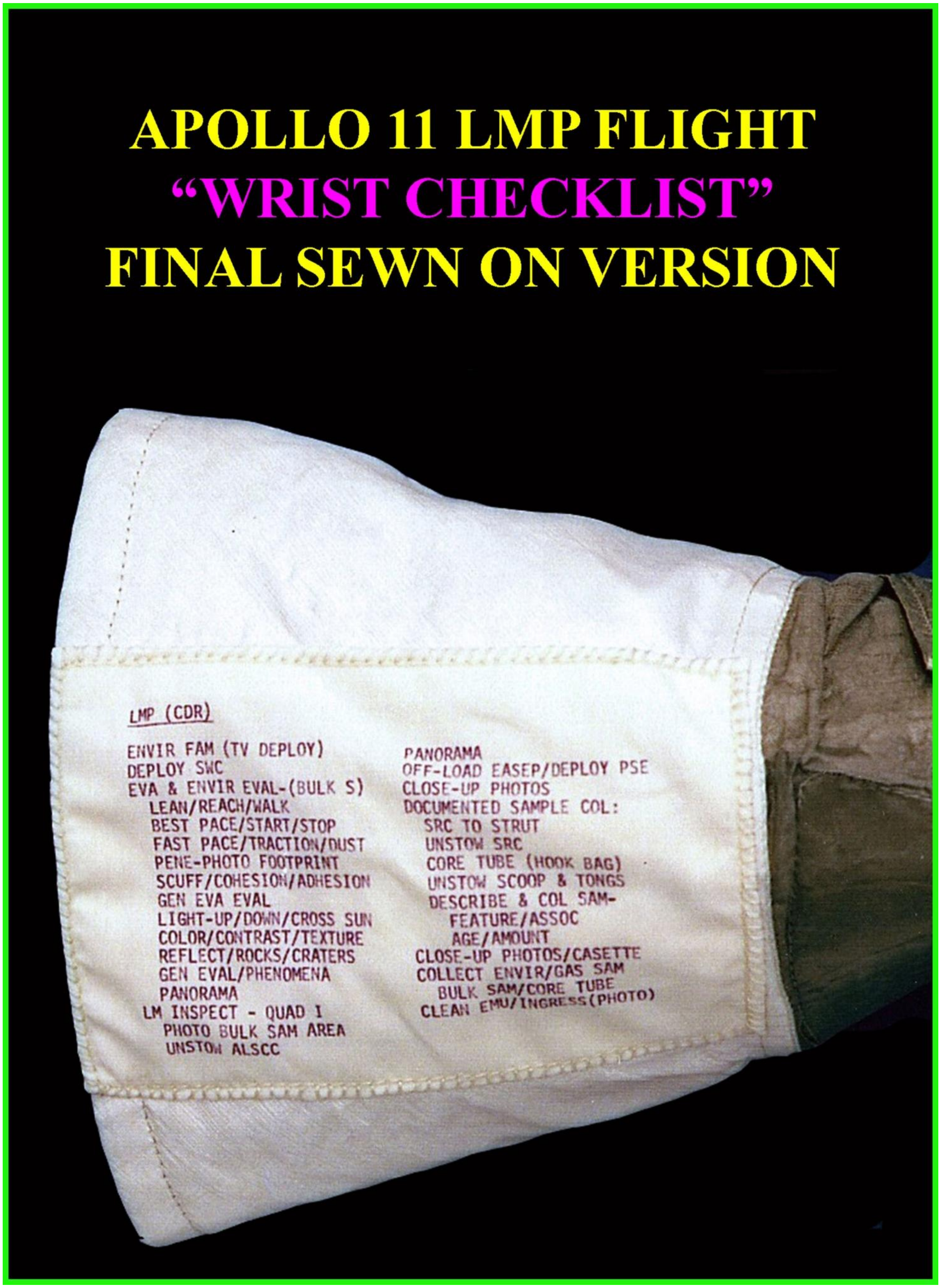
During one of the early Apollo 11 EVA Crew Training Exercises, the idea of a "wrist checklist" was initiated by astronaut Neil Armstrong when he suggested that there should be a written task reminder or as we might refer to today as an "action item list." The task reminder evolved into a checklist that could be secured to the astronaut's EVA glove and was logically named a "wrist checklist."

Since both Armstrong as CDR and Aldrin as LMP had different lunar surface tasks to accomplish, there were two individualized checklists. The photo below represents the first attempt at creating a "wrist checklist."

The below prototype wrist checklist reflects the tasks performed by Aldrin as LMP. Note that tasks in parentheses, i.e. (TV DEPLOY), etc. are tasks to be accomplished by Armstrong as CDR. These tasks, in parentheses, are just a reminder for the LMP. The CDR checklist also had important LMP tasks in parentheses.

Following is a photo of LMP Aldrin wearing the prototype wrist checklist during an EVA crew training exercise:

After noticing that the wrist checklists did not remain in the installed position, i.e. they rotated on the wrist, it was decided to permanently sew the words of the checklist to the astronaut gloves as seen in the below photo. The words fit in the designated area of the glove and could be easily read by the crew.



Subsequent Apollo missions involved considerably more tasks and a new concept had to be created to include entire mission tasks.

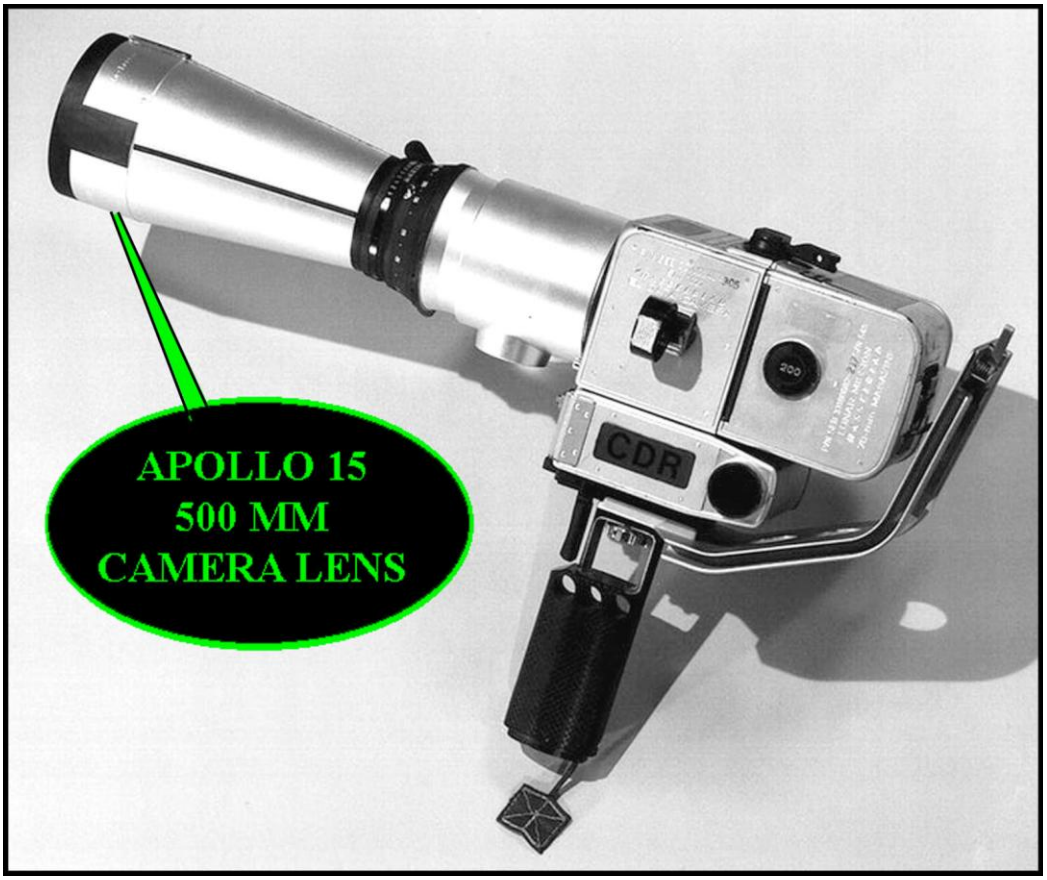
The below photo depicts the final wrist checklist concept used that included a spiral binder with plastic pages that were turned by the astronaut as he proceeded through his tasks

ASTRONAUT DAVE SCOTT'S APOLLO 15 STAND UP EVA

One of the skills that Apollo 15 CDR Dave Scott learned during his geology training was the need to gain a visual perspective of the landing site that he was about to explore.

With this in mind, he requested mission planners to schedule a Stand-Up EVA (SEVA) a couple of hours after touchdown in which he would stand on the ascent engine cover, poke his helmeted head through LM's top hatch and photograph his surroundings.

Practicing the SEVA in the LM mockup was easier said than done. Scott insisted on rehearsing the SEVA procedure fully suited and pressurized to confirm that he was able to "poke" his head through the LM overhead hatch and move a 500 MM camera lens attached to the Hasselblad through the hatch, successfully taking the desired photos.



It was an interesting day as we had to reroute the air supply hose through the overhead hatch to Scott's suit inlet oxygen connector. There was Scott, his head and camera poked through the hatch and the air hose inadvertently getting in his way. At one point during the procedure, the hose wrapped around his helmet. I wish I had photos to show you. Bottom line though, everyone was satisfied with the procedure.

After the mission, Scott said "The SEVA was a useful experience. One of our problems at Hadley (the landing site), was that the resolution of the Lunar Orbiter photography was only 60 feet, so they couldn't prepare a detailed map. The maps we had were best guesses and we had the radar people tell us before the flight that there were boulder fields at the landing site so a rational reason for the stand-up EVA was to look and see if we could drive the rover, because if there were boulder fields down there, and nobody could prove there were no boulder fields, it changed the whole picture."

The view set his mind at ease, appearing to totally contradict his pre-flight fears. The Rover "trafficability," as Scott put it, would be excellent.

Another reason for the SEVA was that people in the world of geology supported the SEVA, and said yes, that will be useful geologically getting photos from the vantage point of the hatch at the highest point of the LM, especially using, for the first time, a 500mm camera lens and having a stable platform by resting the camera on the flat circumference around the open hatch.

Why was there no Stand Up EVA (SEVA) on Apollo 16 or 17? The timing of Apollo 15's landing meant that Scott and Irwin had already been awake for 11 hours. It wouldn't have been wise to then send them out on a full

EVA but it would have also been unrealistic to expect them to go to sleep knowing the moon was just outside the window!

The stand-up EVA filled the gap, while also allowing Scott to get a good idea of the landing site's geography in preparation for driving the lunar rover.

Both Apollo 16 and Apollo 17 were scheduled such that the astronauts would depart on their first EVA soon after landing. And the Apollo 17 moon walkers did just that.

Apollo 16 astronauts would have as well, but their landing was delayed by six hours as they worked out a problem with the command module's engine control system. Young and Duke landed having been awake for 13 hours but having not planned for a stand-up EVA, they started their first outing the next day.

FIRST TEST OF THE LUNAR ROVER TRAINING VEHICLE

Reviewing my KSC Log Books, I have, on many occasions, found experiences that I consider "highlights" of my KSC "Personal Apollo Experience."

One such highlight involved the first test of the 1G Lunar Rover with Apollo 15 astronauts Scott and Irwin in the city of Goleta, Ca. at the General Motors Defense Research Laboratories.

GM was a subcontractor to Boeing, the Lunar Rover prime contractor. Many people remember two things about the Apollo program, Neil Armstrong’s first step on the moon and the astronauts riding the Lunar Rover on the moon, myself included.

On or about October 1st, 1970, I was assigned the task of coordinating the suited portion of the first 1G Lunar Rover Training vehicle test with Apollo 15 astronauts Scott and Irwin in California scheduled for November 24, 1970.

Rather than copying my Log Book notes I felt it might be more interesting for me to include my actual Log Book pages (see below) relating to my effort to coordinate the 1G Lunar Rover Test with the Apollo 15 Prime crew.

MEETING TO DISCUSS MY REQUIREMENTS NECESSARY TO ACCOMPLISH THE FIRST 1G SUITED ASTRONAUT LUNAR ROVER TEST IN GOLETA, CA.

5

Lunar Rover Requirements Meeting Oct 13+14, 1970

1) Capability of weighing cryopacks before + after charge.
2) Station wagon or van to suit up Astronauts.
3) We will supply Ground Stations.
4) Astronaut must build up heat load before riding Lunar Rover,
5) One Suit tech + one HSD tech to monitor Astronaut.
Must monitor system pressure gage.
6) Towels + Gatorade for Astronauts.
7) Techs must be within visible range of Cryopack gages. ≃50'.
8) Astronaut will indicate freezup systems. Low flow, extreme heat. Techs will have ground Station to monitor.
9) We can probably fabricate fill line flex. but must know interface definition with liquid air dewar.
10) Liquid Air per MSC-SD-A-0019, type A. Charge pressure of 60 to 80 PSIG.
11) Need ≃ 75 liters of liquid air for 3 packs. Each Pack takes 7 liters
12) Max 25% O_2 Min. 20% O_2
13) Exercise should not be started too early since we must have time to fill cryopacks. ≃ 1 hour standby time.
14) It is amazing how much Q.C. is going into 1"g" trainer as opposed to cryopacks.

7

14) ~~The volume of~~ Refer to section 3.3.1 of SD-A-0019 for Sampling. Also Table I and Table II
15) Sample is good for 24 hours. Must be resampled after 24 hours.
16) Dewar must be pressurized to 60-80 PSIG.
17) Dewar requirements
   1) Control Value.
   2) filter at outlet.
   3) Regulator
   4) relief value.
18) Moisture or Dew Point not critical. Can be higher than ~~-20~~ -20°F.
19) Need Electrical out let for heat gun.
20) Possible Portable Van.
19) Need Cart to carry ground station around. (Incorporate this for our own exercizes at KSC.
20) How long will test last.

~~Covida~~ Corvile

21) Should perform Comm check before check to determine any anomalies before EMC test. This would establish if shipment damaged equipment.

\]

READINESS REVIEW MEETING TO DISCUSS FINAL PLANS FOR FIRST 1G LUNAR ROVER EXERCISE ON NOVEMBER 24, 1970

Readiness Review Meeting

1) Attend ~~ing~~ meeting to determine schedule for Suited Exercise.

2) Must emphasize that techs can stop test, + must be within range of cryopack gages.

~~3)~~

3) They made a strong point about Astronaut Saftey.

4) If test runs longer than 1.25 hrs. then we must have more than 3 cryopacks since liquid air supply is probably not available in Santa Barbara.

5) Make sure I see facilities including lunar surface.

6) You are limited by the amount of air you have to stop test since you can't recharge packs here.

7) Will chase vehicle include suit + HSD techs.

8) Cryopacks very susceptable to freeze up since Astronaut ~~does not work~~ probably does not work as hard in trainer + weather conditions may not be ideal for cryopacks. Find out how much energy is expended.

305-867-8170

8) Will there be any interface problems with A7LB suit + cryopacks.

9) I would like copy of procedures for EMC test + Crew Station review.

10) Look at Trainer to determine any interface problems.

11) Cryopacks are not configured per -7 PLSS. How is PLSS mounted in LRV.

12) What are the PLSS suports.

13) How do we strap cryopack into LRV. ~~Will~~ Will LRV be moving.

14) TM is not wired into cryopack EVC's.

15) We can communicate with crewman in mode "B" with Ground station in another mode.

16) We can get + need more than one ground station.

17) We should put cryopacks on Astronauts on back of chase vehicle.

18) Cryopacks could freeze up. This should be on flow chart.

19) We can't have test on 4th either since packs have to be PIA'd.

20) What is purpose of EMC check. Is it to check LRV interference with Comm.

21) If we charge packs the night before we need scale to weigh them in the morning to get an idea of how long packs will last.

22) Will 15 lbs afect balaste of vehicle since Cryogenics is used up as vehicle is used.

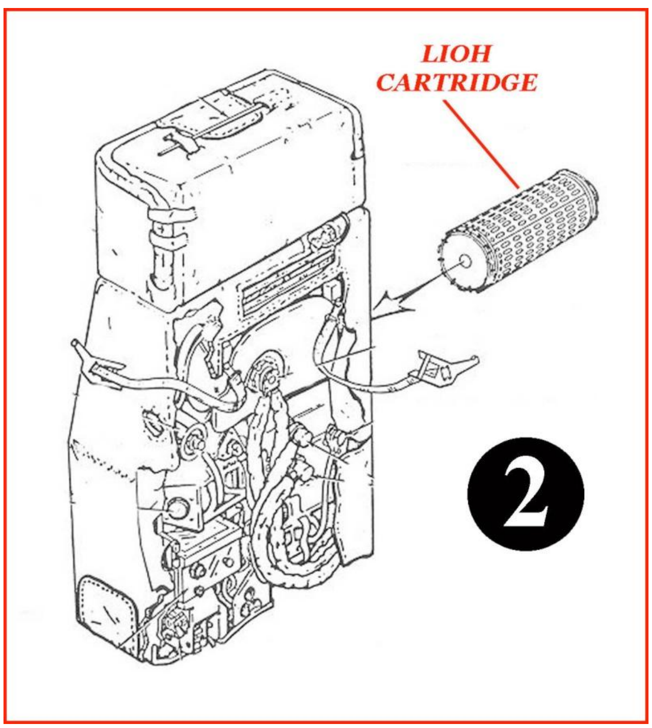
23) Do you need BSLSS.

24) We will get golf carts.

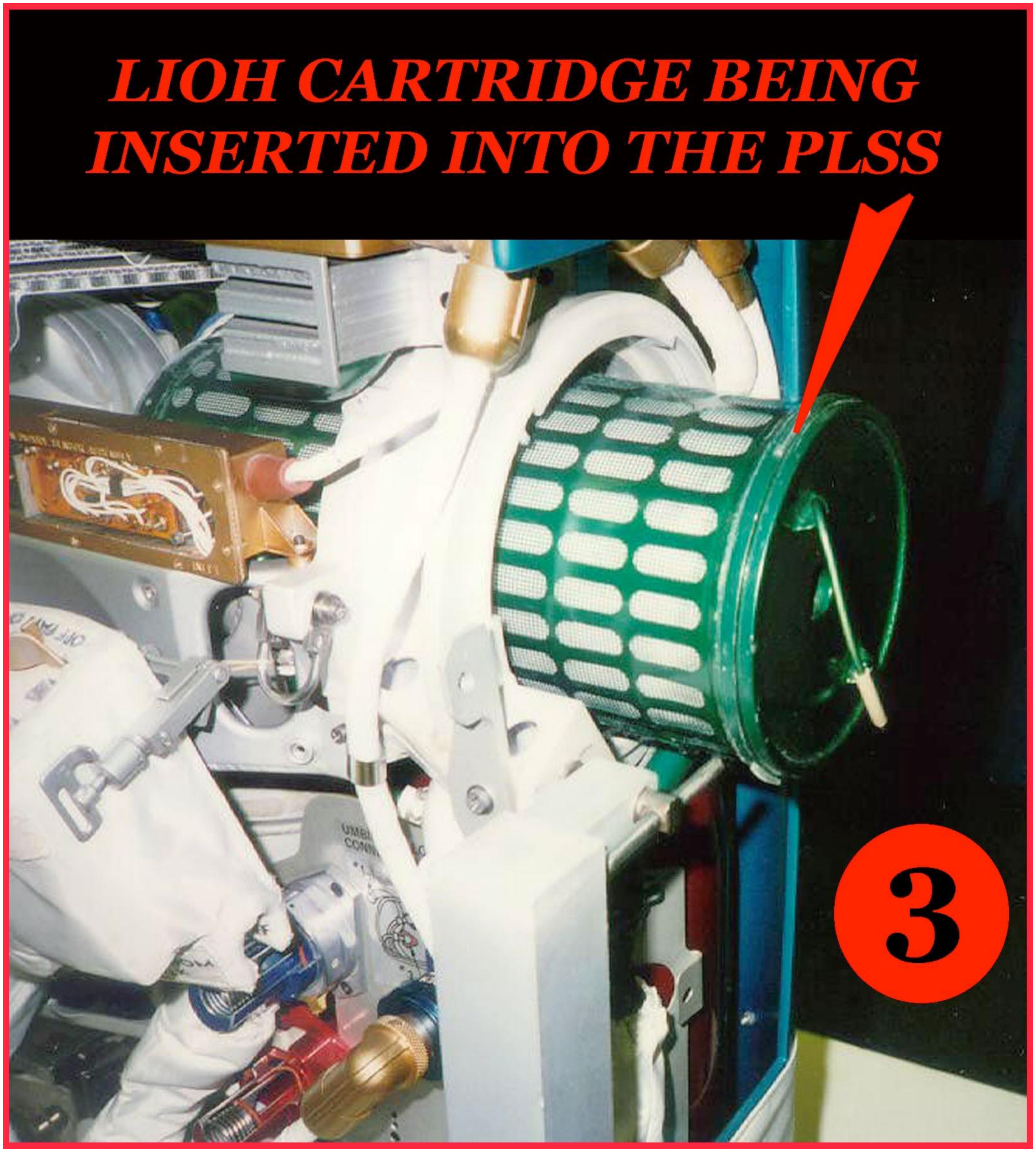
CARBON DIOXIDE REMOVAL FROM THE OXYGEN BEING CIRCULATED THROUGH THE SPACE SUIT VENTILATION SYSTEM

The specimens in the plastic container (Photo #1) are pieces of activated charcoal that were used in the PLSS contaminant control cartridge also known as the LIOH (lithium hydroxide) and charcoal cartridge. For the purpose of this writing, I will shorten the name LIOH and charcoal cartridge to the "LIOH cartridge."

The configuration of the LIOH cartridge is depicted in Figure #2 below as a cylindrical component of the PLSS labeled "LIOH cartridge."

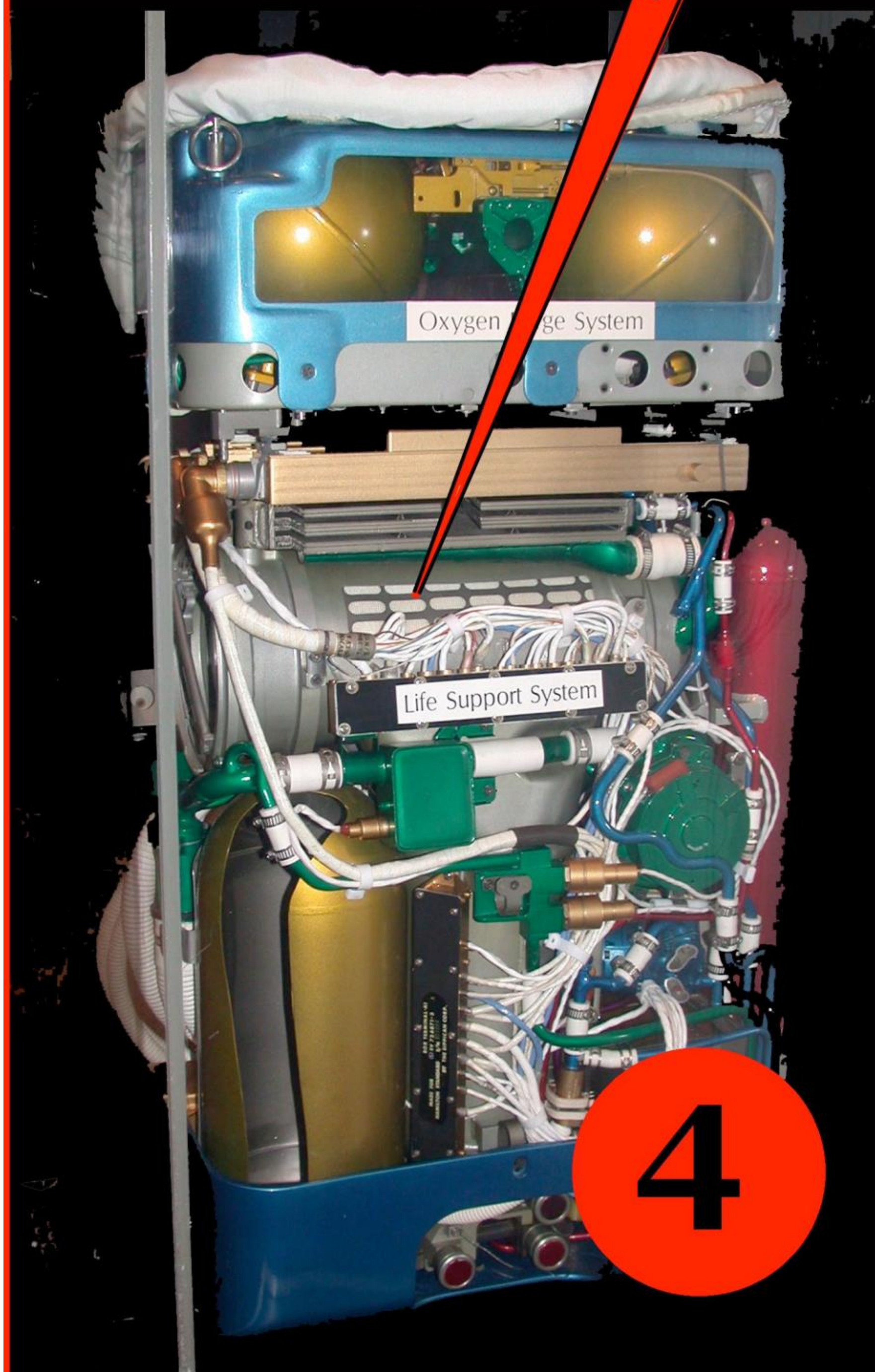


In Photo #3 you can see an actual LIOH cartridge being inserted or being removed from its location inside the astronaut Portable Life Support System (PLSS).



LIOH CARTRIDGE INSERTED INTO THE PLSS

(CUT-A-WAY VIEW)



The LIOH cartridge has the following three basic functions:

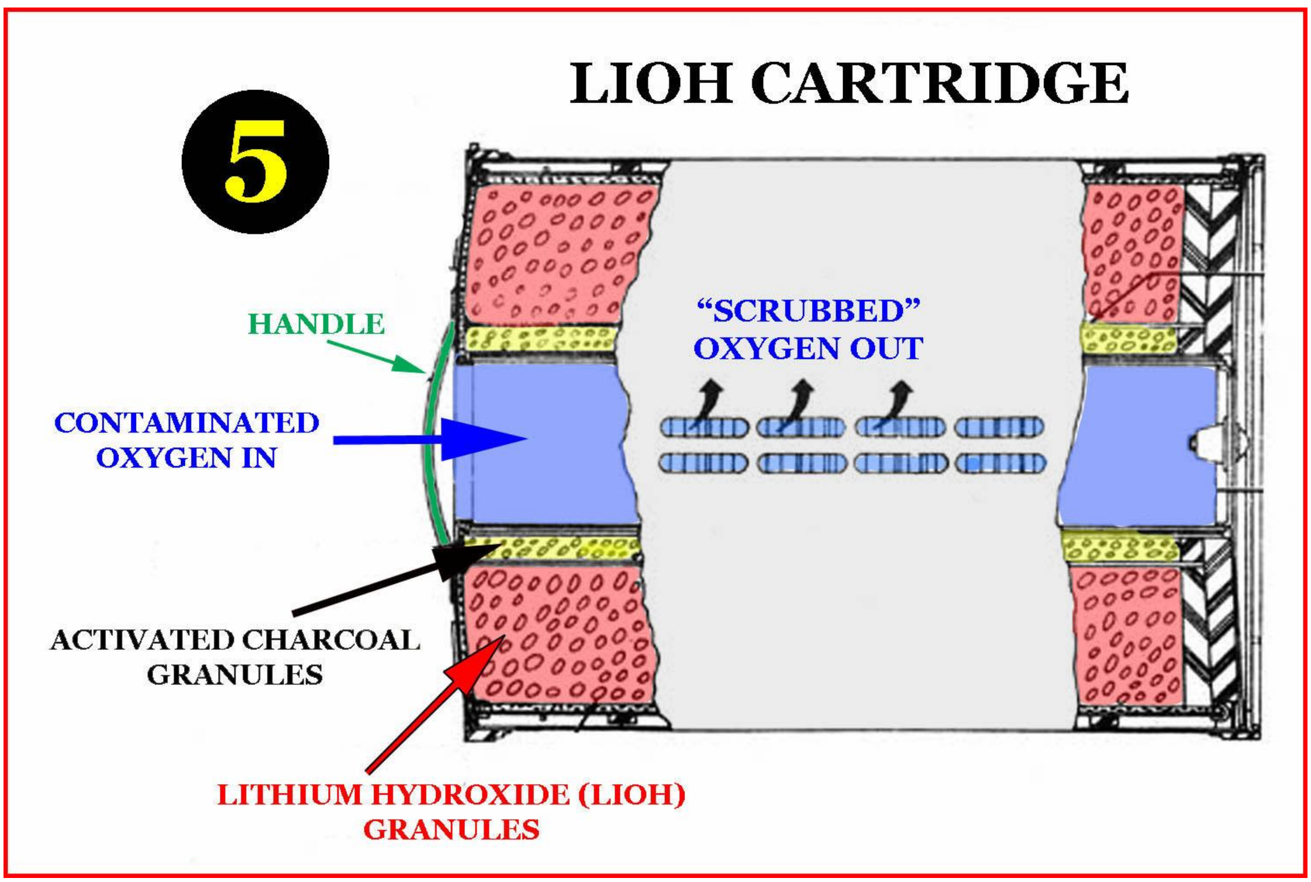
1) Remove the astronaut's exhaled carbon dioxide from the oxygen being circulated through the space suit ventilation system so that the oxygen can be re-circulated as breathable oxygen.

This is accomplished by passing the contaminated oxygen containing the exhaled CO2 (carbon dioxide) through a "bed" of lithium hydroxide (LIOH) granules that removes the CO2 by chemically reacting with the LIOH to form non toxic lithium carbonate allowing the CO2 "scrubbed" oxygen to be re-circulated through the astronaut ventilation breathing circuit (Reference Figure #5).

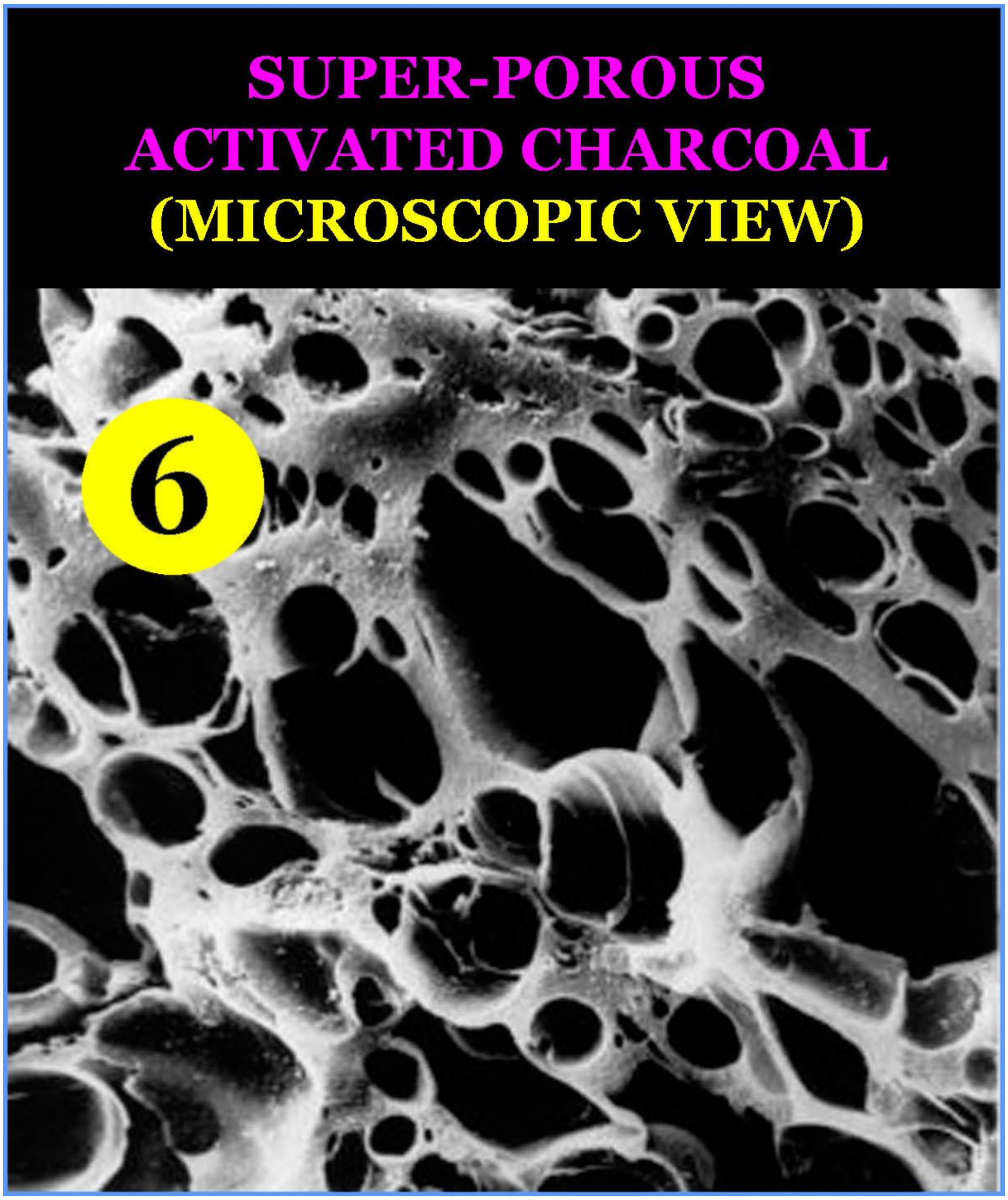
2) Remove foreign particles such as dust particles using a peripheral felt like Filter from the easily "kicked up" loosely packed Lunar soil during EVA.

3) Remove trace contaminant gases such astronaut body odor and other metabolic by-product contaminants as the circulated oxygen in the PLSS space suit ventilation circuit passes through the suit adjacent to the astronaut's body.

This is accomplished by passing the contaminated oxygen over activated charcoal granules (Figure #5) identical to the granules in the plastic dish (Photo #1).



Let's take a closer look at the Activated charcoal granules (Photo #1). Activated charcoal starts life as ordinary, less absorbent charcoal, but when it is treated with steam at exceptionally high temperatures (beyond the temperature of a domestic oven) it becomes super-porous. The highly controlled steam heating process results in active charcoal that has millions of microscopic holes, not just on the inside but across its surface as well (Photo #6).



One gram of activated charcoal has a surface area of about 500 square meters. This is twice as big as the surface area of the average US home.

Surface area is important because increased surface area means that the activated charcoal can absorb more gas particles. Unpleasant odors are made up of gas particles. How does the porous charcoal capture body odor and other trace contaminants?

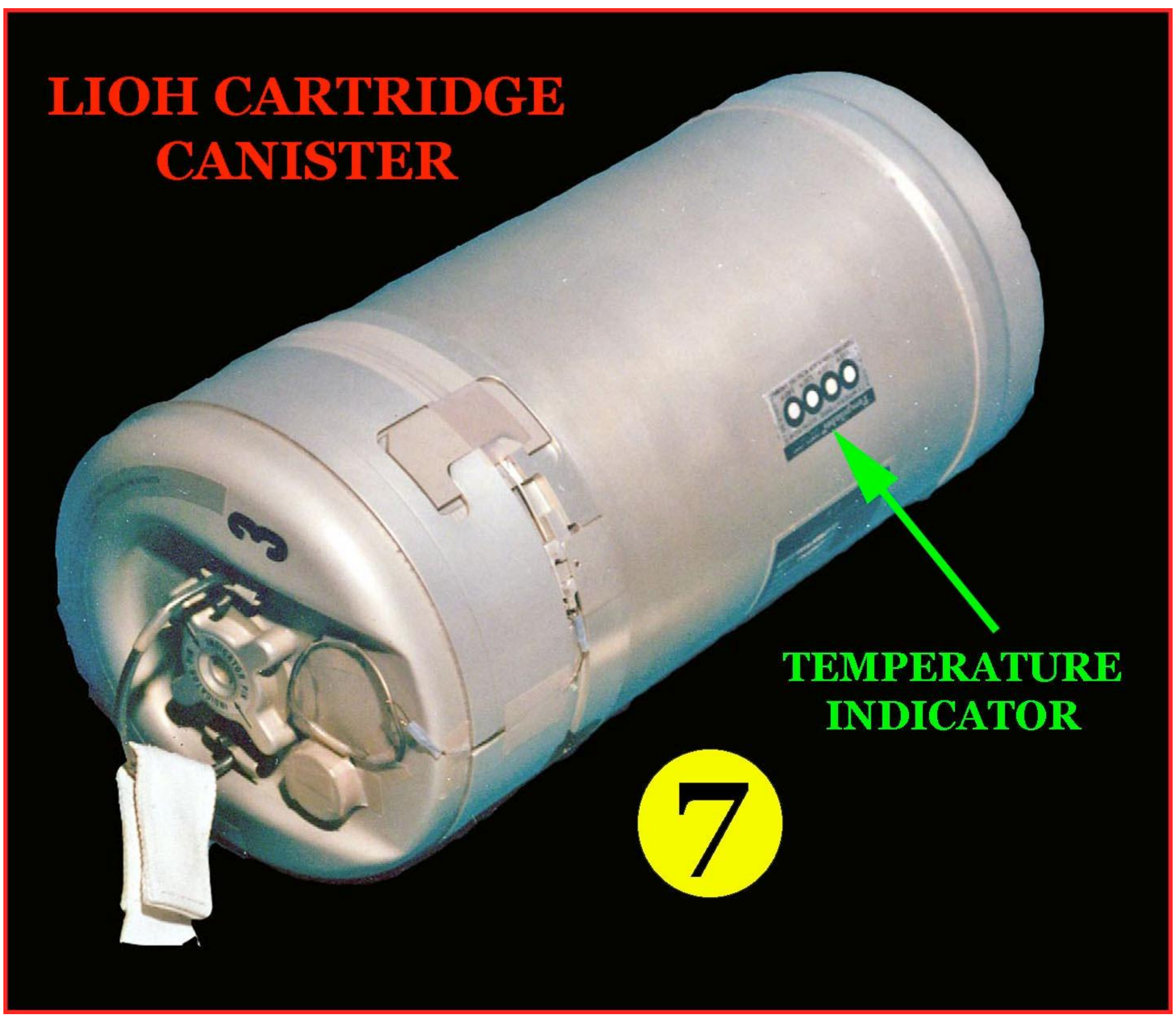
This is a complex chemical process, but it can be compared to a vacuum cleaner. Just as a vacuum sucks up dust, activated charcoal porous granules "suck" odors from the contaminated oxygen. The odors then become attached to the charcoal pores and are trapped inside, just like the dust in the vacuum cleaner bag. The larger the surface area (porosity) the more odor capture.

The Millipore Filter Corporation supplied the activated charcoal to the Garrett AirResearch Corporation who in turn fabricated the LIOH cartridge under a sub-contract to Hamilton Standard, manufacturer of the PLSS.

Photo #7 below represents a canister used to hold the LIOH cartridge. The LIOH cartridge can be used in the PLSS for only one EVA. As we know, we had missions with three EVAs which meant that extra cartridges were required for each mission.

The cartridges were heat sensitive . As a result, the LIOH canister (Photo #7) was designed to contain the LIOH cartridge during shipping and storage and specifically to form a temperature and humidity barrier. Temperature was monitored using the temperature indicator on the outside of the canister (Photo #7).

If one or more of the four white circles on the indicator turned black, we knew that a some point in time the cartridge may have been exposed to temperatures above 110 degrees and damaged, i.e. the LIOH granules possibly absorbed moisture that degraded the amount of CO2 absorption capability.



The resulting damage to a cartridge that had been exposed to out of specification temperatures resulted in a requirement to hand carry the cartridges in the passenger section of a plane so that the location and status of the cartridge could be documented and verified by the individual courier at any point during transport from one location to another.

About a week before the Apollo 11 launch, we noticed that one of the LIOH cartridges assigned to the Apollo 11 PLSSs had been exposed to an out of spec high temperature. I hand carried the cartridge from KSC to Hamilton Standard headquarters in Windsor Locks, Connecticut allowing engineers to inspect and test the cartridge to determine if this was an isolated case. I was in the laboratory and witnessed the inspection and testing of the cartridge in question.

After the cartridge was disassembled and tested, it was determined that the cartridge had, in fact, been exposed to out of specification high temperature. It was never determined when and where the LIOH cartridge had been exposed to the out of spec high temp. Fortunately, we had backup cartridges at KSC and one of them was assigned to replace the damaged cartridge.

PROTECTING OXYGEN HOSE CONNECTORS FROM NON CLEAN ROOM CONTAMINANTS

As discussed previously, the only time the PLSS oxygen connectors were exposed to and not protected from a non clean room ambient environment was in the LM after a lunar surface EVA. When the PLSS oxygen connectors were not connected in a non clean room environment, the connectors were covered with plastic as I discuss below and as seen in the below photo.

When completely suited during LM Prep and Post procedures using a "flight assigned" PLSS/OPS, breathable air was provided by using the air supply from the air console in the below photo. With the PLSS oxygen inlet and outlet hoses disconnected, hanging free, the air console inlet and outlet air supply hoses (below photo) were connected to the suit inlet and outlet oxygen connectors and provided air to the suited crewman.

To protect the PLSS oxygen inlet and outlet hose connectors from possible contamination in the non clean room environment of the crew training building, the PLSS oxygen connectors were covered with plastic as depicted in the below photo.


PLSS
DIS-CONNECTED
OXYGEN CONNECTORS
COVERED WITH
PLASTIC

TIE TACK FLOWN TO THE MOON ON APOLLO 11

TIE TACK IN APOLLO 11 THEMED FRAME

THE STORY BEHIND MY TIE TACK THAT WAS FLOWN TO THE MOON WITH APOLLO 11 ASTRONAUTS ARMSTRONG AND ALDRIN

A call was received at our KSC Hamilton Standard office. Our Secretary Wendy called over to me, "Dan phone call". I picked up the phone, said "hello" with the response, "Is this Mr. Schaiewitz". I said "yes". The voice on the other end said (I'm paraphrasing), "I'm calling on behalf of Astronaut Slayton who in turn said that Astronaut Armstrong would like to include a memento of your choosing to fly with him to thank you for keeping them (he and Aldrin) safe during training. Whatever you choose must be small and light weight". I was unable to respond. The female voice on the other end said " Mr. Schaiewitz, are you there?". It must have been at least 10 seconds before I was able to respond. I think I was only able to say "thank you" and hung up. Explanation: I had been a stutterer most of my life but I usually had my stuttering under control except for unexpected situations and this definitely was one!

BACKGROUND: My responsibilities as Apollo PLSS/OPS KSC EVA Crew Training Mission Manager began with a memo from MSC Crew Systems Division stating that the remaining Apollo 11 and all future mission EVA crew training exercises would be conducted at KSC and all EMU training hardware (suits, PLSS/OPSs, and supporting hardware) would be shipped to KSC in time for a June 6, 1969 Apollo 11 KSC training exercise.

When it was time to take over the KSC PLSS/OPS EVA crew training operations, I'm not sure if I recognized the significance of the important responsibility that I was given as PLSS/OPS EVA crew training mission(s) manager.

The PLSS/OPS training hardware that we received from MSC to support KSC EVA training was totally functionally different than the flight PLSS/OPS whereas the training suits were flight configured and downgraded to training status. Let me repeat and this is very important, *The PLSS/OPS training hardware was totally functionally different from PLSS/OPS flight configured hardware.*

Before I became involved with the PLSS/OPS training units, my work at KSC was with the Flight PLSS/OPS hardware. Because of my intimate knowledge of the flight hardware and my extreme enthusiasm about my work (my dream job), my request to be assigned PLSS/OPS Crew Training Mission Manager was granted (one of the many highlights of my Apollo experience).

I realized that I now had to familiarize myself with a totally new system both from a functional and procedural standpoint and concurrently continue my responsibilities as a KSC HSD engineer. Knowing the frantic pace at which Apollo schedules were moving forward I anticipated that my upcoming new responsibilities were going to be very challenging.

As I previously mentioned, the training PLSS Cryopack and OPS were totally functionally different from the flight configured PLSS/OPS. The flight PLSS/OPS was designed and built to function on the moon, not on earth. All components were, of course, designed with that in mind.

My impression when I first compared the flight PLSS to the training PLSS Cryopack was one of questionable belief or perhaps disbelief. What I saw when looking at the Cryopack was hardware that might have been built in someone's garage! In retrospect, comparing the Cryopack to the flight PLSS that I had lived with day in and day out and labeling it as "garage built" may have been a little too harsh. However my initial observation may not have been too far off!

As we all know, meeting the deadline set by President Kennedy before the end of the decade, Dec. 31, 1969 to land a man on the moon and bring him back safely, required meeting schedules that seemed unrealistic to many and achievable to some, i.e. schedule deadlines that, at least for me, did not give me time to contemplate the reality of my responsibility to provide reliable hardware (PLSS/OPS) for each and every EVA training exercise prior to the Apollo 11 mission. I had my challenges, and very real concerns about hardware reliability and future potential problems. My very first concern was that the training cryopacks did not come with a "paperwork" trail, meaning that there were absolutely no written procedures to inspect and test the cryopack. Yes, that's exactly what I said!

When I asked for inspection and testing procedures, I was told that they do not exist! I was, as you can well imagine, very concerned, to say the least. Every other "life support" (life support being the operative word) hardware system whether used for flight or training required procedures for periodic testing and inspection, procedures for inspecting hose lines, line fittings, hose nozzles for cracks, nicks, cuts, etc. There were also no requirements for functional testing to confirm that all system and component specifications were met, neither informally or formally with a KSC approved and signed document. The cryopacks did not even have a data package that would have included the inspection, testing, charging, cleaning, malfunction and repair history. Being so involved with testing flight PLSS/OPSs, all I could do was "scratch my head" in disbelief!

Not only were the flight PLSSs tested and inspected many times over following very detailed and approved signed procedures, they also provided telemetry to monitor bio-medical and PLSS performance data and included a built in out of spec alert system, i.e. audio alarms and remote control unit visual alerts that prompted the crew member to implement practiced emergency procedures.

I had very real concerns about cryopack hardware reliability and future potential problems. Those concerns were, in my mind, justified. Knowing that potential reliability problems existed along with the inability to monitor astronaut EKG and cryopack real time functional performance, I tried my best to implement astronaut EVA "work around" monitoring procedures that first and foremost addressed the "SAFETY" of the crew.

The overriding concern for me was the "SAFETY" of the Apollo 11 crew during EVA training exercises. Many times, my concerns prevented me from getting a good night's sleep.

As we discovered, there were no formal crew "SAFETY" procedures. As I became more familiar with the PLSS training cryopacks after supporting several Apollo 11 crew training exercises, I was able to generate astronaut safety procedures based on "what I had to work with!" I subsequently incorporated my written procedures in a document appropriately titled "Procedures For Testing The Astronaut Training Cryogenic Life Support Back Pack," KSC Procedure NO: CTE-H-3001/KL-9650. This, in fact, was the inspection and testing procedural document that did not exist, a document that should have been written before the cryopacks were approved for astronaut life support.

We experienced numerous problems, as anticipated, with the training cryopacks (during Apollo 11 KSC EVA training exercises) , i.e. hardware malfunctions and safety issues that could have and on a few occasions did in fact jeopardize the lives of the crewman.

I am proud to say that as PLSS/OPS EVA Crew Training Mission Manager despite all the problems associated with the equipment used, we never missed a planned Apollo 11 crew training exercise as a result of equipment and associated problems.

My experiences and the decisions I had to make (as Apollo PLSS/OPS KSC EVA Crew Training Mission Manager) as a result of maintaining and managing PLSS/OPS EMU training hardware that did not perform as expected were made known to the Astronaut office, specifically to Astronaut chief Slayton. Apparently, Astronaut Slayton and Armstrong more than appreciated the attention we paid to Astronaut Safety, resulting in the aforementioned shocking and "stuttering" initiating "fantastic" memento requesting phone call.