ISS Expedition 38 - US EVA-25 Updates

ISS Expedition 38, US EVA-24, Archived Live Coverage, Video Gallery, Photo Gallery

Spacewalkers install new Ammonia Pump Module in challenging EVA

>>>Archived Live Coverage >>>Video Gallery >>>Photo Gallery

December 24, 2013

International Space Station Astronauts Mike Hopkins and Rick Mastracchio have successfully installed a spare ammonia Pump Module on the Space Station in a seven-hour 30-minute EVA performed on Christmas Eve. The old Pump Module experienced a problem with its Flow Control Valve on December 11 resulting in the loss of one of two external cooling loops - requiring power-downs of ISS Systems.

EVA-24 Photo - Credit: NASA

On Saturday, the crew members successfully removed the old Pump Module so that they could spend their EVA on Tuesday preparing the new Pump Module and installing it on the S1 Truss Segment of the Space Station. The new pump was successfully installed by the two spacewalkers and Mission Control is in the process of testing it before re-integrating it with the Station's cooling circuits to restore full cooling capability later this week.

The day once again started bright and early for the three USOS and their Russian colleagues who spent the day preparing for Russian EVA-37 to be performed on Friday out of the Pirs Airlock. Tuesday's US-based spacewalk originated from the Quest Airlock where Rick Mastracchio and Mike Hopkins started climbing into their space suits to get ready for the EVA.

Photo: NASA

Being helped by Koichi Wakata and Oleg Kotov, the two spacewalkers ingressed their Extravehicular Mobility Units and began a series of checkouts including electrical, biomed, communication and leak checks. With good leak checks and EMU purge complete, the team pressed into the 100-minute ISLE Pre-Breathe Protocol. The In-Suit Light Exercise Protocol consists of a 50-minute pre-breathe of pure oxygen followed by a 50-minute block alternating between exercise and rest in order to remove Nitrogen from the blood stream to prevent decompression sickness.

Once ISLE was complete, the two EV crew members were moved to the smaller crew lock portion of Quest which was sealed off by closing its hatch to allow airlock depressurization to begin.

Dropping from the ambient pressure of ~750mmHg, Quest was deperssurized to 260mmHg for suit leak checks before going all the way down to vacuum. When depress was complete, Mike Hopkins opened the EV hatch and the spacewalkers switched their suits to battery power which marked the official start of the EVA at 11:53 UTC.

First to climb out of the airlock was Mike Hopkins who inspected the safety tethers that were left in place on Saturday. He then attached his and Mastracchio's EMUs to those safety tethers to give Mastracchio the green light to unhook himself from the internal panel of the Airlock and egress as well. After the normal checks of tools and suits, the crew members parted ways as Mike Hopkins headed outboard to External Stowage Platform 3 where the spare Pump Module was located (PM #0006) on the outboard side of the ESP.

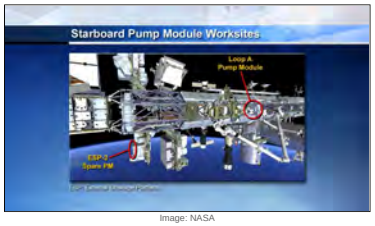


Image: NASA

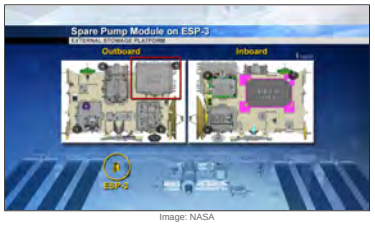


Image: NASA

Starting out at the airlock, Mastracchio went to the zenith side of the airlock where a large QD Bag was located from which he retrieved a Nitrogen/Ammonia Vent Tool that he took to the CETA Cart.

At the inboard CETA cart, Mastracchio retrieved a crew lock bag filled with tools that were left outside on Saturday. The vent tool was placed inside the bag and Mastracchio also made his way out to ESP-3.

At ESP-3, Mike Hopkins started to remove Velcro straps in order to release the large Multilayer Insulation cover that was installed on the pump to protect it while being stowed on the truss for several years. Hopkins struggled with the large cover and waited for Mastracchio to arrive at the work site to have an extra set of hands to remove the large cover and temp-stow it.

Photo: NASA TV

With the cover out of the way, Mike Hopkins guided robotic arm operator Koichi Wakata who moved the arm to a good position for Hopkins to inspect the foot restraint on the arm that was left installed on the SSRMS after EVA-24 for ingress by

Mike Hopkins for his first ride on the Space Station's robotic arm. This being his first time ingressing the arm, he needed some additional time and arm maneuvers to manage to put his feet into the Articulating Portable Foot Restraint and secure himself on the arm.

After being moved out of the way and starting a lengthy arm maneuver, Hopkins had some time to enjoy the view while Rick Mastracchio started work on the spare PM to prepare it for installation.

In its stowed configuration, the PM is connected to its carrier plate via four structural bolts. Three of the five electrical interfaces (called J1 through J5) are connected to cables that supply power to the Pump Module for heater operation and provide a telemetry data link while the other two electrical connectors on the PM were protected by dust caps. The four ammonia Quick Disconnects of the PM (M1 through M4) were also covered with caps.

Photo: NASA TV

Mastracchio's first task was the removal of the four QD caps and two electrical caps and stowing them on a Fish Stringer. It took him just a few minutes to take the caps off and stowing them before Mike Hopkins was moved back to the Pump Module to break torque on the four structural bolts using the Pistol Grip Tool with Torque Multiplier. Each bolt was driven five turns on the PGT which translates to one actual turn on the torqued bolt to break the torque on all four bolts.

When that was complete, Koichi Wakata moved Hopkins away from the Pump Module to allow Rick Mastracchio to remove the three electrical connectors and restrain them out of the way for Pump Module extraction. J4, J5 and J1 were demated without problems and stowed as planned.

Mike Hopkins on the arm

Photo: NASA TV

Dust Cap Removal

Photo: NASA TV

Electrical Demating

Photo: NASA TV

Photo: NASA TV

Above: Hopkins driving the Bolts, Below: Transporting the PM

Photo: NASA TV

Mike Hopkins was moved back to the Pump Module where he used his Pistol Grip Tool to release the four structural bolts. When trying to release Bolt 1, Hopkins ran into trouble as the bolt was not turning. The team decided to use the Torque Multiplier again to break torque on Bolt 1 and the remaining bolts, double checking that the bolts are releasing.

Then once again switching to the PGT alone, Hopkins started releasing Bolt 1 which immediately started turning. Bolts 2 and 4 were also released without problems and Mike Hopkins got ready for the final bolt that would detach the Pump Module.

To get ready for a long ride on the arm with the Pump Module in hand, Hopkins configured his glove heaters and other EMU systems. Also, a scoop was installed on Bolt 2 to make the unhandy pump easier to handle once removed. As Bolt 3 was released, the large Pump Module became detached.

Tethered to the PM and holding onto its hand rails, Mike Hopkins gave Koichi Wakata the green light to start arm motion in order to extract the Pump Module from its MLI shroud. Mastracchio monitored clearances. When the PM was clear, Wakata began a series of pre-programmed maneuvers to move the arm over to the S1 truss taking about 20 minutes to complete.

Meanwhile, Rick Mastracchio configured the ESP-3 work site by restraining the electrical cables within the MLI cover and closing the lid. He picked up a tool bag and headed back to S1 to get ready for the installation of the spare pump.

Riding the arm, Mike Hopkins and the spare Pump Module made their way to the S1 truss, passing by the old Pump Module (#0004) that was stowed on the POA during EVA-24. The robotic arm stopped its automatic maneuver in a stand-off position. From there, the two spacewalkers guided the module into its slot on S1 as Wakata slowly moved the arm as requested by the EV crew. Working efficiently, the crew members quickly positioned the Pump Module and started driving the structural bolts.

Transporting the PM to S1, Meeting up with Pump #4 & Guiding the spare into Position

Photo: NASA TV

Photo: NASA TV

Photo: NASA TV

Bolt 1 was driven without a problem, but Bolt 4 required a number of attempts to achieve the required torque of 25 newton meters. Subsequently, Bolts 2 and 3 were engaged and Mike Hopkins was allowed to release his tether from the module so that the arm could be repositioned for fluid Quick Disconnect Operations.

Because the crew members were running behind the timeline, Mission Control decided to skip the electrical connections and start with the ammonia QDs to protect time for a potential ammonia bake-out at the

Photo: NASA TV

First QD in place

Photo: NASA TV

M1 & M2 connected, M3 & M4 on the PM Jumper

end of the EVA in case of NH3 exposure. The first step of QD Ops was the Pump Module vent as the PM was filled with Nitrogen in its stored configuration which had to be vented before allowing ammonia to enter the Pump Module.

For that, Rick Mastracchio retrieved the Vent Tool and mated the Quick Disconnect to the M3 interface of the Pump Module. To mate M3, the crew went through the usual checklist before opening the valve of the vent tool so that the nitrogen could escape into space. The valve was left open for about one minute before being closed again. Next, the Vent Tool was demated from M3 and stowed.

With the Pump Module in place and vented, the crew members were ready to begin fluid QD ops in earnest, starting with the M1 and M2 connectors (the PM bypass and Radiator return lines). These lines were restrained inside a Generic EVA Cover Bag suspended to the S1 truss segment when the old PM was removed last Saturday. The spacewalkers removed that cover and inspected the M1 QD ahead of mating it to its corresponding interface on the Pump Module. Going through the checklist read by Capcom Doug Wheelock, Mike Hopkins had no trouble mating the QD and opening its valve and also installing the Subject Positioning Device of on the QD.

Next was M2 that also passed a clean inspection was mated as expected followed by the valve opening and SPD installation. With the M1 and M2 QDs in place, the crew members moved on to M3 and M4 which are the PM outlet and inlet lines. Those were in a special configuration, being mated to a Pump Module Jumper Box to connect the accumulator to the cooling loop in order to allow the loop to respond to temperature changes without the PM installed. The box was also restrained in a GTEC bag on S1 that had to be removed by the spacewalkers to access the Jumper Box.

When both crew members were in a good position to access the M3 QD on the Jumper, they started the second half of QD ops.

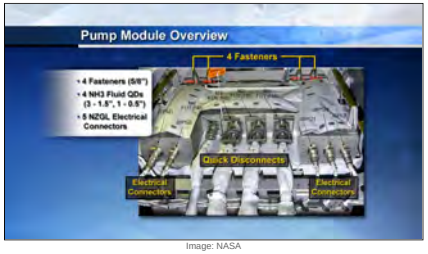


Image: NASA

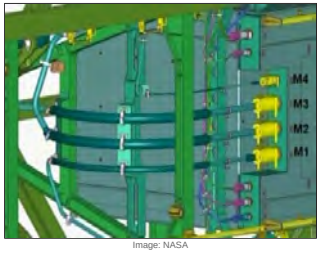


Image: NASA

The crew members took turns holding the Jumper and operating the QDs. Mission Control gave the GO to close the M3 valve. Moving through the simple QD closing checklist, the crew members quickly noted that the QD button on M3 could not be pushed.

M3 is the QD that caused major trouble in 2010 when it did not want to come off the original S1 Pump Module after it had failed. This exact connector again led to head-scratching at Mission Control as flight controllers stood in the back of the room discussing the options that have been developed to troubleshoot a stuck Quick Disconnect.

In the aftermath of the 2010 QD problems, a number of techniques and tools were developed and tested to be better prepared for future challenges with fluid Quick Disconnects. One of those tools, the Bail Control Tool, came to use on Tuesday. Being retrieved by Mastracchio, the tool was installed on the 1.5" QD to give better leverage to actuate the bail on the QD. The tool allows the crew member turn a knob to put significant force on the bail to move it. The team was cleared to make ten full turns on the tool, but the detent button remained up and could not be depressed, even after ten turns as the pressure inside the ammonia line was forcing the bail and button in the opposite direction.

Using the Bail Control Tool

Photo: NASA TV

Photo: NASA TV

The next step in the troubleshooting procedure was to tap the QD button with a hook while the Bail Control Tool was being turned, but that did not resolve the problem. Mission Control then came back to the crew and instructed them to keep pushing the button while fully releasing the Bail Control Tool.

Photo: NASA TV

After several minutes, an elated Mike Hopkins reported that the button was finally in. He held the button while Rick Mastracchio closed the valve to successfully demate the stubborn M3 Quick Disconnect.

Once closed, M3 released some ammonia but that was not of concern. Mission Control send commands to initiate a vent of the M4 line and the Jumper Box which released more ammonia into the aft section of ISS that bounced back to the crew members who reported a large amount of ammonia flakes surrounding them. With both crew members exposed to ammonia, protocols became active to prevent any ammonia from being brought back inside the space station.

Photo: NASA TV

When Mission Control determined that the vent of M4 was complete, the crew members were given the GO to close that valve as well. M4 did not misbehave and closed as expected, clearing the way for demating it and inspecting it before moving it over to the Pump Module for installation. M4 was mated but not yet opened as part of a carefully planned procedure.

M3 was demated from the Jumper Box. Inspecting the QD, Hopkins noted some residual ammonia, but was still given the go-ahead to mate it to the pump. Mating the QD proved to be troublesome as Mike Hopkins could not get it mated on the first and second try. Calmly walking through the steps again, he was finally able to mate it and confirm a good mate via the three prescribed tests - a pull test, visual gap check and snap-back test. Opening the valve was not a problem and the team moved on to M4 once again - installing the P-Clamp on the M4 line that holds it in place when being pressurized. The P-Clamp bolt was hand-started and then driven with the PGT before the crew members went through the valve opening one last time to open the pump inlet valve and install the M4 SPD.

With all QDs installed and valves open, fluid QD ops came to a successful conclusion, about 40 minutes behind the timeline due to the extra time spent with M3.

Afterwards, the two spacewalkers split the electrical work - each connecting the electrical interfaces on one side of the Pump Module - blazing through the task in less than ten minutes. All five electrical connectors were installed without any problems. At that point, the Pump Module was fully integrated with ISS Systems.

SPARTAN flight controllers initiated the ammonia fill of the Pump Module, noting that the system was holding pressure - no leaks were present. PM valves were configured so that the PM could be put through a Bump Test, starting up the pump for a short moment to verify system functionality. All parameters remained nominal and the system started as planned - confirming that the new Pump Module was ready to be integrated with External Thermal Control System Loop A in the coming days after extensive checkouts are complete.

Photo: NASA TV

Ahead of beginning clean ups, the crew members installed Multilayer Insulation covers on the Pump Module to protect it from the harsh thermal environment on the truss segment.

Afterwards, the crew members parted ways as Mike Hopkins was moved to the SSRMS egress position and Rick Mastracchio began to configure the tools and equipment for stowage. He retrieved the GTEC bags and the PM Jumper as well as the vent tool and crew lock bag before heading to the zenith side of Quest to stow the equipment for future use. Hopkins egressed the arm and installed the Articulating Foot Restraint on the CETA Cart before configuring the large ORU bag that was used to hold the tools over the course of the two EVAs. Once both crew members were done configuring their tools and performing a detailed inventory, they went back to the Airlock bringing all bags that needed to return to the inside of ISS. Once back in Quest, the airlock hatch was closed and the crew members hooked their Service and Cooling Umbilicals up to their suits.

Ammonia decontamination procedures had the crew members wait 15 minutes in the depressurized airlock after closing the hatch. When that time was up, the crew members began repressurization by opening the IV hatch equalization valve to reach a low pressure inside the crew lock. Then, the external hatch was unlocked to vent any residual atmosphere including any ammonia into space before closing the hatch again and re-starting repress that also featured the use of analytic equipment to detect any ammonia.

EVA-24 Photo - Credit: NASA

None was detected, marking the successful closure of US EVA-25 that accomplished all primary objectives. The EVA was 7 hours and 30 minutes in duration.

US EVA-25 was the 176th spacewalk dedicated to ISS Assembly and Maintenance for a total of 1,107 hours and 37 minutes. It was Rick Mastracchio's 8th career spacewalk for a total duration of 51 hours and 28 minutes, now ranking 6th on the all-time list. Mike Hopkins made his first EVA on Saturday and has now performed two successful spacewalks for a new total of 12 hours and 58 minutes.

US EVA-25 did not achieve its get-ahead task which was the relocation of the removed Pump Module from the POA (Payload/Orbital Replacement Unit Accommodations) to a permanent stowage location on ESP-3 (where the spare PM came from). To preserve the old PM for potential future use, this task has to be completed in the coming months as part of a clean-up EVA.

ISS Astronauts set for busy Spacewalk to install spare Pump Module

December 23, 2013

Building on the success of their first EVA, International Space Station Astronauts Rick Mastracchio and Mike Hopkins and a big team of Mission Controllers on the ground spent their weekend re-planning the second EVA required to remove & replace the S1 Pump Module.

Photo: NASA/ Mike Hopkins

US EVA-24 performed on Saturday was 5 hours and 28 minutes in duration. Although being shorter than planned, the spacewalk was very successful as the two EV crew members accomplished all objectives - preparing the old Pump Module for removal by disconnecting ammonia lines and electrical connectors.

In addition, the duo of spacewalkers removed the PM and stowed it at a temporary location on the POA which was originally planned to occur on EVA-2 of the initial three-EVA plan.

With these additional tasks performed on EVA-1, Mission Control began re-planning the second EVA to include all operations to install the new Pump Module and re-integrate it into the Station's External Thermal Control System to restore full cooling capability which has not been available since the failure of the Flow Control Valve of the removed Pump Module on December 11.

Space Suit Preparation

Photo: NASA/Mike Hopkins

After the conclusion of US EVA-24 on Saturday, the crew members went back to the Airlock and completed the nominal reconfiguration tasks - connecting their Service and Cooling Umbilicals and switching to ISS power & cooling before switching off their sublimators and closing the hatch for repressurization.

When re-pressurizing, Koichi Wakata, the Suit-IV crew member, radioed to Mission Control that the water on the suit of EV-1 (Mastracchio) was inadvertently activated for a short period of time during repress.

Mission Control asked Koichi Wakata for how long the system was activated and he estimated about one or two seconds. After the crew members got back inside, Mission Control ordered a detailed inspection of the EMU worn by Rick Mastracchio (#3010) to inspect for water inside the suit's sublimator. The crew found none and Mission Control guided them to look in the correct location where a small amount of water was found.

The EMU sublimator is a critical component of the Primary Life Support System as it provides all suit-related cooling including cooling for the Metox/LiOH carbon dioxide removal system, the suit electronics and the person in the suit. The EMU features three tanks, one large and two small tanks, holding about 4.5 Kilograms of pure water at the start of the EVA. Water from the feed water tanks is provided to the sublimator that acts as heat exchanger between the feed water circuit and the liquid transport circuit which circulates water throughout the EMU.

When exposed to vacuum, water flow to the sublimator is initiated and forms a layer of ice on the surface of the sublimator which consists of a porous plate that is exposed to the vacuum of space. Once the ice layer is formed, water from the feed water circuit remains liquid by receiving heat from the transport loop via the sublimator heat exchanger. The heat that is transferred to the sublimator is dissipated into space by the sublimation of the ice layer on the porous plate.

During a spacewalk, the sublimator is started when the airlock is fully depressurized and the hatch is open to make sure it is exposed to a good vacuum for the initial ice formation. At the end of the EVA, the sublimator is turned off before hatch closure and repressurization.

Activating the sublimator in a pressurized environment will result in water entering the system but not freezing or sublimating. In that event, water accumulates inside the sublimator which can be troublesome when exposing that accumulated water to vacuum on a subsequent EVA without proper suit-drying.

Even activated for one or two seconds, the quantity of water released into the system could become a problem on the next EVA. Mission Control looked at options to dry out the suit, but teams decided to take a different path and have Mastracchio switch space suits.

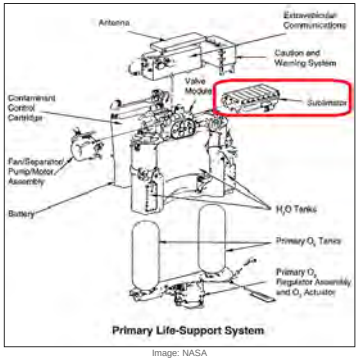


Image: NASA

US EVA-25 was delayed from Monday to Tuesday to allow the crew to re-size the remaining good EMU (#3005) for use by Mike Hopkins and re-size #3011 for Rick Mastracchio in order to have #3010 remain inside ISS for proper drying. EMU re-sizing and testing was underway on Sunday. Initially, #3005 was planned to be worn by Mike Hopkins for all of the EVAs, but a late switch had Hopkins wear #3011 during EVA-24 that was also used by Luca Parmitano when the water intrusion problem occurred in July 2013.

After identifying that the failure of the Fan Pump Separator of the EMU's Primary Life Support System was caused by a contamination in Servicing Water Flow, Mission Control decided to have Hopkins wear this suit because it had its Fan Pump Separator replaced and did not come into contact with the contaminated water supply since.

#3005 is still using the old Fan Pump Separator that did come into contact with the contaminants at least one, however, the current believe is that the Fan Pump Separator needs repeated exposure to this contaminated water before failing. It is not expected that any failure like that of #3011 in July will occur on #3005 in the near future. EVA-25 will again use the Helmet Absorption Pad and the snorkels as a last resort in case of water build-up in the helmet.

US EVA-25 Procedures

On Tuesday, December 24, Rick Mastracchio (EV-2, EMU #3011) and Mike Hopkins (EV-1 EMU #3005) will begin their second PM R&R Spacewalk at 12:10 UTC on Tuesday after completing nominal preparations consisting of suit donning, EMU checkouts and ISLE Pre-Breathe followed by the depressurization of the Quest Airlock.

Image: NASA

As EVA-25 begins, the removed Pump Module will be residing on the POA (Payload/Orbital Replacement Unit Accommodations) where it was installed after its removal. The S1 PM position will be empty with ammonia lines & electrical interfaces removed and tied to the truss segment. The spare pump module is installed on the outboard side of External Stowage Platform-3.

The objectives of EVA-25 are the removal of the spare from ESP-3 after completing necessary preparations of the new unit, the transport to S1 and the installation of the spare on the truss as well as the connection of ammonia Quick Disconnects and electrical connectors. As a time-permitting get-ahead, the removed Pump Module would be moved from the POA to ESP-3 to preserve it for potential future use with an external Flow Control Valve.

US EVA-25 once again features a Bingo Time of 5 hours and 15 minutes which is a standard part of ammonia procedures. Should fluid QD operations not be complete at PET+5:15, the crew would have to stand down and stop fluid work to allow sufficient time for ammonia bake-out. (Depending on consumables, there is some wiggle room for that Bingo Time.) EVA-25 is expected to take about 6 hours and 10 minutes.

Climbing out of the Airlock first, Mike Hopkins will configure safety tethers and make sure both crew members are secured properly to begin translation.

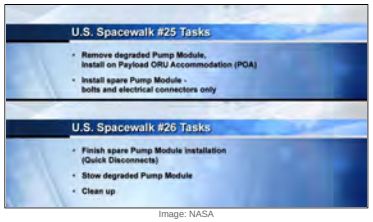
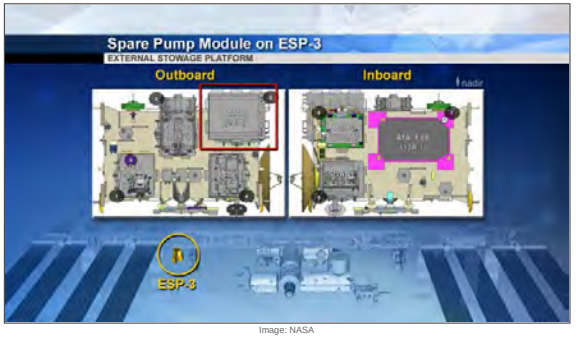


Image: NASA



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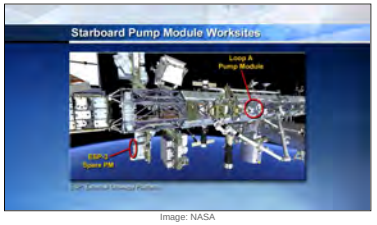

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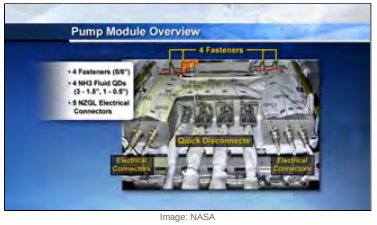

Image: NASA

When all tethers are in place, Rick Mastracchio will be given the GO to exit the airlock to start the EVA. Tool reconfigurations will be performed at the CETA Cart where Crewlock Bags and a large ORU Bag have been stowed on the previous EVA. Hopkins will also stop by at the crewlock zenith side to retrieve an Ammonia/Nitrogen Vent Tool. The two crew members will then make their way to External Stowage Platform 3 to prepare the spare Pump Module for installation.

Once at ESP-3 the crew members will get started by removing the protective Multilayer Insulation from the spare Pump Module. The spacewalkers will remove the MLI flaps that cover the connectors of the PM and also remove tape and velcro that is used to hold the PM electrical connectors in place.

In its stowed configuration, the Pump Module is not connected to any fluid lines and is filled with Nitrogen. The four ammonia Quick Disconnects of the module are protected by caps (The connectors are designated M1 through M4 and are three 1.5" connectors and one smaller 1/2" QD (M4). M4 is the PM inlet, M3 is the outlet, M2 is the return line coming from the Interface Heat Exchangers and M1 is the radiator bypass.) The PM also has five electrical and data connectors - designated J1 through J5. When stowed on ESP-3, the J1, J4 and J5 lines are connected to provide power to the PM and housekeeping telemetry to allow insight into the status of the PM. J2 and J3 are protected by caps.

To get the spare Pump ready for installation, all six caps (four QD caps, two electrical caps) are removed and stowed on the crew member's Fish Stringer which is then stowed inside the Crew Lock Bag. On the GO of Mission Control which comes after flight controllers deactivated the Pump Module, the three electrical connectors will be demated.

A wire tie will be used to bundle the three cables outside of the Pump Module extraction area.

The next step is breaking torque on the four structural bolts that are holding the spare PM in place using the Pistol Grip Tool to make about one turn on each of the four bolts which is performed by Rick Mastracchio. While he is breaking torque, Mike Hopkins will guide robotic arm operator Koichi Wakata into position for SSRMS ingress. The arm is pre-positioned ahead of the EVA and the final maneuver is performed manually by Wakata.

Once secured in the Articulating Portable Foot Restraint on the robotic arm, Mike Hopkins will again provide directions to Wakata who will maneuver to arm into a position for Hopkins to reach the spare Pump Module.

When Hopkins is in position, he will take the Pistol Grip Tool and change its settings before driving bolts 1, 2 and 4 expecting 13 to 16 turns before the bolts pop out signaling a good release. Afterwards, Hopkins secures the Pump Module to himself using a tether. Also, a scoop is installed on one of the bolts for additional stabilization of the PM once removed. Ahead of driving the final

bolt, Hopkins will make sure his suit is configured properly including glove heaters, visor, cooling and HAP because he will not be allowed to let go of the PM when it is removed.

The final bolt will be driven to detach Pump Module from its installation plate. Stowing the PGT and holding onto the Pump Module that is 175 by 127 by 91 centimeters, Hopkins will verify that all tethers and cables are out of the way before giving the GO for the SSRMS back-off maneuver. Koichi Wakata will then slowly move the arm away from the ESP-3 structure as Hopkins and Mastracchio monitor all clearances. After a series of single-joint maneuvers, Wakata will initiate two automated OCAS maneuvers taking several minutes as the arm slowly moves Hopkins and the Pump Module over to the S1 truss segment.

While Hopkins is on the move, Mastracchio stows the electrical connectors inside the Multilayer Insulation on ESP-3 for long-term survival before departing the work site and translating to the S1 work site to verify that the PM install location is clear of connectors and tethers.

Arriving at S1, Hopkins will guide Wakata from a pre-programmed stand-off position to the proper arm position for the installation of the Pump Module using the truss rail guides as a reference. Mastracchio will also monitor clearances and position. Slowly sliding into position, the Pump Module will find its new home on the S1 Truss.

As soon as the PM is in position, Hopkins will take the Pistol Grip Tool to install bolts 1 and 4 which need to be engaged to achieve a minimum bolt configuration. Bolt 3 will follow and the scoop that was installed earlier will be removed to access bolt 2 in order to fully engage all four bolts so that Hopkins can release his tether from the PM.

The five electrical connectors stowed inside the Truss will be untied for installation which will be performed by Rick Mastracchio. The J1-J5 connectors will be mated in any order.

Image: NASA

Image: NASA

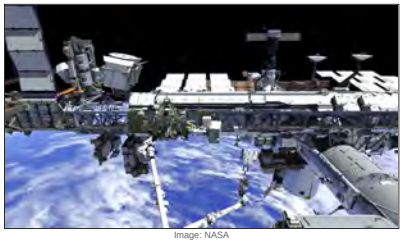

Image: NASA

While Mastracchio is busy with the electrical work, Mike Hopkins will set up the Vent Tool on the M3 Quick Disconnect of the spare PM that has to be vented before being re-integrated into the cooling system. To mate the QD Vent Tool, Hopkins will go through the QD mating checklist:

BLOCK C – MATE QD

1. Remove QD caps as required
2. Inspect male and female QD for debris or damage
3. Verify female QD ready to mate
   - √ Detent button – up
   - √ Locking collar – locked position
   - √ Fwd white band – not visible
4. Assess side load potential prior to mate
5. Mate QD
   - √Fwd white band – visible
6. Perform snapback test
   - √Fwd white band visible
7. Perform pull test (Stay clear of button, release ring, and bail trigger)
8. Perform visual gap test

Image: NASA

When Mastracchio is done with the connectors, SPARTAN Mission Controllers will power-up the Pump Module to verify that all valves are in the proper configuration for the Nitrogen vent. Because all electrical and data connections have to be in place to allow SPARTAN insight into PM telemetry, the vent can not take place until all connectors are mated and Mission Control has provided a GO. When the green light is given, Hopkins will go through the following steps to open the Vent Valve:

BLOCK D – Open Valve

1. Assess and counteract side loads (do not move bail if QD under significant side-loading)
2. Rotate locking collar to unlocked position (not on 1.5 in)
3. Depress detent button
4. Push bail to forward position
5. √ Aft white band visible
6. √ Detent button – up
7. Rotate locking collar to locked position (not on 1.5 in)

Image: NASA

Venting is expected to take approximately 60 seconds and the completion will be confirmed by Mission Control. Upon completion of the vent, Hopkins can close the valve again and work his way through the QD demate checklist to remove the Vent Tool:

Image: NASA

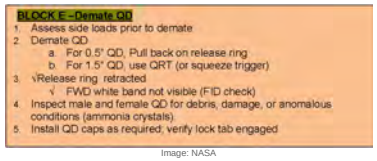

Image: NASA

At that point in the EVA, about 3 hours and 10 minutes will have elapsed according to test runs at the Neutral Buoyancy Lab - giving the spacewalkers 125 minutes to complete the fluid QD ops which will begin with a repositioning of the SSRMS to move Hopkins to the proper position for QD mating. Mastracchio will be releasing tethers from the ammonia lines and the GTEC cover bags that were stowed on the truss structure during EVA-24.

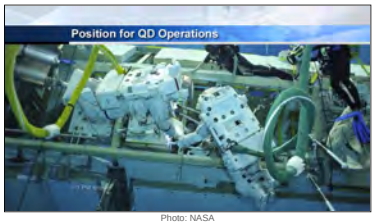

Photo: NASA

Photo: NASA

The four ammonia lines will be moved very carefully to their respective positions across the face of the Pump Module by Hopkins while Mastracchio removes the GTEC bags and stows them. The first ammonia Quick Disconnect to be mated is M1 (bypass). Mike Hopkins will be in charge of QD ops and Mastracchio will lend a hand when needed. Hopkins will be going through the Block C and Block D checklists (see above) to mate and open the M1 QD - also installing the S1 SPD (Subject Positioning Device). When M1 is successfully installed, SPARTAN will initiate the Pump Module Ammonia Fill through M1 that takes about 10 minutes to complete.

Ammonia Quick Disconnects

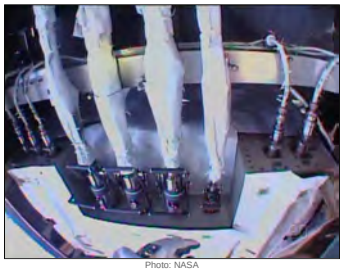
Photo: NASA

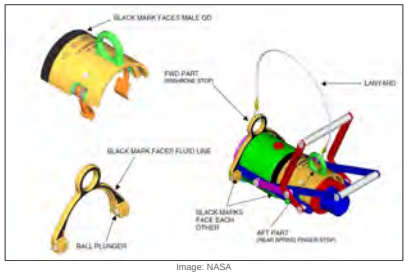

Image: NASA

Meanwhile, Hopkins will receive the GO for the mating and opening of the M2 QD again going through the checklists that will be double-checked with Mission Control to make 100% sure that the QDs are properly installed along with the SPD. With M2 in place, only the M3 and M4 (outlet & inlet) QDs remain which are attached to the Pump Module Jumper Box. First, the M3 valve is closed (Block B) so that SPARTAN can initiate a Pump Module vent via M4 that is about five minutes in duration. The next step is repeating the Block B to close the M4 valve.

Photo: NASA

Then, Hopkins will demate M4 from the Jumper (Block E) and mate it to its corresponding Pump Module connector (Block C). Next, M3 is demated from the Jumper and mated on the Pump Module. The Jumper is stowed on Rick Mastracchio's Body Restraint Tether.

The M3 valve is opened on MCC Go, but M4 has to be closed until its P-clamp is re-installed to hold the line in position when being pressurized. Hopkins will start turning the P-Clamp bolt with his fingers and then use the Pistol Grip Tool to finish the 12 to 14 turns expected on that P-Clamp.

Again waiting for Mission Control's GO, Hopkins will open the M4 valve performing the Block D checklist to open the final valve to integrate the spare PM with the External Thermal Control System.

To configure the pump for its new life at S1, Hopkins will use a wire tie to restrain all three SPD lanyards of the 1.5" QDs to a QD bail.

At this point in the EVA, Mission Control will assess remaining time and consumables and check with the crew members to decide whether to press on with the big get-ahead task of moving the old Pump Module from the POA to ESP-3. Moving the PM to ESP-3 is important to have it connected to ISS power and data systems for heater activation and telemetry monitoring so that the PM can be preserved for future use with an externally mounted Flow Control Valve.

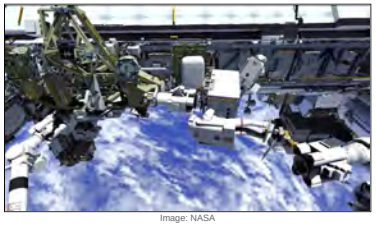
Image: NASA

Should this task not be completed, the old PM would be able to survive sitting on the POA for several weeks to months, but to make sure the PM remains operational, a clean-up EVA would be required in early 2014 to move it over to ESP-3.

If time permits, Mike Hopkins would stay on the arm and Koichi Wakata would move him over to the POA. Once there, Hopkins would install a scoop on the PM for stabilization during transportation and also tether himself to the module before starting to hold the PM and give the GO for POA release that is performed on command. When release is confirmed, Hopkins will pull the PM away from the POA and give Wakata the GO to maneuver to a backoff position and then over to ESP-3.

In the meantime, Mastracchio will close-out the S1 work site by

Image: NASA

installing Multilayer Insulation on the Pump Module that was just installed and relocate tools to the CETA Cart and ORU Bag.

Both crew members will meet at ESP-3 for the installation of the removed Pump Module that is carefully moved into position by Mike Hopkins as the SSRMS reaches its position at ESP-3. Mastracchio will restrain the electrical connectors so they do not interfere with the installation.

The next step is the removal of the Adjustable Grapple Bar that was installed on EVA-24 to allow the POA to grapple the PM. Mastracchio will use the PGT to drive the AGB bolt and pull the T-Handle to the unlock position and slide the single pin end of the AGB out of its receptacle in order to remove the other two pins from the PM and with that the AGB itself. The AGB is then reconfigured to its smallest setting and temp-stowed on a tether.

Adjustable Grapple Bar Removal

Image: NASA

Photo: NASA

Next, the SSRMS is moved for the installation of the PM that is once again performed using the PGT to drive Bolts 1,4 and 3 (in that order), release the scoop that was used to handle the PM in order to engage Bolt 2 to fully attach the Pump Module to ESP-3.

Rick Mastracchio will install six protective caps on the Pump Module to protect all four Ammonia Quick Disconnects and the J2 and J3 electrical connectors. J1, J2 and J3 are mated to the electrical lines of ESP-3 to connect the PM to ISS power and data.

Image: NASA

After closing out the work site by installing insulation, the crew members will part ways as Hopkins picks up the Adjustable Grapple Bar and rides the robotic arm over to External Stowage Platform 2 to install the AGB in its original location, on a Flex Hose Rotary Coupler.

Mastracchio will go back to the CETA Cart of reconfigure tools and equipment by placing the crew lock bags inside the ORU bag and stowing the Vent Tool and PM Jumper on the crew lock zenith side where a QD Bag is located. The ORU Bag is stowed inside the Airlock to come back inside.

At ESP-2, Hopkins will egress the arm and remove the foot restraint to stow it on ESP-2 and make his way to the Airlock to finish the EVA. Both crew members will ingress the Airlock to close out a busy EVA.