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SKYLAB EXPERIENCE BULLETIN NO. 13

TOOLS, TEST EQUIPMENT AND CONSUMABLES
REQUIRED TO SUPPORT INFLIGHT MAINTENANCE

DISTRIBUTION AND REFERENCING

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MAN-MACHINE ENGINEERING DATA APPLICATIONS
OF
SKYLAB EXPERIMENTS M487/M516

BULLETIN NO. 13

TOOLS, TEST EQUIPMENT AND CONSUMABLES
REQUIRED TO SUPPORT INFLIGHT MAINTENANCE

This document is the thirteenth in a series of releases which are intended to make available to NASA and contractor personnel those results from the Skylab Man-Machine Engineering Experiments which have design and requirements relevance to current projects and programs. This method of data distribution has been instituted as a convenient way to provide early access to Skylab experience and is intended as an interim measure, to be followed up by a thorough experiment report six to nine months after receipt of all Skylab flight data.

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DEFINITIONS

Inflight Maintenance (IFM) refers to those tasks which were performed aboard Skylab to either correct a problem (repair) or to prevent a problem from occurring (servicing).

Scheduled Maintenance consisted of those in-flight housekeeping tasks and component replacement tasks to be accomplished on a regular basis to enhance equipment life. Typical tasks included inspecting, cleaning and replacing various filters and screens.

Unscheduled Maintenance consisted of those in-flight repair tasks for which tools and procedures were provided but which were not scheduled in the mission timeline. Unscheduled maintenance was performed when discrepancies were noted during normal operations or while performing scheduled maintenance. Fault isolation, repair and reverification were the usual steps. Repair consisted primarily of removing and replacing failed items.

Contingency Maintenance refers to those in-flight maintenance tasks for which no specific tools, spares or procedures were provided. Each such task had to be treated in real time as it occurred.

Sparing - Selected spare parts were provided to permit in-flight replacement of critical components.

TOOLS, TEST EQUIPMENT AND CONSUMABLES
REQUIRED TO SUPPORT INFLIGHT MAINTENANCE

SUMMARY

Tools selected for Skylab were primarily those required for specific tasks that were approved for inflight accomplishment plus a few general purpose tools such as a pry bar, hammer, and Swiss Army knife. Skylab crewmen found a use for virtually every tool they had on board.

Two primary complaints were voiced by Skylab crewmen regarding tools. First, all the necessary tools were not included; and, secondly, if a tool was available, it sometimes did not perform well because of safety requirements that had been imposed to render the tools ready for flight. Most of the tools were stripped of their original finish and replated with safety-acceptable exterior coatings; this resulted in some instances of poor fits between interconnecting elements such as handles, drivers, extensions, and end fittings.

Arrangement of tools in the tool kits and the method of retention were also criticized by the Skylab crewmen. A common complaint was that some tools fit tightly into the drawer cutouts while others were so loose that they were not restrained at all. The crewmen also indicated that the placement of tools and tool kits at numerous locations throughout the cluster was undesirable and they recommended that all tools be grouped in one specific area.

The most significant conclusion derived from the post mission assessment was that if viable inflight maintenance programs are to be implemented on future manned missions, a complete range of hand tools, test equipment, and consumables should be included within the onboard inventory.

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PRE-SKYLAB EXPERIENCE

Although manned space programs prior to Skylab demonstrated that man in space is capable of conducting many of the activities that he accomplishes on earth, the crewman could only realize a limited part of the broad spectrum of possible task and work activities because of the confinement of the small volume space vehicles and short duration missions of pre-Skylab programs, i.e., Mercury, Gemini and Apollo. Thus, data concerning the crew's ability to use tools and assemble and disassemble equipment as functions of IFM were naturally limited.

Although no IFM capability was designed into the Mercury and Gemini vehicles, a small tool kit consisting of screwdrivers, a crescent wrench, a pair of needle nose pliers and a roll of tape was included in the Gemini cockpit for contingency use. A limited set of tools was developed for the Apollo missions but no planned IFM program was implemented as a nominal portion of the missions. The crewman tool set (Fig. 1) carried in the Apollo Command Module, provided multipurpose tools and/or attachments for Apollo mission activities. The Apollo crewman tool set contained the following items: a tool set pouch, a torque wrench, an emergency wrench, two T-handles, an adapter handle, two end wrenches, 6" x 7/16" driver, 10" x 5/32" driver, 4" x 5/32" driver, 4" x 7/32" driver, a hook, D-ring extension handle, and a 20" tether. Each tool had a tether ring with velcro strap attached. All tools were capable of being used with a PGA gloved hand. The lunar module inflight tool set (Fig. 2) contained a torque wrench, docking tool, and driver. A staging failure contingency kit containing cables, mylar cutters, and connector pliers was flown on the later LMs.

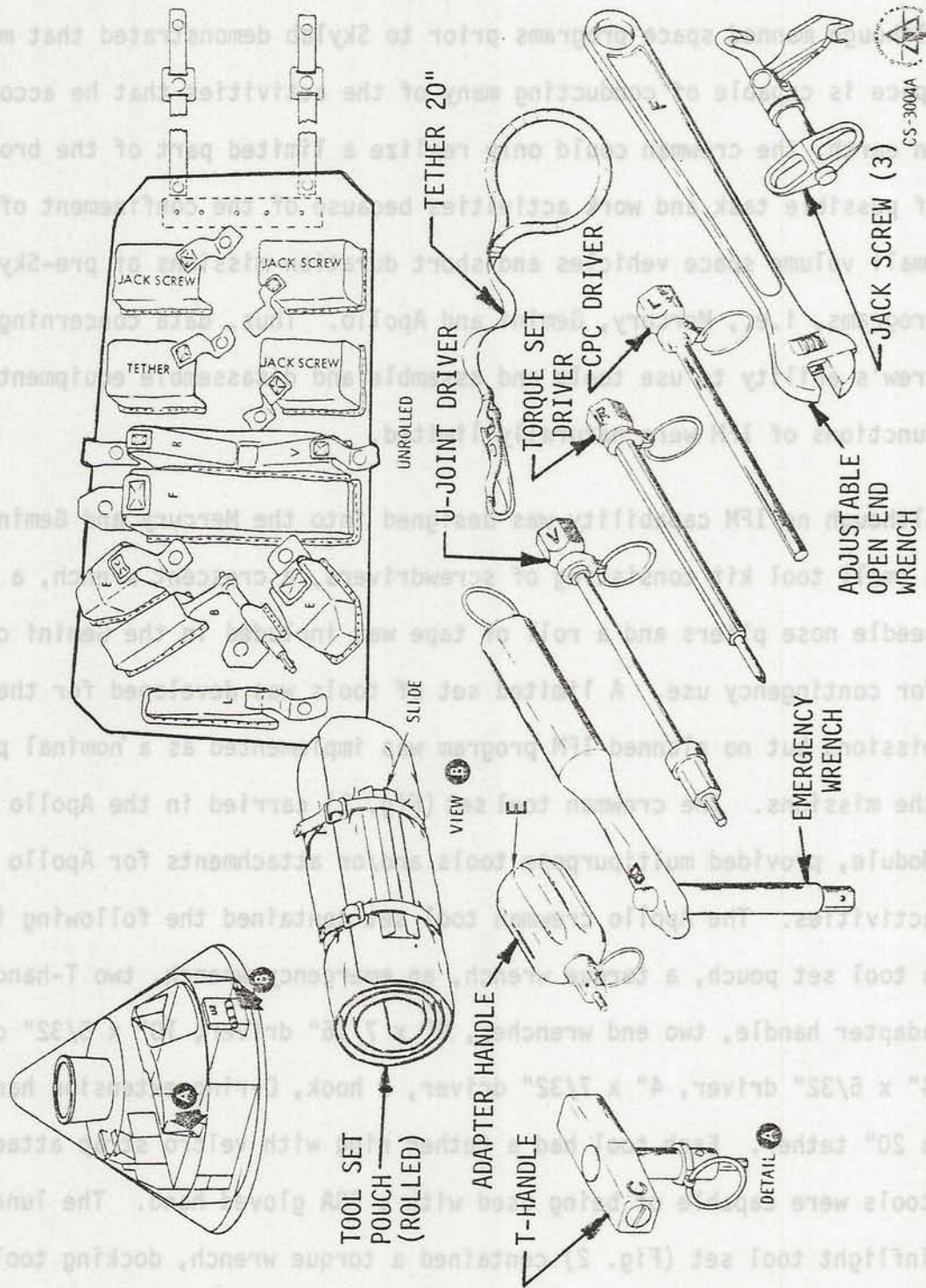


Figure 1 - Crewman Toolset (Apollo Command Module)

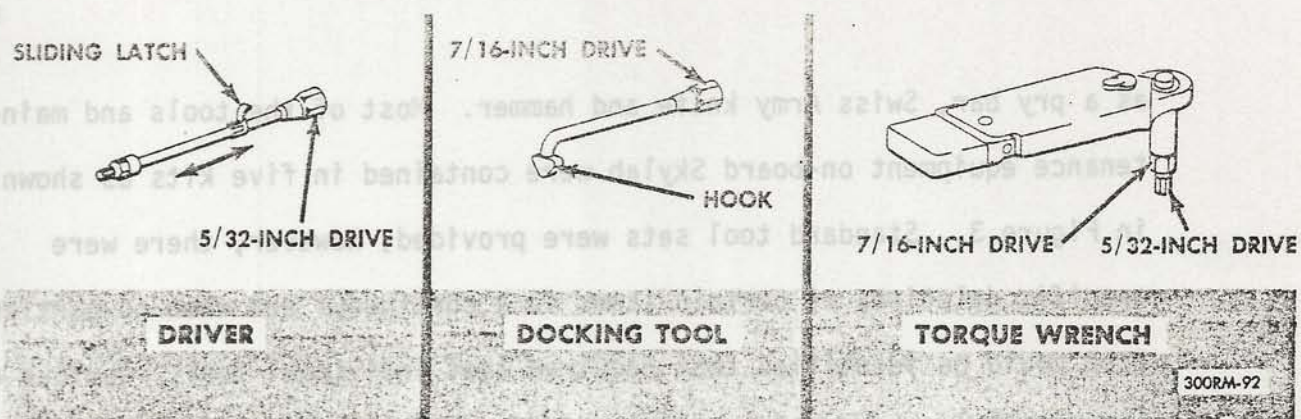


Figure 2 - Inflight Tool Set (Apollo Lunar Module)

In the event the space suit PGA was damaged it could be repaired by use of the Apollo EMU maintenance kit. The kit was approximately 20.32 by 15.24 by 3.81 centimeters (8 by 6 by 1.5 inches) and weighed 0.17 kilograms (0.38 pounds). There was one kit aboard the command module, stowed in a locker on the aft bulkhead.

The CM tool set pouch had a tool retention device made of synthetic cloth. The pouch had pockets with retention flaps and Velcro tabs; for zero-g stowage, it had Velcro pile exposed so it could be attached to the CM structure. For launch and entry stowage, it was rolled and fitted into a re-inforced bag alongside of the CWG/LCG stowage bag.

SKYLAB DESIGN

Initial Tool and Equipment Selection

The tools and associated equipment selected for the Skylab Program were primarily those required for specific tasks that were approved for inflight accomplishment, and a few tools of a general purpose classification such

as a pry bar, Swiss Army knife and hammer. Most of the tools and maintenance equipment on-board Skylab were contained in five kits as shown in Figure 3. Standard tool sets were provided, however, there were specific deletions of certain items in a continuous set when no particular task could be identified that required that individual tool. Obvious debris generators (saws, drills, etc.) and all types of test equipment were excluded from the initially launched inventory of maintenance equipment.

Tool and Equipment Description

The complete Skylab tool/maintenance equipment inventory initially launched on-board the SWS is listed in ref. 1, Appendix page 1-3. The categorization of the tool/maintenance equipment consists of the following complement of five basic kits:

- (1) Tool Kits 1 and 2 were stowed in two experiment compartment stowage lockers, E623 and E624 as shown in Figure 4. Each tool kit (Figures 5 and 6) was a portable, drawered metal box with a carrying handle. Each tool kit had five drawers mounted on tracks as shown in Figure 6 with drawer 2c removed for use as a separate unit.
- (2) The portable repair kit (Figures 4 and 7) located in the OWS, locker E620, contained supplies to perform meteoroid puncture repairs on the pressurized SWS structure, miscellaneous house-keeping repairs, and atmosphere leak detection. The teflon tape and sealant putty was provided for use in sealing joints, and

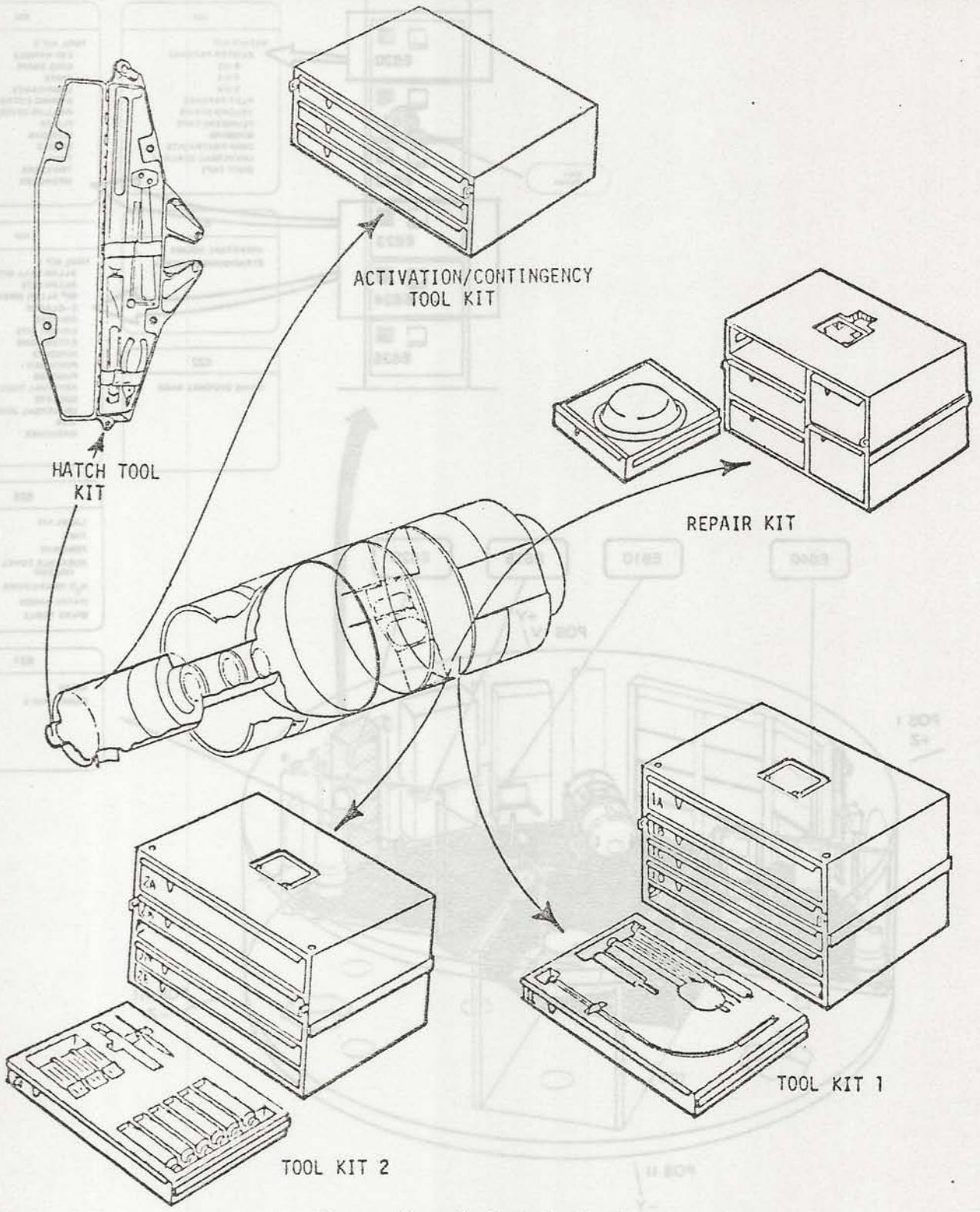


Figure 3 - Skylab Tool Kits

Figure 4 - Experiment Compartment Storage Locations

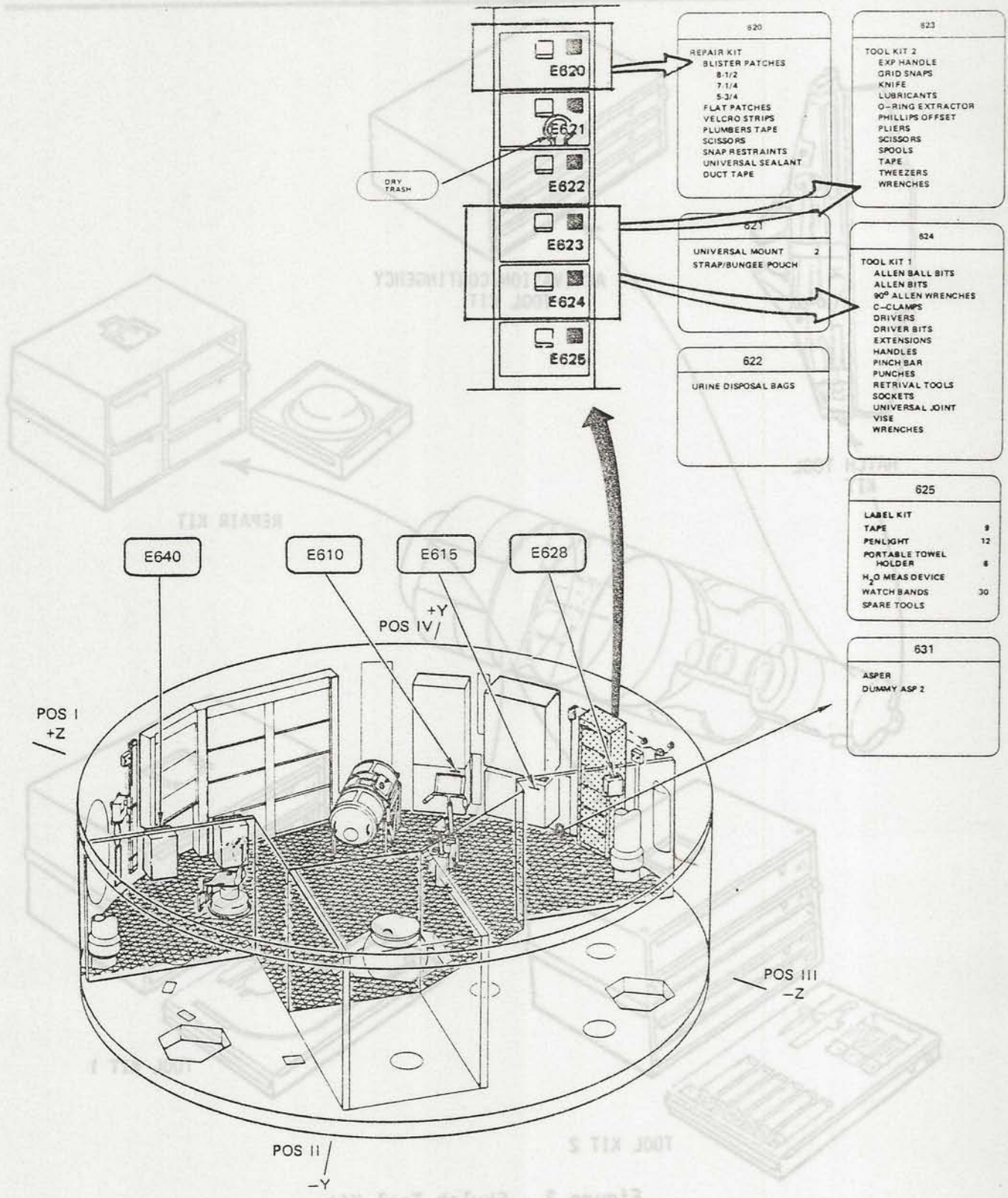


Figure 4 - Experiment Compartment Storage Locations

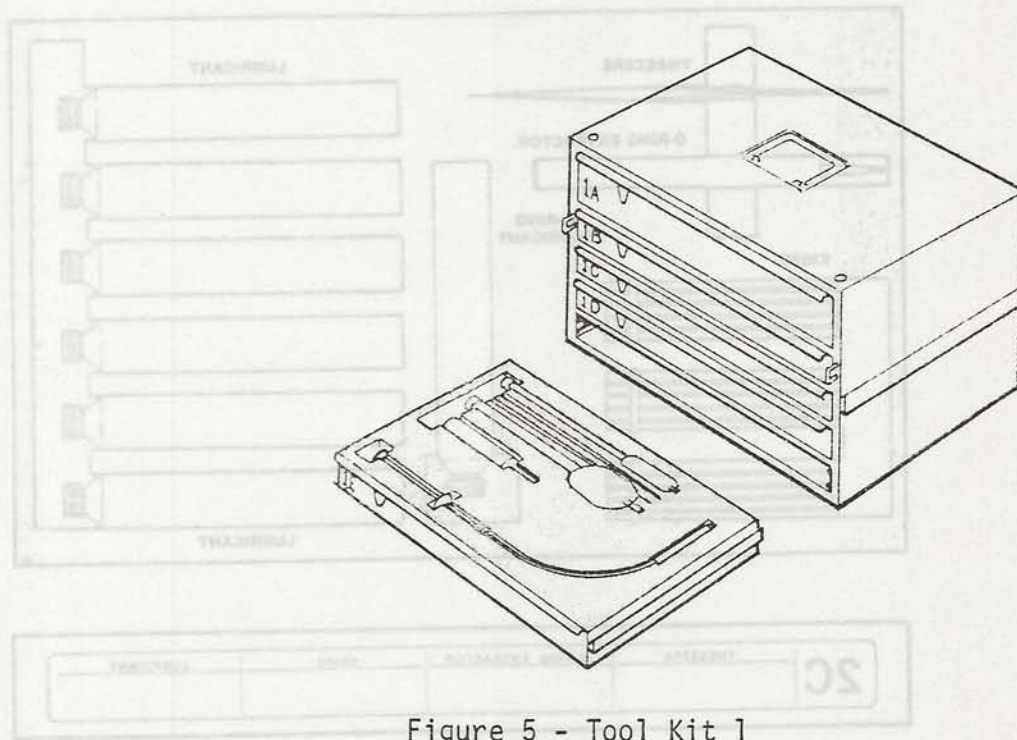
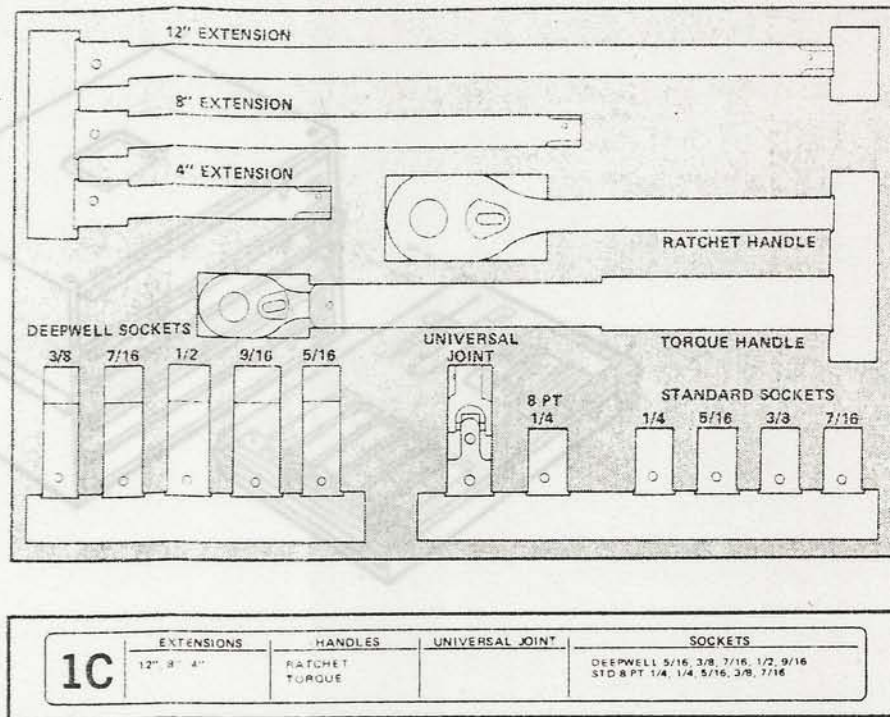
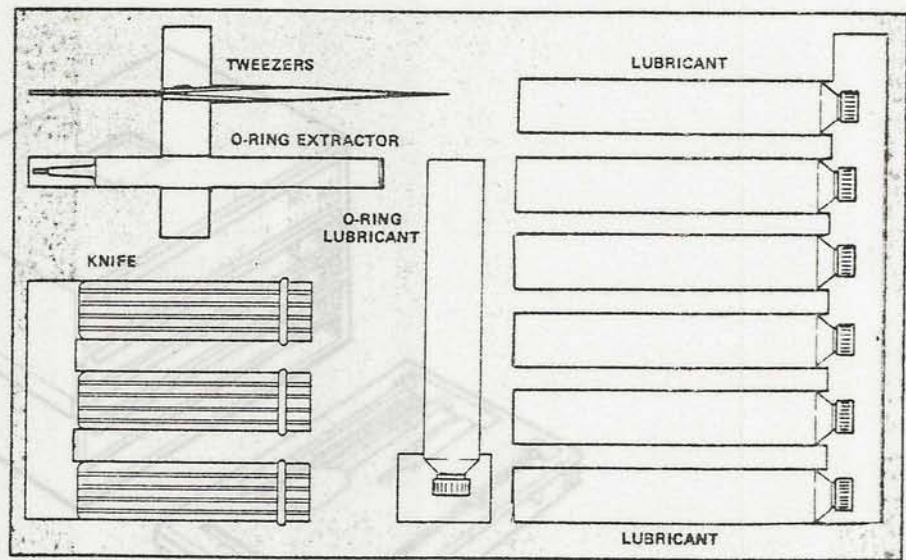
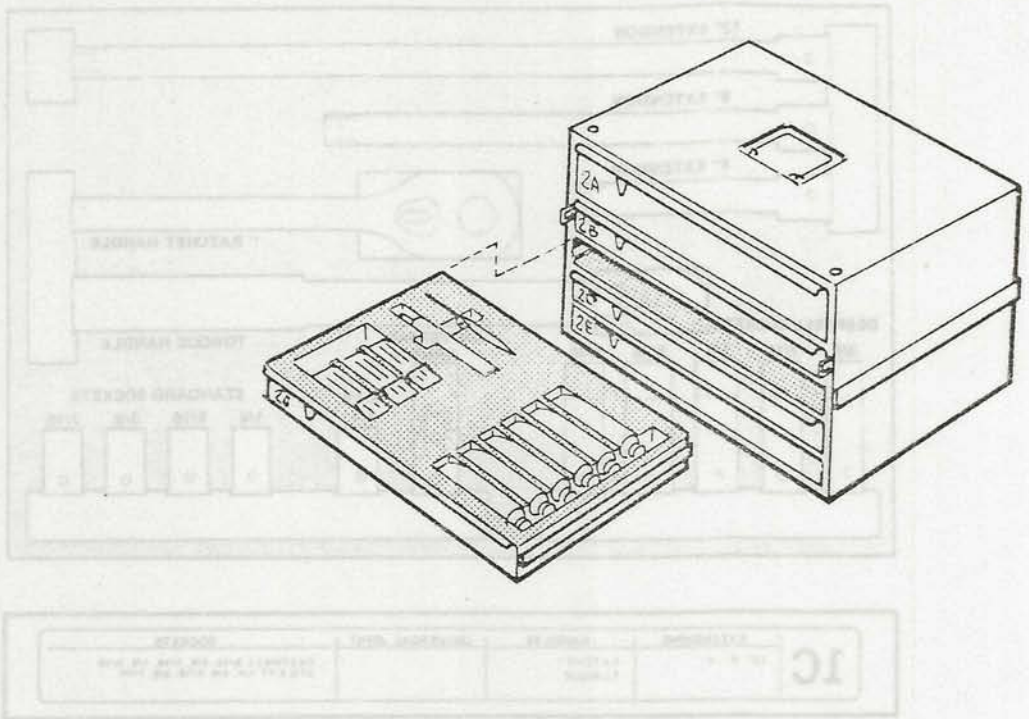


Figure 5 - Tool Kit 1

Figure 5 - Tool Kit 1



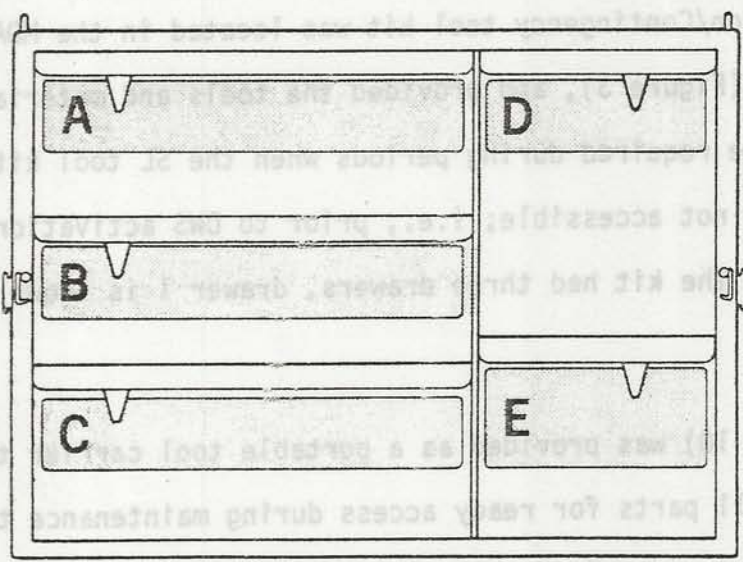
2C	TWEEZERS	O-RING EXTRACTOR	KNIFE	LUBRICANT

Figure 6 - Tool Kit 2

A	BLISTER PATCHES	
	$8\frac{1}{2}$	

B	BLISTER PATCHES	
	$7\frac{1}{4}$	

C	BLISTER PATCHES	FLAT PATCHES
	$5\frac{1}{4}$	



D	PORTABLE LEAK DETECTOR AND ACCESSORIES	

E	VELCRO STRIPS PLUMBERS TAPE SCISSORS SNAP RESTRAINTS UNIVERSAL SEALANT DUCT TAPE	

Figure 7 - Repair Kit

tape was also provided to repair fabric damage to items such as air ducts and sleep privacy curtains. Adhesive-backed Velcro and grid mounted snaps were provided to allow for convenient restraint of repair kit stowed items.

- (3) The MDA hatch tool kit (Figure 8) located on the forward side of the MDA axial port hatch contained tools required for disassembly of the AM forward hatch, AM aft hatch, and OWS hatch, should a hatch jam during opening. The kit contained sockets, a ratchet handle, a pinch bar, wrenches, a tool caddy, and a utility belt.

- (4) The Activation/Contingency tool kit was located in the MDA locker M144 (Figure 3), and provided the tools and materials that might be required during periods when the SL tool kits in the OWS were not accessible; i.e., prior to OWS activation and during EVA. The kit had three drawers, drawer 1 is shown in Figure 9.

The tool caddy (Figure 10) was provided as a portable tool carrier to restrain tools and small parts for ready access during maintenance tasks. Large or long tools were restrained through use of pockets. Elastic strips and two see-through pouches with slotted, fluorocarbon rubber diaphragms on one side, provided temporary stowage for small tools and small parts. Three tool caddies were provided.

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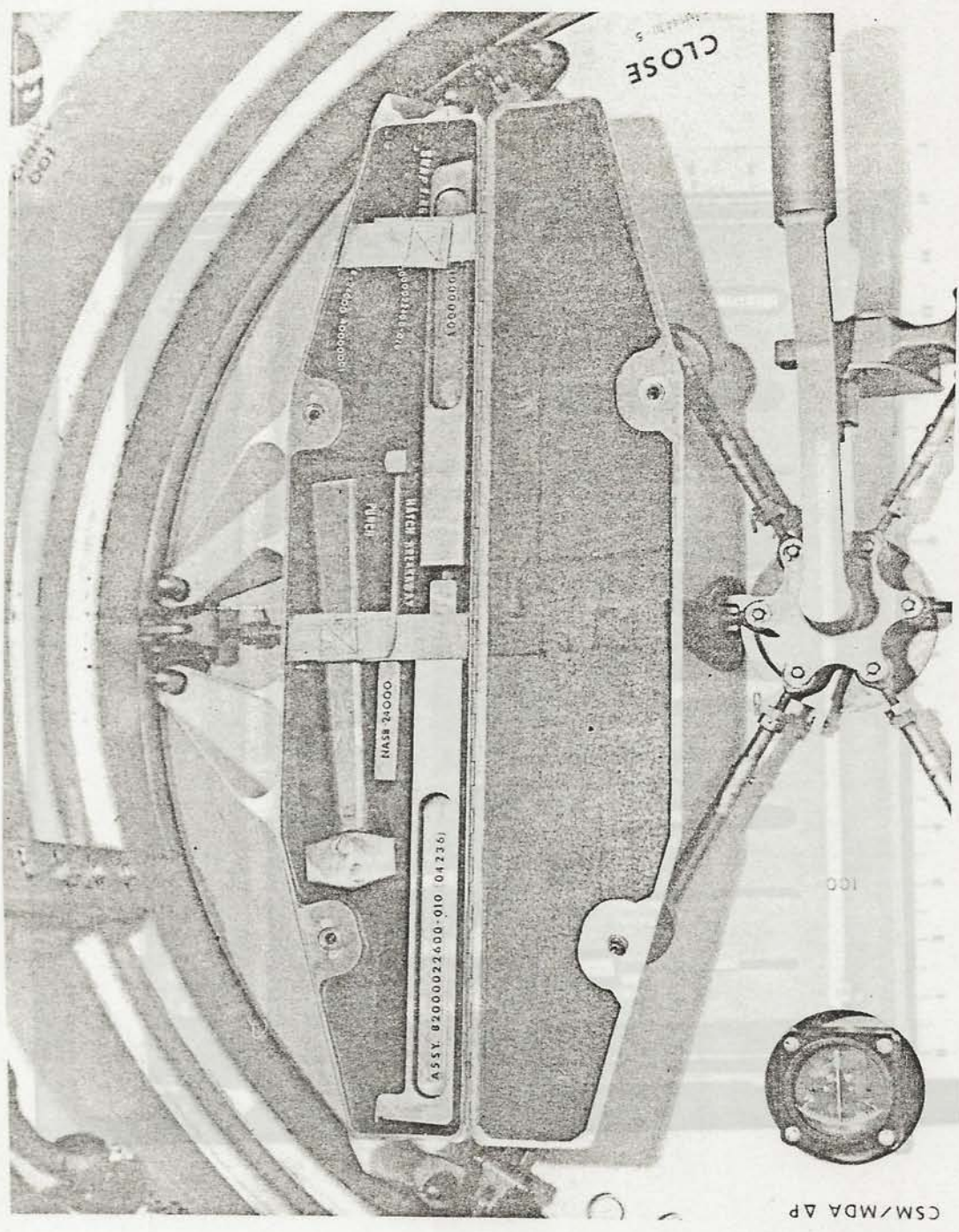


Figure 8 - MDA HATCH TOOL KIT

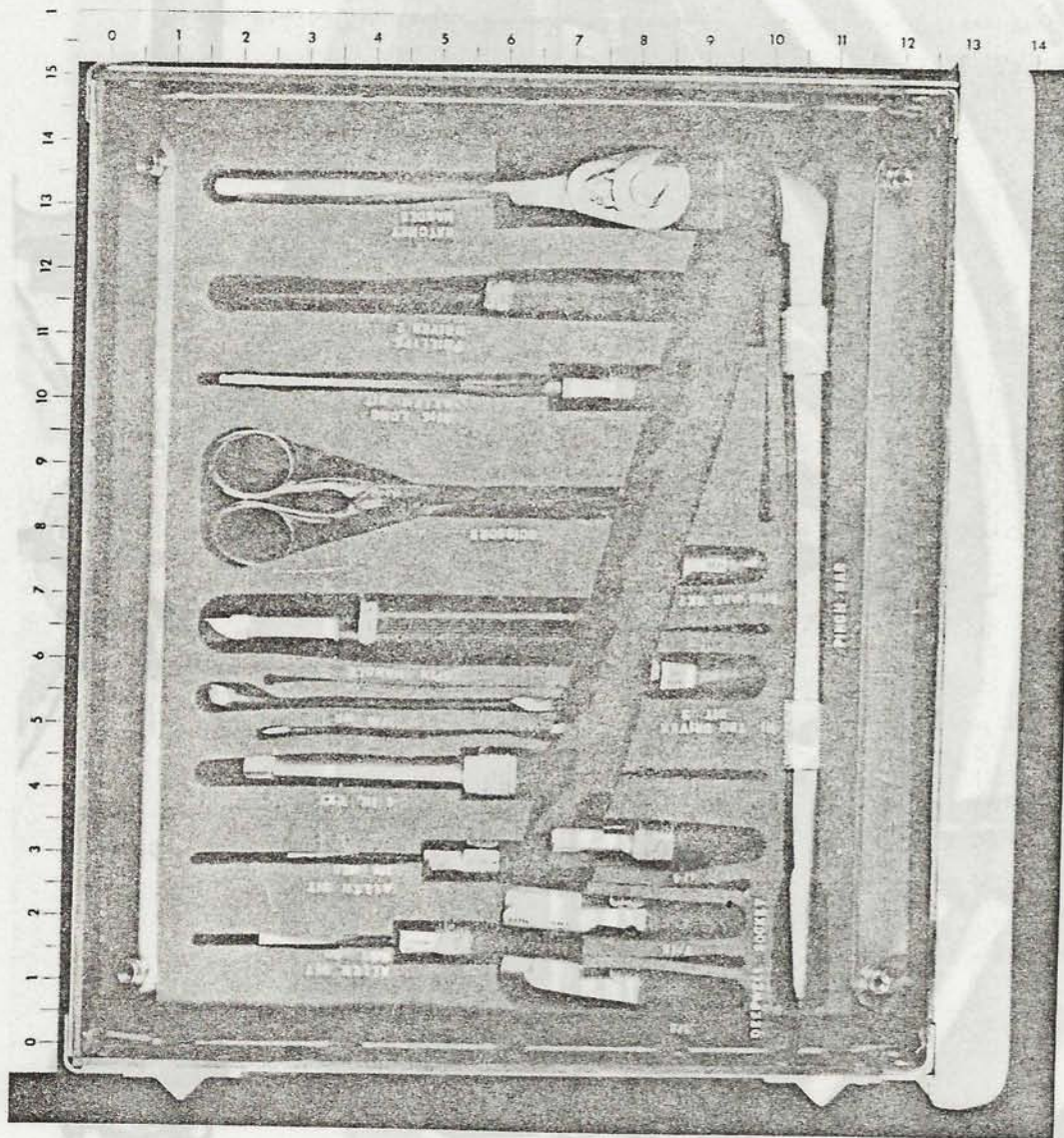


Figure 9 - DRAWER 1, ACTIVATION/CONTINGENCY TOOLS, MDA

The portable utility belt (Figure 11), an adjustable belt worn around the crewman's waist, was used to restrain the tool caddy, disposable bags, and miscellaneous items while conducting maintenance tasks.

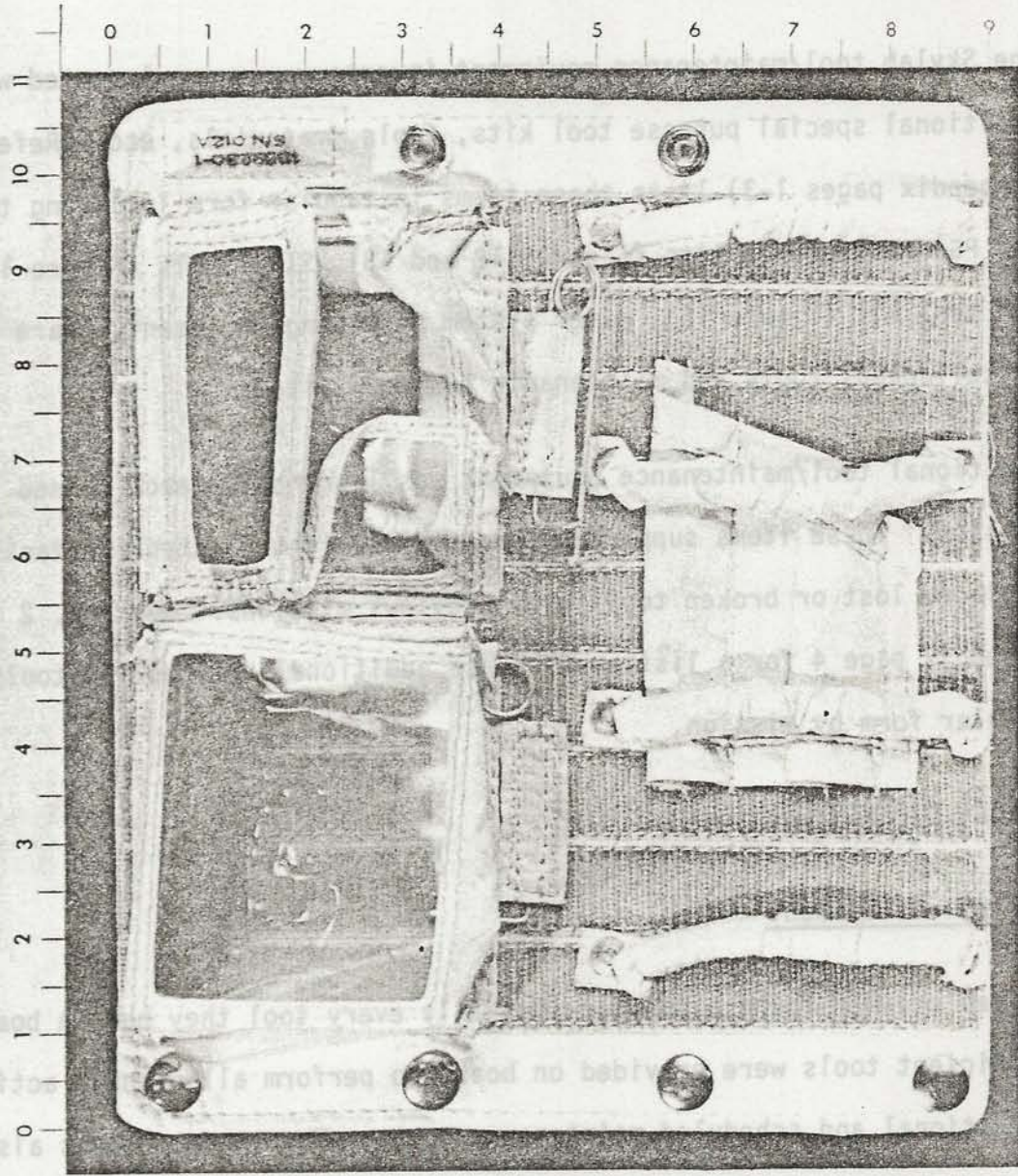


Figure 10 - SWS TOOL CADDY, P/N 1B89230-1
(TOOL CADDY)

proved to be adequate for most of the unscheduled and contingency maintenance tasks. However, some additional tools were required and launched onboard the three CSM's to provide capability to correct equipment

The portable utility belt (Figure 11), an adjustable belt worn around the crewman's waist, was used to restrain the tool caddy, disposable bags, and miscellaneous items while conducting maintenance tasks.

The Skylab tool/maintenance equipment inventory was supplemented with additional special purpose tool kits, tools, materials, etc. Reference 1 (Appendix pages 1-3) lists these items in tabular form including the EMU and PGA maintenance kits (Figures 12 and 13), S190 tools (Figure 14), CSM tool kit (Figure 15), water system servicing equipment, spare and miscellaneous tools and maintenance equipment items.

Additional tool/maintenance equipment was launched on each manned mission. These items supported specific inflight maintenance tasks and replaced lost or broken tools from previous missions. See ref. 2 Appendix page 4 for a listing of these additional, resupplied tools in tabular form by mission.

SKYLAB EXPERIENCE

Overall Assessment

Skylab crewmen found a use for virtually every tool they had on board. Sufficient tools were provided on board to perform all planned activation, operational and scheduled maintenance tasks. The onboard tools also proved to be adequate for most of the unscheduled and contingency maintenance tasks. However, some additional tools were required and launched onboard the three CSM's to provide capability to correct equipment

LIBRARY IS - ONE INTERVIEW KIT, ENH* b/w V57B-208000-01
(ONE INTERVIEW KIT, ENH)

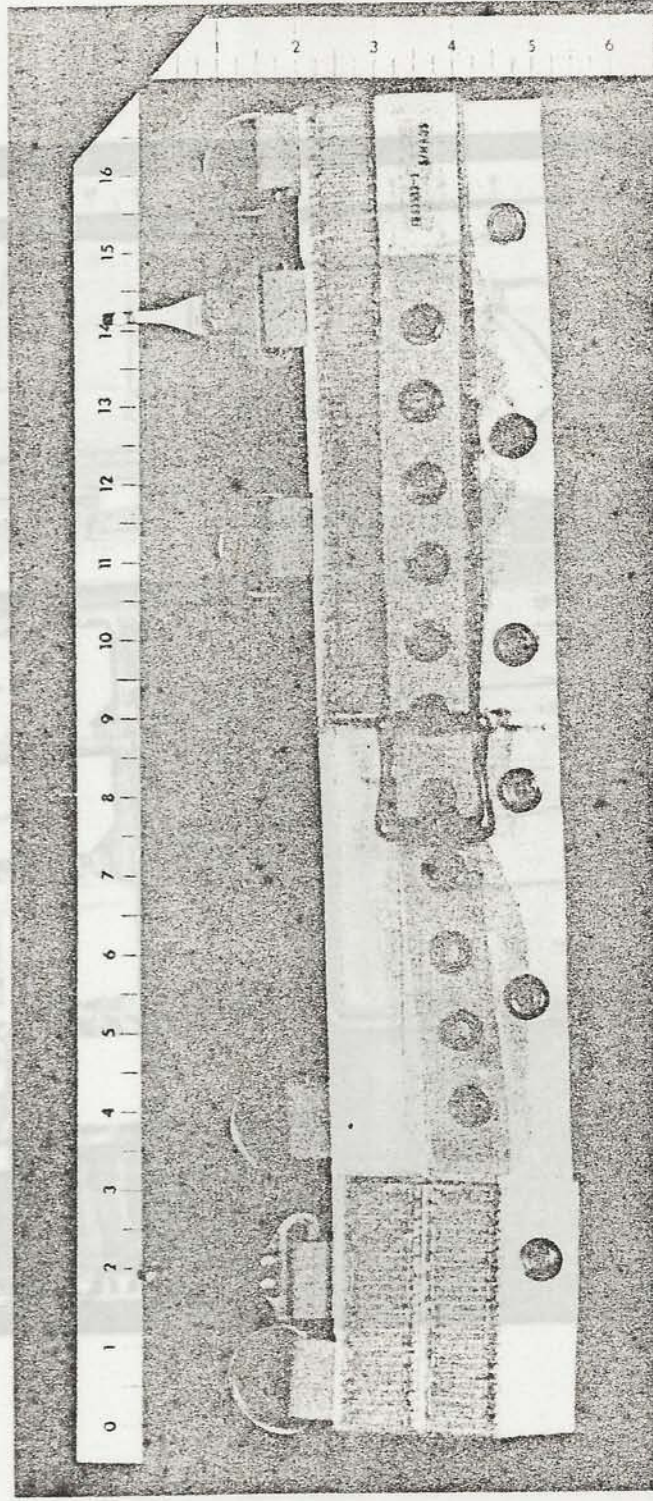


Figure 11 - UTILITY BELT, P/N 1B83593-1
(UTILITY BELT)

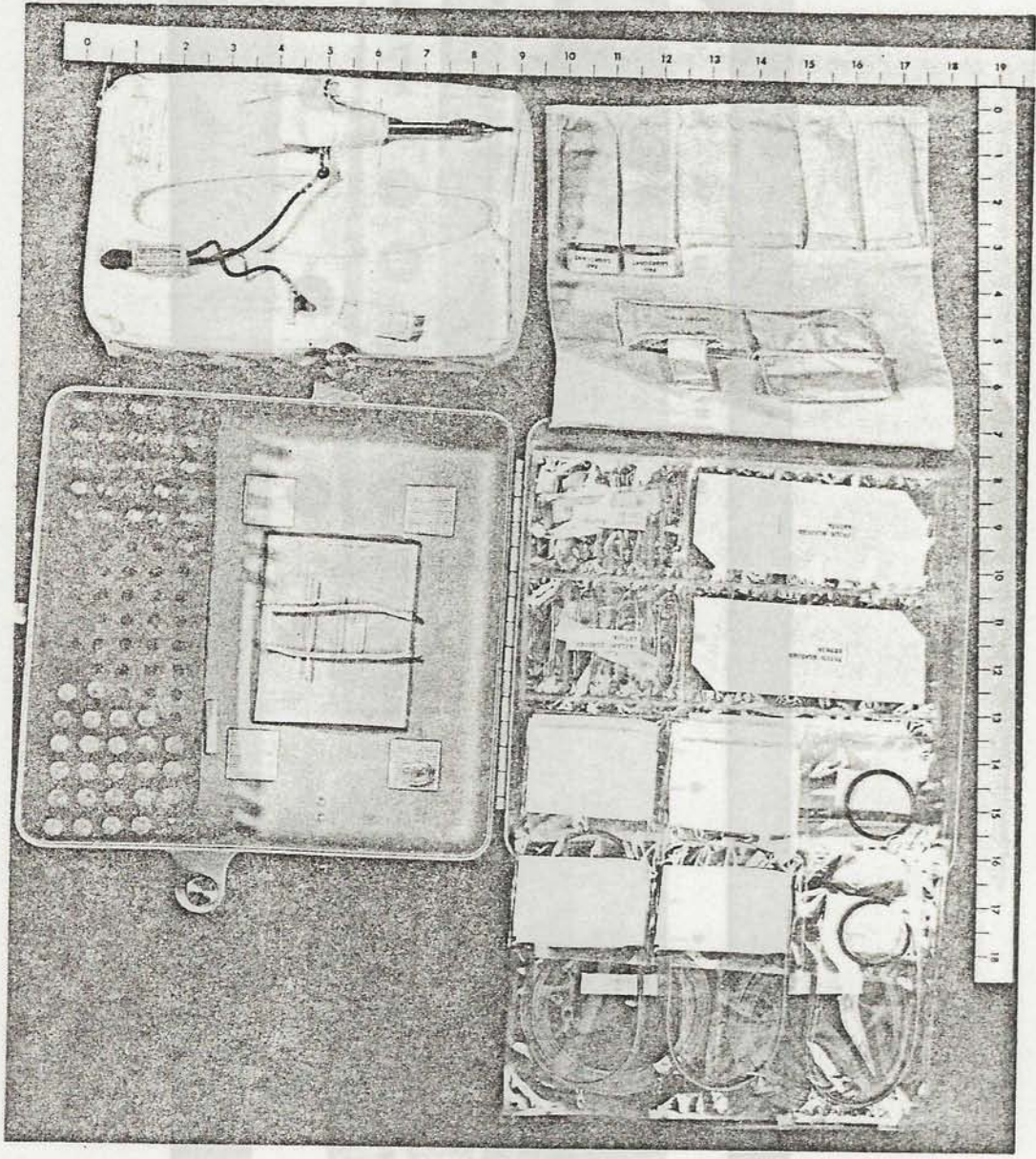


Figure 12 - OWS MAINTENANCE KIT EMU, P/N A7LB-508000-01
(OWS MAINTENANCE KIT, EMU)

(UNCLASSIFIED)
L-ERESOL M/TM YLITD 11 870011
L-ERESOL M/TM YLITD 11 870011

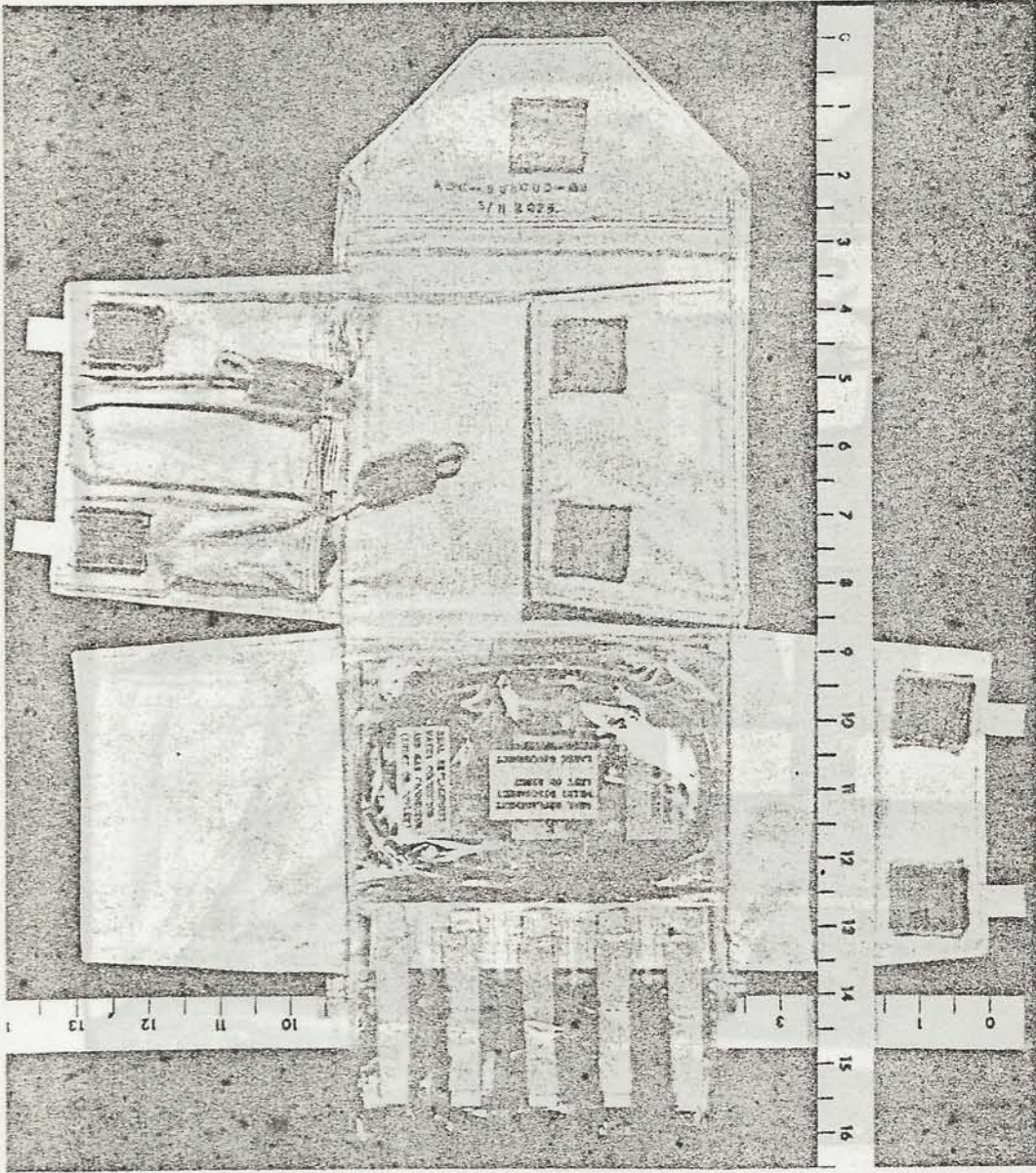


Figure 13 - PGA MAINTENANCE KIT, P/N A6L-503000-11 (PGA MAINTENANCE KIT)

PGA MAINTENANCE KIT

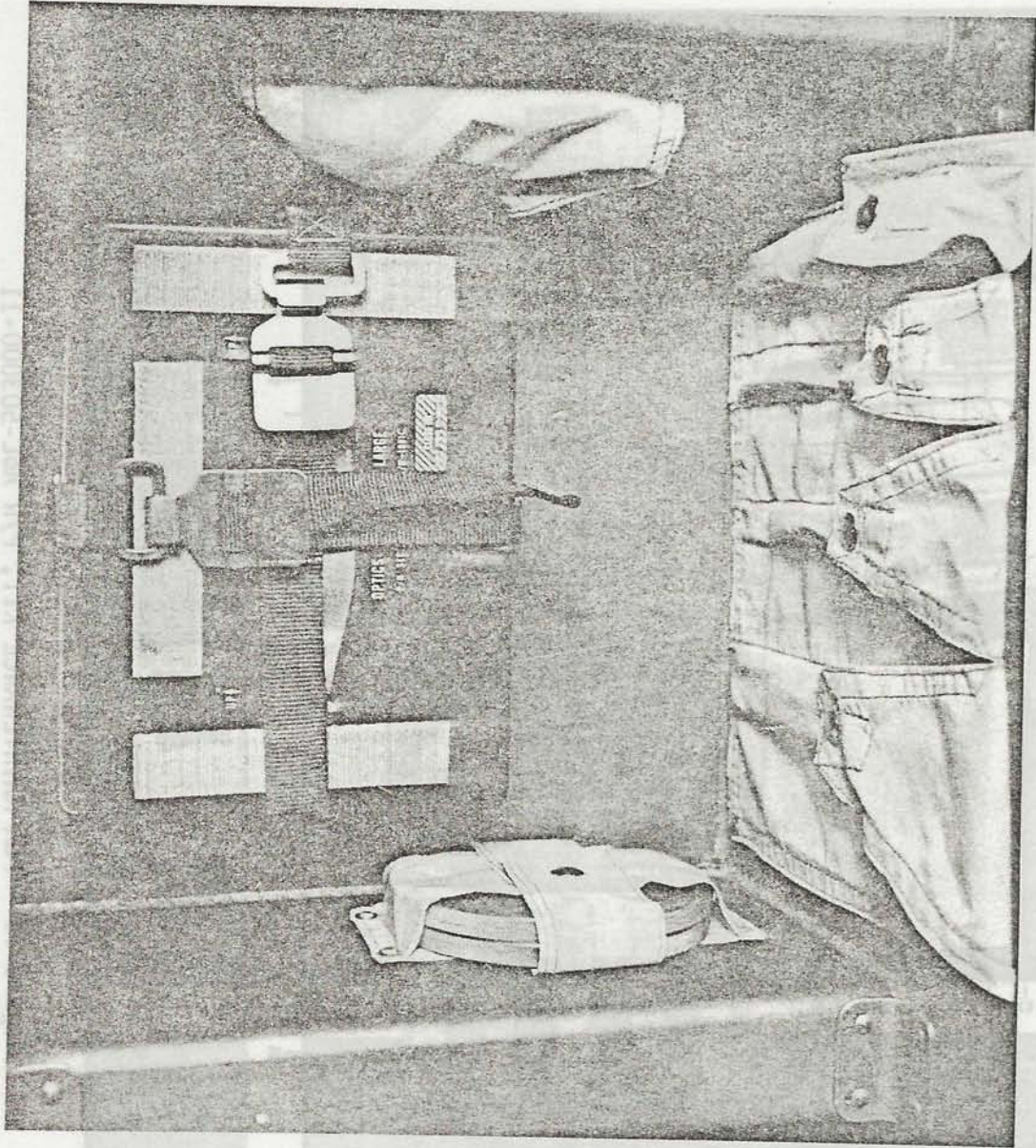


Figure 14 - S190 TOOL KIT

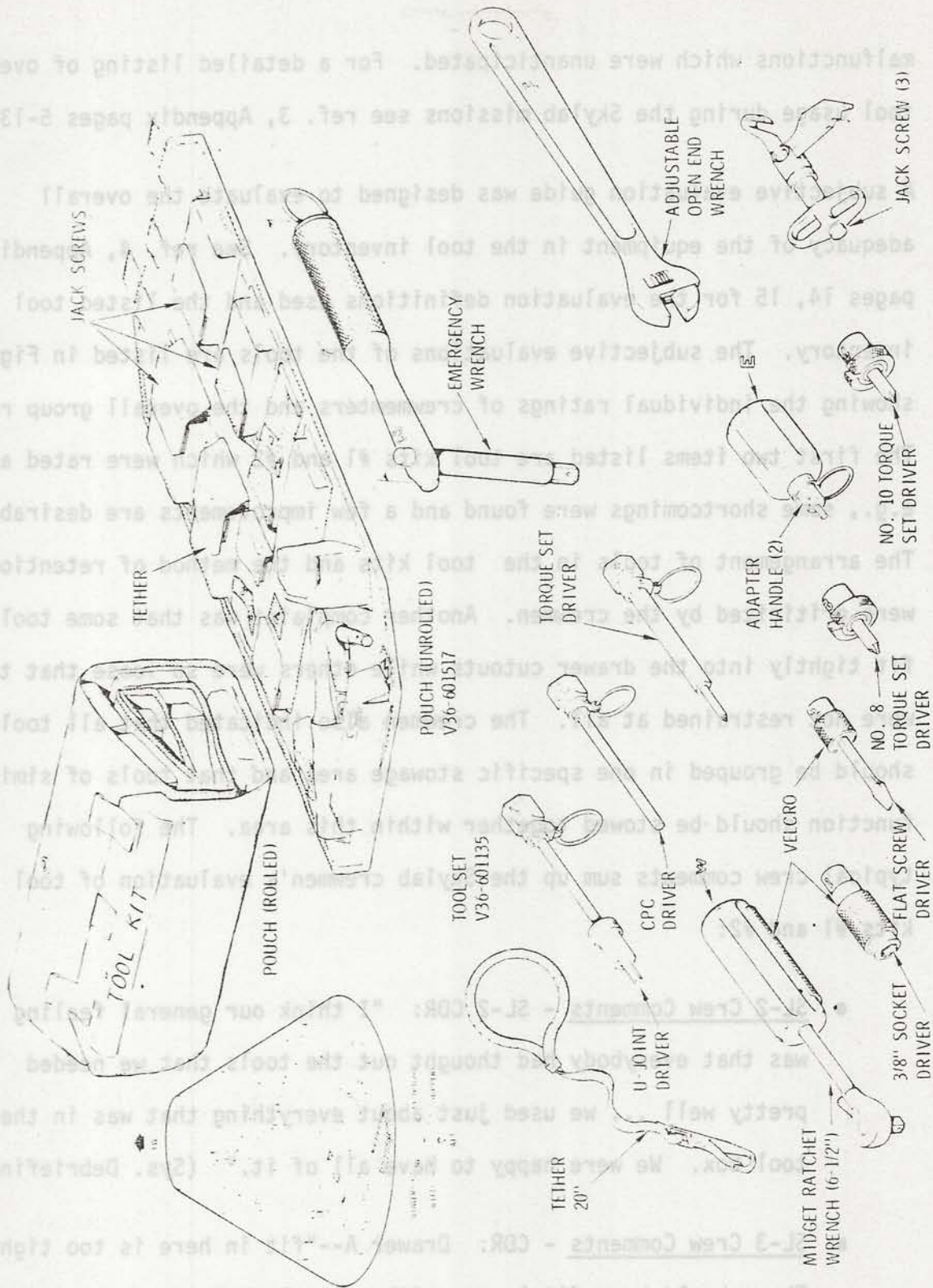


Figure 15 - Crewman Toolset

malfunctions which were unanticipated. For a detailed listing of overall tool usage during the Skylab missions see ref. 3, Appendix pages 5-13.

A subjective evaluation guide was designed to evaluate the overall adequacy of the equipment in the tool inventory. See ref. 4, Appendix pages 14, 15 for the evaluation definitions used and the listed tool inventory. The subjective evaluations of the tools are listed in Figure 16, showing the individual ratings of crewmembers and the overall group rating. The first two items listed are tool kits #1 and #2 which were rated adequate, e.g., some shortcomings were found and a few improvements are desirable. The arrangement of tools in the tool kits and the method of retention were criticized by the crewmen. Another complaint was that some tools fit tightly into the drawer cutouts while others were so loose that they were not restrained at all. The crewmen also indicated that all tools should be grouped in one specific stowage area and that tools of similar function should be stowed together within this area. The following typical crew comments sum up the Skylab crewmen's evaluation of tool kits #1 and #2:

- SL-2 Crew Comments - SL-2 CDR: "I think our general feeling was that everybody had thought out the tools that we needed pretty well ... we used just about everything that was in the tool box. We were happy to have all of it." (Sys. Debriefing)
- SL-3 Crew Comments - CDR: Drawer A--"fit in here is too tight. They should have fit looser with a little Velcro on them to hold

Figure 16 - SUBJECTIVE EVALUATION (TOOLS)

TOOL INVENTORY	INDIVIDUAL RATINGS												SL GROUP RATING SL PROGRAM
	SL-2 MISSION			SL-3 MISSION			SL-4 MISSION			SPT	SL GROUP RATING SL PROGRAM		
	CDR	PLT	SPT	CDR	PLT	SPT	CDR	PLT	SPT				
1. Tool Kit #1	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Very Good	Adequate	Excellent	Adequate	Excellent	Adequate	
2. Tool Kit #2	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Very Good	Adequate	Excellent	Adequate	Excellent	Adequate	
3. Repair Kit	No Comment (N.C.)	N.C.	N.C.	Adequate	Adequate	Not Used	None	None	None	None	None	Adequate (SL-3)	
4. S190 Tool Kit	N.C.	Adequate	N.C.	None	Adequate	Not Used	None	Adequate	None	Adequate	None	Adequate (1 CM User per Mission)	
5. M512 Tools	Adequate	Adequate	Adequate	Adequate	Not Used	Not Used	None	None	None	Very Good	None	Adequate	
6. EMU Maint. Kit	N.C.	N.C.	N.C.	Adequate	Not Used	Adequate	Adequate	Not Used	Excellent	Very Good	Excellent	Adequate (SL-3) Very Good (SL-4)	
7. Tool Caddy	Not Used	Activation Only	Activation Only	Unacceptable	Poor	Not Used	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	
8. Tools, MDA	Adequate	Adequate	Adequate	N.C.	N.C.	Adequate	N.C.	Adequate	N.C.	Adequate	N.C.	Adequate (1 CM User per Mission)	

em down in their places" ... "screwdriver bits ought to be located in order of size" ... "There's Velcro on the tools but there's no Velcro on the drawer" ... "tools should be arranged systematically."

PLT: tool kit number 1 and 2 ... "we got a wide assortment of tools and they're most of the tools that we need to do the job" ... "the tools don't fit the Mosite very well. They're loose and we had to put tape around them or over them to keep them in."

- SL-4 Crew Comments - CDR: "Tool kit number 1 and 2. I would essentially rate them as very good."

SPT: "First of all just the general packaging. I think the idea of the soft packaging is all right."

PLT: "...there ought to always be a separator between drawers to keep stuff from the lower drawer from coming up and jamming the drawer above. This is a general point of philosophy that should apply throughout the workshop .. it's very frustrating, and I know that the other flights have experienced the same problem because the tools that are always floating free had been taped in by a previous crew.' ... 'a major shortcoming of the tool kits is the stowage provided for them.' 'You can take 50 pounds of force to pull the tool out one time, and then the next time you put it in there, it floats free and jams the drawer.' ... 'the Mosite cutout method of restraint is not satisfactory."

The other items listed in the tool inventory of the subjective evaluation format (Figure 16) were also rated as adequate except the tool caddy which was rated unacceptable. The repair kit was rated as adequate by the SL-3 CDR but it had a low use rate because crewmen did not have much to repair where the kit equipment could be utilized. The S190 maintenance kit did not have a high use rate but one crewman user per mission rated the kit as adequate.

The SL-3 CDR rated the M512 tools as adequate but redundant. The EMU maintenance kit was rated as adequate by the SL-3 crew (CDR and SPT) and rated very good by the SL-4 CDR and SPT. The tool caddies were used on several occasions but proved to be inadequate for retaining tools at the worksite. Two of the SL-2 crewmen used it for activation only, two crewmen never used it and the group consensus was that the tool caddy was unacceptable, i.e., gross shortcomings were found and improvements are mandatory. The MDA tools were rated as adequate by one crewman user per mission. The SL-4 PLT complained that "the items come out of their stowage locations and jam the drawers."

Examples of typical tool use situations are presented in the following sections to illustrate the need for tools and their many applications during the course of a given mission.

IVA Tool Usage

Onboard tools, spares and procedures were adequate for all scheduled IVA IFM activities. However, a number of additional tasks were added and

the frequency of performance was varied. See ref. 5, Appendix page 16 for a listing of the scheduled IVA IFM tasks conducted during the Skylab missions.

Typical tool and equipment usage for scheduled IVA IFM tasks are listed below as representative examples of the range of IFM tasks accomplished by the Skylab crews. Parenthetical comments address crew tool usage for each case.

1. Periodic Cleaning - Vacuum cleaned OWS heat exchanger vanes, ECS inlet screens, OWS air mixing chamber, MDA and AM circulating fans, WMC debris (coarse, coarse/fine, fine) filters, etc. (vacuum cleaner).
2. Consumable Replacement - WMC filter and charcoal cartridge (screwdriver, 5/32 square bit, spin type handle, pliers). WMC odor control filter (ratchet handle, handle-torque, 5-150 in-lbs, 1/2 in. deep-well socket). Urine separator (bit, screwdriver, 3/16 hex., 5 in. shank, 4 in. shank, and spin type handle).

Typical tool usage for unscheduled IVA IFM tasks are listed below, parenthetical notes related to tools actually used.

1. Video tape recorder replacement (5/16 in. open end wrench, 11/32 open end wrench, ratchet handle - 5-150 in-lbs, universal joint, screwdriver - 5/32 sq. bit, 3/16 hex. - 2 in. and 5 in. shanks, 3/16 hex-90 degree, hi-torque No. 3, 4 in. and 8 in. extensions).

2. Replace TV input station (9/16 in. open end wrench, pliers, ratchet handle, universal joint, 4 in. extension, 3/8 in. std. socket).
3. Replace WMC hot water dispenser valve (torque wrench, 0-600 in. lbs, 4 in. extension).
4. Replace Mol Sieve Fan (pliers, connector, electrical).
5. TV power cable checkout/replacement (digital multimeter).
6. Replace AM Tape Recorder (Std. screwdriver - 3/16 blade)
7. Replace Teleprinter Assembly (Screwdriver - 5/32 hex, ratchet handle).
8. Replace fire sensor control panel (screwdriver, 5/32 hex, pliers, connector, electrical).

Tools and materials were also placed on-board Skylab to provide a general maintenance capability in order to permit repair of failed equipment for which no specific IVA IFM activity was anticipated. Additional maintenance tools and equipment were launched on-board the three CSM's to provide capability to correct equipment malfunctions which were unanticipated.

Typical tool and equipment usage for contingency IFM tasks are listed below. Parenthetical notes indicate tools used for each event.

1. Condensate System Leak Check (open end wrenches - 9/16 inch and 11/16 in., adjustable wrench, 1-3/8 in. crowfoot wrench, torque wrench, 0-600 in-lbs, socket-std, 3/8 in., ratchet handle).

2. Install Rate Gyro Package (Multimeter, open end wrench, and the following RGP tools - ratchet handle - 1/4 in. drive, extension - 6 in. - 1/4 in. drive, universal joint - 1/4 in. drive, ratchet handle - 3/8 in. drive, screwdriver - bit, 3/16 hex - 1/4 in. drive, screwdriver - bit - Hi Torque No. 3 - 1/4 in. drive, removal tool-cable plug and socket - deepwell - 9/16 in. thin-wall).

3. S009 Drive Motor Replacement (ratchet handle, screwdriver - bit - 3/32 hex - 3-1/2 in. shank, screwdriver - Phillips No. 1, and pliers - pin straightener - electrical connector).

4. Ergometer Pedal Screw Replacement (Swiss Army Knife, handle-torque 5-150 in-lbs, vise-bench type).

5. Dump Probe Troubleshooting (multimeter, spin type handle, seal assembly).

6. Remove Video Tape Recorder Circuit Boards (screwdriver - bit - 3/16 hex - 90 degree, extension - 4 in., std. screwdriver - 3/16 blade).

7. Primary Coolant Loop Servicing (screwdriver - bit - 3/16 hex - 3-1/2 inch, handle torque - 5-150 in-lbs, 3/8 in. std. socket, pressure sensitive tape).

8. S019 Extension Mechanism Repair (spin type handle, Phillips No. 1 screwdriver).

9. S192 Attenuator Adjustment (Swiss Army Knife - filed blade for screwdriver).

10. Install T027 Tripod (screwdriver - bit - 3/16 hex - 5 in. shank, ratchet handle).

Tools were also placed on-board Skylab to support the many servicing functions (assembly/disassembly) required as each new crew came on-board. This was an especially active period for the SL-2 crew during the initial activation of the OWS. Some duplicate tools were included for use during activation when the same tool was concurrently required by two crewmen.

Typical tool usage for activation tasks are listed below. Parenthetical notes indicate actual tools used.

1. Remove Trash Airlock Launch Restraints (screwdriver, bit - 3/16 hex - 90 degree, handle-speeder brace type, screwdriver - bit - 3/16 hex - 5 in. shank).

2. Shower Activation (screwdrivers (1/4 and 5/32 hex), pliers - connector - electrical, ratchet handle, spin type handle and 7/16 in. std. socket).

3. SAL Window Initial Installation (spin type handle and 7/16 in. std. socket).

4. Remove Food Tray & Table Cover Launch Restraints (screwdriver - bit 3/16 hex - 2 in. shank, ratchet handle).

5. Unstow M509 AME from Launch Configuration (screwdriver - bit, 3/16 hex - 2 in. shank, ratchet handle, 8 in. extension 7/16 in. deep-well socket).
6. Vacuum Cleaner Activation (pliers - needle nose, spin type handle).
7. Install CSM/MDA Interchange Duct (screwdriver - bit, 5/32 square).
8. Fecal/Urine Collector Activation (screwdriver - 5/32 hex, ratchet handle).

EVA Tool Usage

It should be noted that none of the tools in the initial tool inventory were designed for EVA usage. In order to properly interface with the EVA glove, tool handles had to be enlarged by wrapping them with tape. Since the tools were not equipped with tethers or tether attach points, it was necessary to also use tape to attach the required tethers. However, the tools proved to be adequate for EVA after handles were taped and tethers attached.

See ref. 2, Appendix page 4 for a listing of the special tools launched to support the SEVA operation, parasol deployment (on SL-2 and SL-3), and the IVA/EVA rate gyro package installation.

The following list of typical EVA tool usage tasks will indicate the extensive use made of tools in the EVA environment. Parenthetical notes address the actual tools used.

1. SAS wing deployment (cable cutter, double prong tool, metal cutter, mushroom tool, wing deployment tool)(see Figure 17).
2. Freeing of relay in CBRM #15 (ball peen hammer).
3. EVA portion of Rate Gyro 6-pack installation (special electrical connector pliers and 24 ft. cable).
4. S055, S056, and S082A door ramp latch removal (7/16-inch open end/box wrench).
5. S193 Antenna repair (vice grips, hammer, screwdriver, allen bit, connector pliers, disable plug and jumper box).
6. S054 filter wheel repair (screwdriver, penlight, extension mirrors).
7. Zero-g fixture cover retrieval (ratchet wrench and straight screwdriver blade attachment).

Tool Losses and Failures

During the Skylab missions, a ratchet handle failed, the 4-inch diagonal cutters and a 5-inch long, 3/16-hex screwdriver bit were broken and a pinch bar was lost.

The ratchet handle mechanism fell apart during activation. The 4-inch diagonal cutters were broken during an attempt to remove the spheres from the M553 sphere forming wheel. The 5-inch long, 3/16-hex screwdriver

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SOLAR ARRAY SYSTEM TOOLS

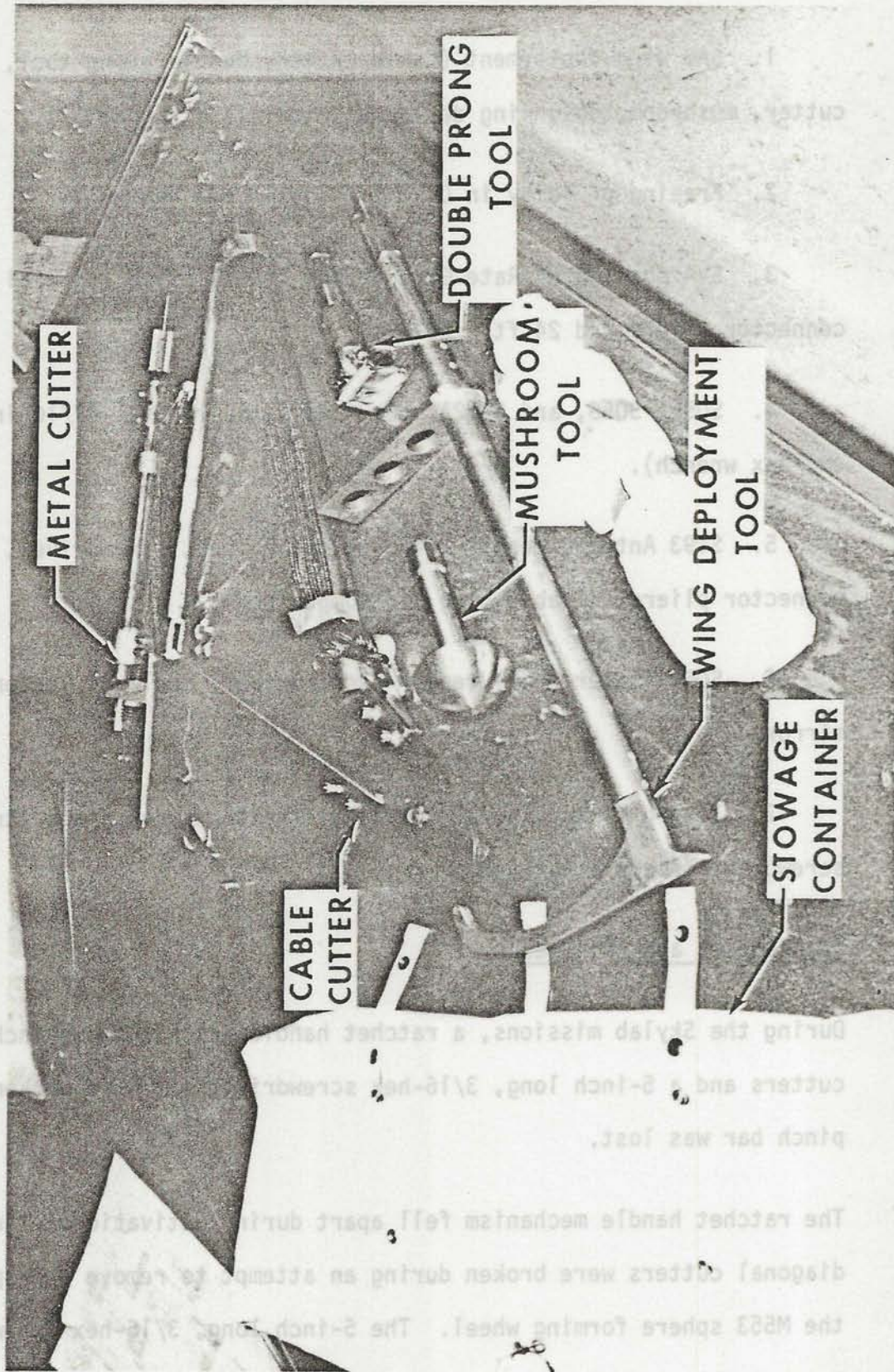


Figure 17 - SAS Wing Deployment Tools

bit was defective, i.e., the bit shank turned in the socket adapter. The pinch bar was left tethered to the SAS wing during the OWS solar wing deployment EVA.

Post Mission "Tools Needed" Evaluation

During inflight and postflight debriefings the crews expressed preference for the following "tools needed" which were not within their on-board inventory:

- SL-2 Crew Comments - hacksaw, hand and power drills, whetstone, rubber mallet, metal shears, and files (rattail and round file).
- SL-3 Crew Comments - hacksaw, electric drill with bits, epoxy, drill, soldering iron, crimpers, emery cloth, oil and polishing cloth, pair of good dykes, good strong wire cutters, cable cutters, and "a good light that you wear on your head".
- SL-4 Crew Comments - crimper/cutter, soldering gun, files, electrician's screwdriver, metals shears, rubber mallet, hacksaw, additional screwdrivers and wrenches (high use rate), additional rolls of tape, screwdrivers with larger blades, file on Swiss Army knife, pegboard, and leak detector.

CONCLUSIONS/RECOMMENDATIONS

1. If viable inflight maintenance programs are to be implemented on future manned missions, a complete range of hand tools, test

- equipment, and maintenance consumables should be included within the onboard inventory.
2. Unplated IVA tools should be designed for compatibility with EVA use.
 3. The Skylab crewmen demonstrated that tools could be effectively employed (IVA and EVA) in the zero-g environment.
 4. A tool summary or listing should be available onboard for crew visibility of the entire tool inventory during future manned spacecraft missions.
 5. Skylab manned mission experience indicates that future spacecraft tool kit design should include tools that don't have a preflight specific use, but might be used, rather than justifying each onboard tool before flight. This will result in a more complete off-the-shelf tool inventory for IFM contingency tasks.
 6. The Skylab crewmen concluded that the tool caddy was unacceptable for off-line maintenance tasks. Design studies should be implemented to develop a more useful tool transport and retention device.
 7. All tools should be stowed in one specific area.
 8. Sufficient tools were provided onboard to perform all planned maintenance tasks. Off-the-shelf type hand tools were adequate and no special features are required for use in space.

9. Based on Skylab experience, additional tools should be added to the tool inventory, especially those needed but not available aboard Skylab, e.g., hacksaw, hand or power drill, whetstone, metal shears, crimper/cutter, soldering iron crimpers, soldering gun, rubber mallet, leak detector, emery cloth, oil and polishing cloth.
10. Tools should be arranged systematically in the tool kit drawers with separators between drawers to keep tools in the lower drawer from coming up and jamming the drawer above.

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- 9. SL-3 SWS Systems Debriefing (Exp. M-487 and M-516 Related Comments).
- 10. SL-4 SWS Systems Debriefing, JSC 08833, March 1974.

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6. Staff of NASA JSC, Training Office, Crew Training and Procedures Div.: Skylab 1/3 Technical Crew Debriefing Report JSC 08478, October 4, 1973.

7. Staff of NASA JSC, Training Office, Crew Training and Procedures Div.: Skylab 1/4 Technical Crew Debriefing Report JSC 08809, February 22, 1974.

RAW DATA APPENDIX

<u>REFERENCE</u>	<u>SOURCE</u>	<u>PAGE</u>
1	MSFC SL Crew Systems Mission Evaluation, August 1974, NASA TMX-64825, pp. 267, 268, 269	1
2	MSFC SL Crew Systems Mission Evaluation, August 1974, NASA TMX-64825, p. 270	4
3	MSFC SL Crew Systems Mission Evaluation, August 1974, NASA TMX-64825, pp. 272-280	5
4	SL-4 Evaluation Experiments Checklist and Log (Rev. A), October 11, 1973, NASA LBJ Space Center, pp. 3-6 and 3-7	14
5	MSFC SL Crew Systems Mission Evaluation, August 1974, NASA TMX-64825, p. 244	16

SKYLAB TOOL KITS 1 and 2	
TORQUE HANDLE	CONNECTOR PLIERS
TORQUE WRENCH	PIN STRAIGHTENER PLIERS
SPIN HANDLE	3/32 BLADE DRIVER
RATCHET HANDLE	3/16 BLADE DRIVER
SPEEDER HANDLE	PHILLIPS DRIVER 1
EXPERIMENT HANDLE	PHILLIPS DRIVER 2
4 INCH EXTENSION	PHILLIPS OFFSET DRIVER
8 INCH EXTENSION	HAMMER
12 INCH EXTENSION	1/16 PUNCH
SOCKETS	3/32 PUNCH
1/4 8 POINT STD SOCKET	3/16 PUNCH
1/4 STD SOCKET	0-RING EXTRACTOR
5/16 STD SOCKET	KNIFE
3/8 STD SOCKET	TWEEZER
7/16 STD SOCKET	RETRIEVAL MIRROR
SOCKETS	RETRIEVAL HOOK
5/16 DEEPWELL SOCKET	MECHANICAL FINGERS
3/8 DEEPWELL SOCKET	PINCH BAR
7/16 DEEPWELL SOCKET	VISE
1/2 DEEPWELL SOCKET	C CLAMP
9/16 DEEPWELL SOCKET	VELCRO-PILE
3/8 BLADE DRIVER BIT	VELCRO-HOOK
HI-TORQUE DRIVER BIT 1	3/4 INCH NEUTRAL TAPE
HI-TORQUE DRIVER BIT 2	1 INCH RED TAPE
HI-TORQUE DRIVER BIT 3	2 INCH NEUTRAL TAPE
1/16 ALLEN BIT	SAFETY WIPE
3/32 ALLEN BIT	LACING TWINE
7/64 ALLEN BIT	LUBRICANT
1/8 ALLEN BIT	H2O SYSTEM LUBRICANT
5/32 SQ ALLEN BIT	SCISSORS
5/32 ALLEN BIT	

Table 23. Skylab Tool/Maintenance Equipment - 1 of 3

<u>ACTIVATION/CONTINGENCY</u>	<u>UTILITY BELT</u>
<u>TOOL KIT</u>	TOOL 4 (TORQUE TIP 10)
SPIN HANDLE	TOOL 5
RATCHET HANDLE	TOOL 6 (TORQUE TIP 6)
4 INCH EXTENSION	CSM TETHER
1/4 DEEPWELL SOCKET	CSM JACK SCREW
5/16 STD SOCKET	S190 TOOLS
3/8 DEEPWELL SOCKET	S190 LARGE SPANNER WRENCH
7/16 DEEPWELL SOCKET	S190 SMALL SPANNER WRENCH
HI-TORQUE DRIVER BIT 3	S190 SCREWDRIVER
3/64 ALLEN WRENCH	S190 SCISSORS
1/4 WRENCH	S190 TAPE
1/8 ALLEN BIT	<u>WATER SYSTEM SERVICING</u>
5/32 SQ ALLEN BIT	<u>EQUIPMENT</u>
3/16 90 DEG ALLEN BIT	HOSE ASSEMBLY
3/16 LONG ALLEN BIT	JUMPER HOSE ASSEMBLY
ACCUTRON TIMER KEY	ADAPTER ASSEMBLY
1/16 ALLEN WRENCH	HOSE ASSEMBLY
7/16 WRENCH	DEIONIZER ASSEMBLY
CONNECTOR PLIERS	ADAPTER ASSEMBLY
PHILLIPS DRIVER 2	ADAPTER ASSEMBLY
1/8 BLADE DRIVER	HOSE ASSEMBLY
3 INCH FLAT PATCH	<u>MISCELLANEOUS TOOLS AND</u>
5-3/4 BLISTER PATCH	<u>EQUIPMENT</u>
7-1/4 INCH BLISTER PATCH	VACUUM CLEANER
8-1/2 INCH BLISTER PATCH	DOCKING LATCH TOOL
UNIVERSAL SEALANT	LATCH RELEASE TOOL
1 INCH RED TAPE	SEAL ASSEMBLY
2 INCH NEUTRAL TAPE	ORIFICE CLEANING TOOL
SCISSORS	BIOCIDE WIPES
PINCH BAR	
TOOL CADDY	

Table 23. Skylab Tool/Maintenance Equipment - 2 of 3

<u>SL-2 Mission</u>	<u>SL-3 Mission</u>	<u>SL-4 Mission</u>
<p><u>SEVA Tools</u></p> <p>End Grip, MSFC Pole SAS HOOK Double Prong Adapter Cable Cutter Shear Assembly Pole Tether Restraint Tool Extender Rods (3) Waist Tether (L) Waist Tether (R) Release Mechanism Claw Assembly</p> <p><u>Parasol Tools</u></p> <p>Strap Wrench (2) Screws/Allen Tools</p> <p><u>Miscellaneous</u></p> <p>Swiss Army Knife</p>	<p><u>Resupplied Tools</u></p> <p>Ratchet Handle, 3/8 Drive Swiss Army Knife</p> <p><u>Rate Gyro Package Tools</u></p> <p>Ratchet Handle, 3/8 Drive 9/16 Deepwell Socket, 3/8 Drive No. 3 Hi-Torque Bit, 1/4 Drive (2) Ratchet Handle, 1/4 Drive Screwdriver Bit, 3/16 Hex, 1/4 Drive Universal Joint, 1/4 Drive Extension, 4 inch, 1/4 Drive 3/8 Open End/Box End Wrench RGP Connector Pliers (2) 90 Degree Nose Connector Pliers</p> <p><u>Parasol Tools</u></p> <p>Hex Head Wrench (2) Rod Disconnect Tool</p>	<p><u>Resupplied Tools</u></p> <p>Screwdriver Bit, 3/16 Hex, 5 inch 3/16 Blade Screwdriver Swiss Army Knife (3) Red Tape, 1 inch Diagonal Cutter Pliers, 6 inch General Purpose Tape (2 Rolls)</p> <p><u>Miscellaneous</u></p> <p>9/16 Flarenut Wrench 7/8 Crowfoot Wrench Sharpening Kit 9/64 Allen Wrench (2) Screwdriver Bit, 9/64 Hex Hi-Torque Screw Removal Tool S193 Repair Screwdriver EPC DRC Connector Pliers Capture Latch Release Tool ATM TV Installation Tool</p>

Table 24. Additional/Resupplied Tools

<u>TOOL NOMENCLATURE</u> <u>APPLICATION</u>	
Adapter Assembly (61A830387-1) Service/Deservice Cluster Water Systems	Replace Teleprinter Assembly Replace Fire Sensor Control Panel Replace M074 Electronics Module Activate Fecal/Urine Collector Remove Dump Hose Launch Restraints Activate Vacuum Cleaner Plenum Bag Stowage Close M171 Metabolic Analyzer Sample Inlet Valve
Adapter Assembly (61A830387-2) Service/Deservice Cluster Water Systems	Refrigeration System Vent Valve Operation Adjust M172 Zero Crossover, Lateral Shower Activation AM Tape Recorder Disassembly
Adapter Assembly (61A830357-7) Service/Deservice Cluster Water Systems	Bit, Screwdriver, 5/32 Square Replace Speaker Intercom Assembly Replace WMC Filter and Charcoal Cartridge Replace Video Tape Recorder Relocate MDA Intercom Assembly Install CSM/MDA Air Interchange Duct Unstow OWS/VCS Duct
Adapter, Double Prong Deploy OWS Solar Array	Relocate M168 Stowage Container Remove VC Tree from Film Vault
Bar, Pinch Deploy OWS Solar Array	Bit, Screwdriver, 3/16 Hex, 2 in. Shank Replace Video Tape Recorder Remove Food Tray Launch Restraints Remove Food Table Cover Launch Restraints Suit Drying Station Activation Wardroom Window Activation Remove Portable Fan Launch Restraints Remove OWS/AM VCS Duct Launch Restraints Relocate Food Container
Belt, Utility General Usage	
Bit, Screwdriver, 3/32 Hex, 3 1/2 in. Shank Adjust M074 Transducer Adjust M172 Zero Crossover, Axial Repair S019 Extension Mechanism Replace S009 Drive Motor	
Bit, Screwdriver, 7/64 Hex, 3 1/4 in. Shank Remove M554 Composite Casting Specimens AM Tape Recorder Disassembly	
Bit, Screwdriver, 5/32 Hex, Replace Dump Probe Assembly	

Reference 3

TOOL NOMENCLATURE

APPLICATION

Remove OWS Film Vault Launch Restraints
S063 Experiment Pre-Preparation
Unstow M509 ANE from Launch Configuration
M074 SMMD Preparation
M172 BMMD Preparation
Remove H₂O Dispenser Launch Restraints
Remove ED74 Camera Mount
Remove ED74 Mass Measurement Assembly
Adjust M172 Zero Crossover, Axial
Adjust M172 Zero Crossover, Lateral
Remove Circular/Conical Shoe Cleat from ATM
C/D Chair
Replace Ergometer Pedal Screw
Bit, Screwdriver, 3/16 Hex, 2 in. Shank,
Modified
Replace Video Tape Recorder
Bit, Screwdriver, 3/16 Hex, 3 1/2 in.
Primary Coolant Loop Servicing
Bit, Screwdriver, 3/16 Hex, 5 in. Shank
Replace Urine Separator
Replace Urine Separator Motor and Filter
Replace Urine Separator Support and Filter
Replace Video Tape Recorder
Unstow OWS/AM VCS Duct
Activate Fecal/Urine Collector
Remove Trash Airlock Launch Restraints

Remove Portable Fan Launch Restraints
Remove Dome Locker Launch Restraints
Install T027 Tripod
Relocate T027 Sample Array Container
Relocate T027 Photometer Container
Remove T025 Launch Restraints
Perform Wardroom Water Purge
Unstow ED74 Mass Measurement Beam Assembly
Remove Urine System Separator
Deploy Skylab Parasol
Remove Video Tape Recorder Circuit Boards
Bit, Screwdriver, 3/16 Hex, 1/4 in. Drive,
RGP Tools
Install Rate Gyro Package
Bit, Screwdriver, 3/16 Hex, 90 Degree
Replace Video Tape Recorder
Activate Fecal/Urine Collector
Remove Trash Airlock Launch Restraints
Activate Wardroom Window
Relocate S149 Container
Relocate S183 Stowage Rack
Remove Video Tape Recorder Circuit Boards
Bit, Screwdriver, 1/4 Hex
Shower Activation
Open/Close M171 Vacuum Valve
Bit, Screwdriver, Hi-Torque No. 2
Configure SAL for S063 Operation
Bit, Screwdriver, Hi-Torque No. 3
Replace Video Tape Recorder

Table 25. Skylab Tool/Equipment Usage - 2 of 9

<u>TOOL NOMENCLATURE</u>	<u>APPLICATION</u>
Coolanol System Leak Inspection	Extension, 4 in. Replace Hot Water Dispenser Valve Replace TV Input Station Replace Urine Separator Replace Video Tape Recorder Clean Solenoid Vent Port Filter Primary Coolant Loop Servicing Remove Video Tape Recorder Circuit Boards Replace OWS Heat Exchanger Fan
Bit, Screwdriver, Hi-Torque No. 3, 1/4 in. Drive, RGP Tools Install Rate Gyro Package	Extension, 6 in. 1/4 in. Drive, RGP Tools Install Rate Gyro Package
Bit, Screwdriver, Standard, 3/8 Blade Replace WMC Filter and Charcoal Cartridge Relocate Spare Condensate Module	Extension, 8 in. Replace Video Tape Recorder Relocate Spare Condensate Module Remove Dome Locker Launch Restraints Unstow M509 AME from Launch Configuration Relocate T027 Sample Array Container
Caddy, Tool General Usage	Extension, 12 in. Relocate S149 Container Relocate T027 Sample Array Container Relocate T027 Photometer Container Relocate S183 Stowage Rack Relocate Wardroom and WMC Spare Hotwater Heaters
Cleaner, Vacuum General Usage Clean OWS Air Mixing Chamber Clean ECS Fan Inlet Screens Clean WMC Ventilation Unit Filters Clean OWS Heat Exchanger Vanes Clean OWS Solenoid Vent Port Filter	Extractor, 0-Ring Replace Wash Cloth Squeezer Bal-Seal
Cutter, Cable Deploy OWS Solar Array	Fingers, Mechanical General Usage
Deionizer Assembly, Water System Servicing Service/Deservice Cluster Water Systems	
End Grip, MSFC Pole (Mushroom) Deploy OWS Solar Array	

Table 25. Skylab Tool/Equipment Usage - 3 of 9

TOOL NOMENCLATURE

APPLICATION

Hammer, Ball Peen, 8 oz.
Free Stuck CBRM #15 Relay
Handle, Experiment Wrench
Relocate T027 Sample Array Container
Relocate S183 Stowage Rack
Handle, Ratchet
Replace WMC Odor Control Filter
Replace Teleprinter Assembly
Replace TV Input Station
Replace Urine Separator
Replace Urine Separator Motor and Filter
Replace Video Tape Recorder
Clean OWS Solenoid Vent Port Filter
Unstow OWS/AM VCS Duct
Activate Fecal/Urine Collector
Remove Food Tray Launch Restraints
Remove Food Table Cover Launch Restraints
Relocate OWS Electrical Panel Support
Remove Portable Fan Launch Restraints
Remove OWS/AM VCS Duct Launch Support
Remove WMC Vent Cover
Remove Dome Locker Launch Restraints
Replace OWS Heat Exchanger Fan
Primary Coolant Loop Servicing
Install T027 Tripod
Shower Activation
S063 Experiment Pre-Preparation
Unstow M509 PSS Stowage Rack

Unstow M509 AME from Launch Configuration
MI72 BMMD Preparation
Remove H2O Dispenser Launch Restraints
Configure SAL for S063 Operation
Relocate T027 Sample Array Container
Relocate S183 Stowage Rack
Remove S190B Launch Restraints
Remove T025 Launch Restraints
Wardroom Window Purge
Remove Window Cover from ATM C/D Console
Foot Restraint
Remove SAL Window Covers from M512 Foot Restraint
Relocate Wardroom and WMC Spare Hotwater Heaters
Remove Circular/Conical Shoe Cleat from ATM C/D Chair
Unstow ED74 Mass Measurement Beam Assembly
Deploy Skylab Parasol
Coolanol System Leak Inspection
Replace S009 Drive Motor
Remove Video Tape Recorder Circuit Boards
Handle, Ratchet, 1/4 in. Drive, RGP Tools
Install Rate Gyro Package
Handle, Ratchet, 3/8 in. Drive, RGP Tools
Install Rate Gyro Package
Handle, Speeder, Brace Type
Remove Trash Airlock Launch Restraints
Activate Wardroom Window
Relocate S149 Container

Table 25. Skylab Tool/Equipment Usage - 4 of 9

TOOL NOMENCLATURE

APPLICATION

Remove Film Vault Launch Restraints
Relocate T027 Photometer Container
Remove ED74 Camera Mount
Remove ED74 Mass Measurement Assembly

Handle, Spin Type
Replace Dump Probe Assembly
Replace WMC Filter and Charcoal Cartridge
Replace Fire Sensor Control Panel
Replace M074 Electronics Module
Relocate MDA Speaker Intercom Assembly
Install CSM/MDA Air Interchange Duct
Activate Fecal/Urine Collector
SAL Window Initial Installation
Remove Dump Hose Launch Restraints
Activate Wardroom Window
Activate Vacuum Cleaner
Relocate M168 Stowage Container
Relocate Spare Condensate Module
Shower Activation
M074 SMMD Preparation
Install Urine Separator
Relocate T027 Sample Array Container
Relocate S183 Stowage Rack
Plenum Bag Stowage
Remove M554 Composite Casting Specimens
Refrigeration System Vent Valve Operation
Adjust M074 Transducer
Adjust M172 Zero Crossover, Axial

Adjust M172 Zero Crossover, Lateral
Remove VC Tree from Film Vault
Remove Urine Separator
Repair S019 Extension Mechanism
AM Tape Recorder Disassembly

Handle, Torque, 5-150 in.-lbs.
Replace Urine Separator Support and Filter
Replace Video Tape Recorder
Relocate Food Container
Close M171 Metabolic Analyzer Sample Inlet Valve
Open/Close M171 Metabolic Analyzer Vacuum Valve
Wardroom Window Moisture Removal
Replace Ergometer Pedal Screw
Primary Coolant Loop Servicing

Hook, SAS
Deploy OWS Solar Array

Hose Assembly, Water Servicing Deionizer Service/Deservice Cluster Water Systems

Hose Assembly, Jumper Service/Deservice Cluster Water Systems

Hose Assembly, Water Separator Plates Service/Deservice Cluster Water Systems

Hose Assembly, Water System Servicing (61A830355-13)
Service/Deservice Cluster Water Systems

TOOL NOMENCLATURE

APPLICATION

Joint, Universal
Replace TV Input Station
Replace Video Tape Recorder
Relocate S183 Stowage Rack

Joint, Universal, 1/4 in. Drive, RGP Tools
Install Rate Gyro Package

Kit, Cluster Leak Repair
General Usage

Kit, OWS Maintenance, EMU
Maintain EMU Seals and O-Rings

Kit, PGA Maintenance
Clean/Antifog Treat EMU Helmet

Knife, General Purpose
General Usage
Replace M487 Battery
S183 Malfunction Procedure
Replace Ergometer Pedal Screw
Primary Coolant Loop Servicing

Lubricant, O-Ring, General Purpose
General Usage
Lubricate M092 LBNP Waist Seal Zipper
Lubricate Ergometer Pedals

Lubricant, O-Ring, Water System
General Usage

Multimeter, Digital
Checkout Rate Gyro Package
DAC Camera Checkout
TV Power Cable Checkout
S183 Malfunction Procedure
Condensate Dump Probe Checkout

Pliers, Connector, Electrical
Replace Mol Sieve Fan
Replace WMC Filter and Charcoal Cartridge
Replace TV input Station
Replace Fire Sensor Control Panel
Replace Video Tape Recorder
Shower Activation
Replace WMC Vent Filter
Replace OWS Heat Exchanger Fan

Pliers, Cutter, Diagonal, 4 in.
Remove M553 Sphere Specimens from Disc

Pliers, Needle Nose
Activate Vacuum Cleaner

Pliers, Pin Straightener, Electrical Connector
Replace S009 Drive Motor
Primary Coolant Loop Servicing

Pliers, Vise Grip Type
Deploy OWS Solar Array
Remove Hi-Torque Screws

Table 25. Skylab Tool/Equipment Usage - 6 of 9

TOOL NOMENCLATURE
APPLICATION

Removal Tool, Cable Plug, RGP Tools Install Rate Gyro Package	Screwdriver, Standard, 3/16 Blade Replace AM Tape Recorder Replace EVA/IVA Liquid Gas Separator Replace Portable Timer Tone Battery Disassemble S054 Film Magazine AM Tape Recorder Disassembly Remove Video Tape Recorder Circuit Boards Install Gas/Coolant Separator in ATM C&D Coolant Loop Screwdriver, S190 Replace S190 Magazine Drive Assembly Disconnect S190 Shutter Drive Mechanism
Remove Tool, Cable Plug 90 Degree, RGP Tools S082B Auxillary Timer Installation	Sealant, Universal (Polybutene Putty) Seal Condensate System Connections
Scissors, S190 Replace S190 Cassett	Seal Assembly Replace Dump Probe Assembly
Scissors, 6 in. General Usage	Grid Snaps General Usage
Screwdriver, Phillips No. 1 Repair S019 Extension Mechanism Replace S009 Door Drive Motor Adjust S192 Attenuator Engage M133 Tape Recorder Pinch Roller	Socket, Deepwell, 7/16 in. Unstow M509 PSS Stowage Rack Unstow M509 AME from Launch Configuration Remove Window Cover from ATM C/D Console Foot Restraint Relocate Wardroom and WMC Spare Hotwater Heaters Replace OWS Heat Exchanger Fan
Screwdriver, Phillips No. 2 Install S054 Shutter Override Actuator M133 Post Operation Activities	Socket, Deepwell, 1/2 in. Replace WMC Odor Control Filter
Screwdriver, Standard, 3/32 Blade Adjust Fire Sensor Sensitivity M487 Sound Meter Level Frequency Analyzer Calibration Adjust S192 Attenuator	
Screwdriver, Standard 1/8 Blade S054 Filter Wheel Positioning	

Table 25. Skylab Tool/Equipment Usage - 7 of 9

TOOL NOMENCLATURE
APPLICATION

Socket, Deepwell, 9/16 in.
Wardroom Window Moisture Removal

Socket, Deepwell, 9/16 in., Thinwall, RGP Tools
Install Rate Gyro Package

Socket, Standard, 1/4 in.
Relocate T027 Sample Array Container
Coolant System Leak Inspection

Socket, Standard, 5/16 in.
Relocate T027 Sample Array Container
Relocate S183 Stowage Rack

Socket, Standard, 3/8 in.
Replace TV Input Station
Clean Solenoid Vent Port Filter
Coolant System Leak Inspection
Primary Coolant Loop Servicing

Socket, Standard, 7/16 in.
SAL Window Initial Installation
Relocate OWS Electrical Panel Support
Remove MMC Vent Cover
Shower Activation
Unstow M509 PSS Stowage Rack
Remove S190B Launch Restraints

Tape, S190
Replace S190 Cassette

Disconnect S190 Shutter Drive

Tape, Pressure Sensitive, 2 in.
General Usage
Deploy OWS Solar Array
Wardroom Window Moisture Removal
ATM Door Ramp Latch Removal
Primary Coolant Loop Servicing

Tape, Pressure Sensitive, 1 in. Red
Condensate System Leak Check
S183 Malfunction Procedure
Failed Component Identification

Tape, Pressure Sensitive, 3/4 in.
Remove OWS SOP Launch Restraints
Plenum Bag Stowage

Vise, Bench Type
Replace Ergometer Pedal Screw
Wire, Safety
Deploy OWS Solar Array

Wrench, Adjustable
Condensate System Leak Check

Wrench, Allen, 5/64
Remove Video Tape Recorder Circuit Boards

Wrench Allen 9/64
Mark I Exerciser Repair

TOOL NOMENCLATURE APPLICATION	
Wrench, Allen, 3/16 S082B Auxillary Timer Installation	M172 BMMD Preparation Remove OWS SOP Launch Restraints Wardroom Window Moisture Removal Condensate System Leak Check
Wrench, Crowfoot, 1 3/8 in. Condensate System Leak Check	Wrench, Open End, 11/16 in. Condensate System Leak Check Wardroom Window Moisture Removal
Wrench, Open End, 5/16 in. Replace Video Tape Recorder Install H ₂ O Gun Resupply Remove H ₂ O Gun Resupply	Wrench, Open End, 3/4 in. M172 BMMD Preparation Connect Radio Noise Burst Monitor Antenna Disassemble S054 Film Magazine Condensate System Leak Check
Wrench, Open End, 11/32 in. Replace Video Tape Recorder	Wrench Strap Deploy Skylab Parasol
Wrench, Open End, 3/8 in. Replace Video Tape Recorder M074 SMMD Calibration	Wrench, S190 Spanner, Small Replace S190 Dessicant Assembly Replace S190 Magazine Drive Assembly
Wrench, Open End, 3/8 in., RGP Tools Install Rate Gyro Package	Wrench, Torque, 0-600 in.-lbs. Replace WNC Hotwater Dispenser Valve Condensate System Leak Check
Wrench, Open End, 7/16 in. Relocate Portable Water Tank M172 BMMD Preparation Remove SAL Window Covers from M512 Foot Restraint ATM Door Ramp Latch Removal	
Wrench, Open End, 9/16 in. Replace TV Input Station	

Table 25. Skylab Tool/Equipment Usage - 9 of 9

DATE 10/11/73 M487-3 SUBJECTIVE EVALUATION GUIDE 3

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INSTRUCTIONS

Using the following 15-point guidelines, evaluate the overall adequacy of the equipment provided to accomplish routine and unscheduled maintenance tasks and the design acceptability of the tasks themselves from the point of view of access, logistic management during disassembly/reassembly, tool and component/parts restraint, and overall ease of task accomplishment.

EVALUATION DEFINITIONS

RATING DEFINITION

EXCELLENT IMPROVEMENTS ARE NOT NEEDED AND WOULD ONLY BE A MATTER OF PERSONAL PREFERENCE

VERY GOOD MINOR IMPROVEMENTS ARE POSSIBLE BUT NOT REALLY NECESSARY

ADEQUATE SOME SHORTCOMINGS FOUND AND A FEW IMPROVEMENTS ARE DESIRABLE

POOR NUMEROUS SHORTCOMINGS FOUND AND IMPROVEMENTS ARE NECESSARY

UNACCEPTABLE GROSS SHORTCOMINGS FOUND AND IMPROVEMENTS ARE MANDATORY

DATE 10/11/73:

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-TOOL INVENTORY -

- * TOOL KIT #1
- * TOOL KIT #2
- * REPAIR KIT
- * S190 MAINT KIT
- * M512 TOOLS
- * EMU MAINT KIT

-MAINTENANCE TASKS -

SCHEDULED REPLACEMENT ITEMS

- * SOLIDS TRAPS
- * MOL SIEVE CHAR CANISTERS
- * PPCO2 INLET/OUTLET CARTGS
- * PPO2 CARTGS
- * EVA/IVA COOL GAS SEPARATOR
- * WMC VENT FILTER
- * WMC CHAR CANISTER
- * FECAL COLLECTOR FILTER
- * URINE SEPARATORS

SCHEDULED CLEANING ITEMS

- * OWS AIR MIX CHMB SCREENS
- * WMC VENT FILTER

UNSCHEDULED REPLACEMENT ITEMS

- * FANS
- * VALVES
- * SEALS
- * LIGHTS
- * OTHER (define item)
- * UNSCHEDULED REPAIR ITEMS
- * IDENTIFY TASK AND EVALUATE

- MISC. SUPPORT ITEMS -

- * ADEQUACY OF WORK SITES
- * ADEQUACY OF LIGHTING
- * ADEQUACY OF ON-BOARD DATA PKG
- * ADEQUACY OF PRE-FLT PREP FOR MAINT TASKS

DESCRIPTION	QUANTITY	UNIT	LOCATION	STATUS	REMARKS
SCHEDULED REPLACEMENT ITEMS					
SOLIDS TRAPS	5	qts	00 MD-20		
MOL SIEVE CHAR CANISTERS	5	qts	00 MD-20		
PPCO2 INLET/OUTLET CARTGS	5	qts	00 MD-20		
PPO2 CARTGS	5	qts	00 MD-20		
EVA/IVA COOL GAS SEPARATOR	1	qts	00 MD-20		
WMC VENT FILTER	5	qts	00 MD-20		
WMC CHAR CANISTER	5	qts	00 MD-20		
FECAL COLLECTOR FILTER	5	qts	00 MD-20		
URINE SEPARATORS	5	qts	00 MD-20		
SCHEDULED CLEANING ITEMS					
OWS AIR MIX CHMB SCREENS	5	qts	00 MD-20		
WMC VENT FILTER	5	qts	00 MD-20		
UNSCHEDULED REPLACEMENT ITEMS					
FANS	5	qts	00 MD-20		
VALVES	5	qts	00 MD-20		
SEALS	5	qts	00 MD-20		
LIGHTS	5	qts	00 MD-20		
OTHER (define item)	5	qts	00 MD-20		
UNSCHEDULED REPAIR ITEMS					
IDENTIFY TASK AND EVALUATE					
MISC. SUPPORT ITEMS					
ADEQUACY OF WORK SITES					
ADEQUACY OF LIGHTING					
ADEQUACY OF ON-BOARD DATA PKG					
ADEQUACY OF PRE-FLT PREP FOR MAINT TASKS					

Reference 5

TASK DESCRIPTION	PLANNED FREQUENCY	SL-2 FREQUENCY	SL-3 FREQUENCY	SL-4 FREQUENCY
Vacuum Clean - OWS Heat Exchanger Vanes				6 days
Vacuum Clean - ECS Inlet Screens	7 days			
OWS Air Mixing Chamber		7 days	3 days	2 days
OWS Heat Exchanger Fans	7 days	7 days	3 days	2 days
MDA Fans	7 days	7 days	3 days	2 days
AM Circulating Fans	7 days	7 days	3 days	2 days
WMC Debris Coarse Filter	7 days			
WMC Debris Coarse/Fine Filter				
WMC Debris Fine Filter				
Replace - WMC Vent Unit Fine Filter	7 days	7 days	12 days	2 days
Replace - Shower Filter	7 days	Following Crew Showers		12 days
Replace - Mol Sieve Solids Traps	11 days	11 days	11 days	11 days
Replace - Inlet CO ₂ Detector Cartridges	14 days	14 days	14 days	14 days
Replace - WMC Vent Fine/Coarse Filters	28 days	On MD-28	On MD-59	On MD-28
Replace - Fecal Collector Filter	28 days	28 days	28 days	28 days
Replace - Urine Separator Filter	28 days	---	---	---
Replace - Mol Sieve Charcoal Canister	28 days	28 days	28 days	28 days
Replace - WMC Filter and Charcoal Cartridge	28 days	On MD-28	On MD-59	On MD-27
Replace - Outlet CO ₂ Detector Cartridge	28 days	28 days	28 days	28 days
Replace - PPO ₂ Sensor	SL-3 & 4		Activation	Activation
Replace - ATM C&D Cooling Water Filter	Activation			
	Before & After EREP Operation	On MD-4	On MD-58	On MD-50
Replace - EVA/IVA Gas Coolant Separator	SL-2	On MD-25		
	SL-3 & 4		---	---
Replace - Urine Separator	Activation			
	SL-2 & 3			
	Deactivation	Deactivation	Deactivation	
Vacuum Clean - OWS Solenoid Vent Filter	SL-3 & 4		Activation	Activation
	Activation			

Table 20. Scheduled IFM - Conducted

SOLAR ARRAY SYSTEM TOOLS

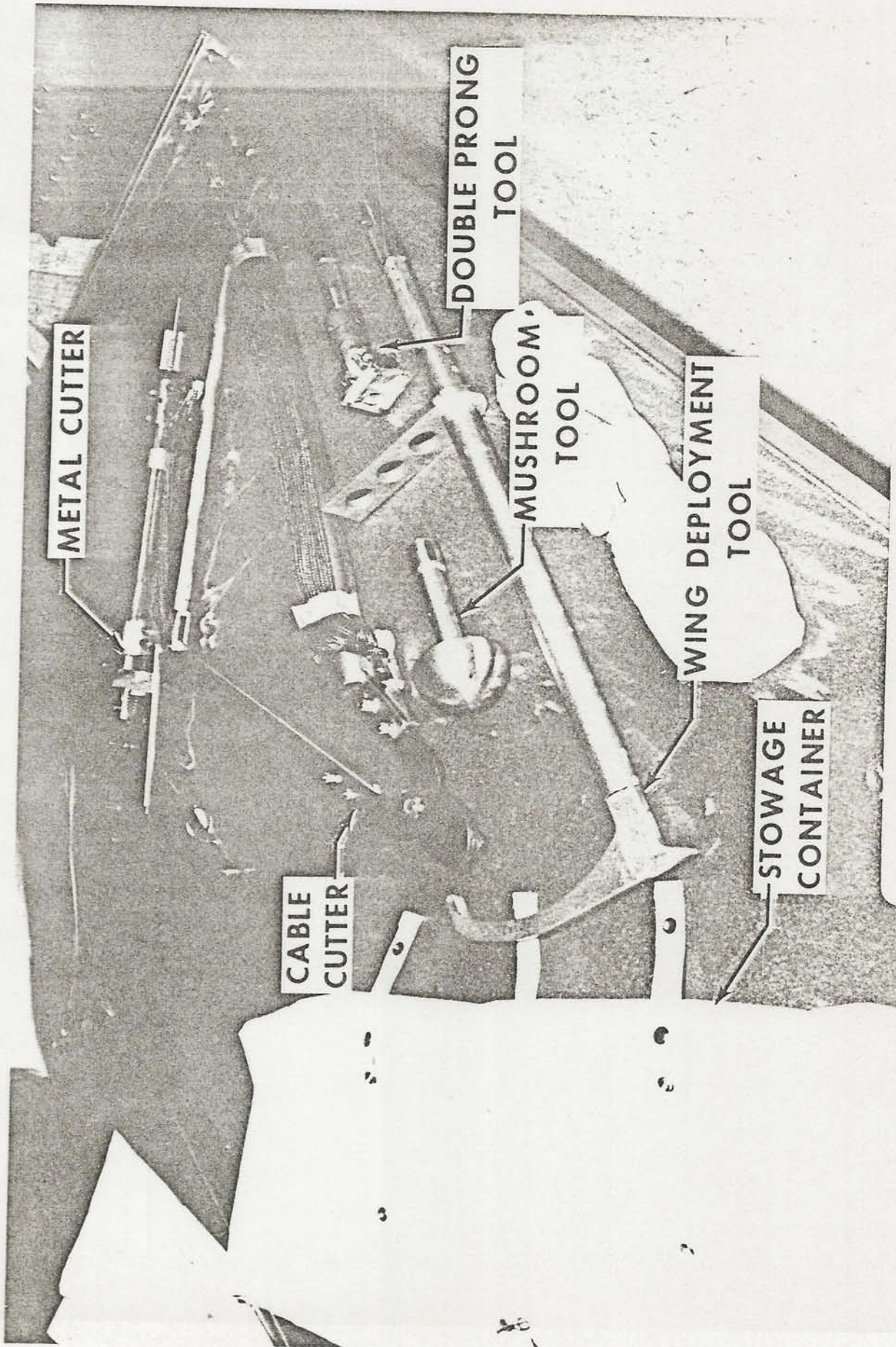


Figure 17 - SAS Wing Deployment Tools

