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EMERGENCY EGRESS REQUIREMENTS FOR CAUTION AND WARNING, LOGISTICS, MAINTENANCE, AND ASSEMBLY STAGE MB-6 OF SPACE STATION FREEDOM

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Introduction

The safety and survival of the crewmembers has been the prime concern of NASA. Previous studies have been conducted mainly for emergencies occurring during the operating mode of the fully assembled Station. The present study was conducted to evaluate the emergency requirements for the caution and warning, logistics, maintenance, and assembly stage MB-6 of the Station in space. Effective caution and warning is essential to achieve safe egress in emergencies. In order to survive a long period in space, the safety and emergency requirements for maintenance, logistics, and extravehicular assembly operation in space must be met.

Objectives

The objective of the study was to have an independent evaluation of the safety and emergency egress requirements for caution and warning, logistics, maintenance, and assembly of the Station in space.

Emergency Egress

Emergency egress is defined as the egress from a pressurized element when an event makes the element uninhabitable and ingress into a contiguous pressurized element that is safe.

Caution and Warning Methods

The Data Management System of the Station will provide the caution and warning signals, while EMAD will provide an additional warning for emergency situations. At present, EMAD has limited independent sensors for detecting emergency situations. It is recommended that the sensors located throughout the Station for detecting emergency situations should also be connected to EMAD to improve the effectiveness of the EMAD system. A suggested location for the work stations is the midsection of the modules. According to the current plan, there is no EMAD panel in logistics modules. A drag on EMAD panel is recommended for logistics modules to supplement the auditory alarm in an emergency.

A graphical cum alphanumerical format is recommended for displaying emergency action information (figure 1) at the Multipurpose Application Consoles. The detailed specifications of the graphical model, consistent with the human factors requirements have to be developed. The emergency action depends on the location of the crew members for a particular accident; as such, the action message should be appropriate at each work station for a particular emergency.

EMERGENCY ACTION INFORMATION DISPLAY

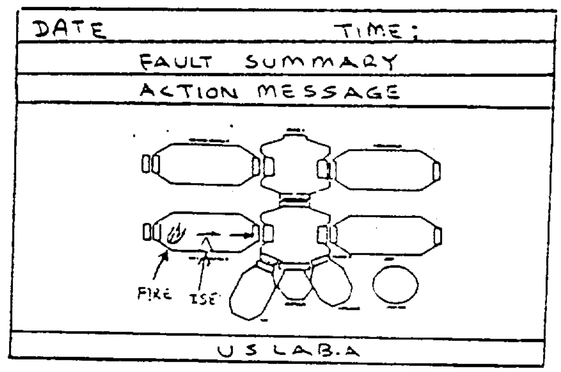

FIGURE 1

<u>Operation of Mini/Pressurized Logistics Modules (MPLM/PLM)</u>

The function of logistics modules is to support cargo transportation in racks from the US LAB, JEM, Columbus modules, and nodes to PLM and vice versa. The major tasks for logistics operation consist of handling racks to and from MPLM/PLM units. The average time required for handling a rack is estimated to be about 30 minutes. Based on the Neutral Buoyancy Simulation conducted recently (1), it is suggested that two persons are required to safely handle a rack as shown in figure 2.

HANDLING A RACK

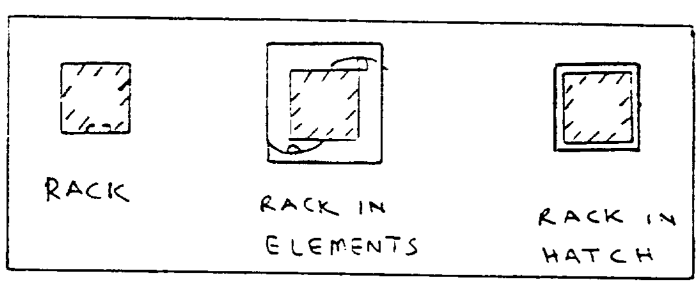

FIGURE - 2

One person as the front and a second person at the rear should hold a rack handgrip by one hand and use the other hand for translation guidance (figure 2). Recessed handgrips located centrally at the front and rear of a rack are recommended for translation purposes. Special care should be exercised while crossing hatch openings as the clearance between a moving rack and a hatch opening is very limited as shown in figure 2. In addition, the speed of translation during rack handling should not exceed 1 foot/second to allow frequent stops required to achieve a controlled movement and avoid accidents.

In an emergency during logistics operation, crew members present in MPLM/PLM should egress to the attached node. There is a probability of a catastrophe in case of a large fire occurring in the attached node (3). A contingency drag on oxygen supply is recommended for the waiting period of trapped crewmembers in this situation.

Maintenance Mode of Major Equipment

A typical Intravehicular Activity (IVA) for maintenance consists of shutdown, safing, gain access, replace or repair, close access, and testing of Orbital Replaceable Units or Orbital Maintainable Items, done sequentially by one person (2). A total of 640 IVA preventive and corrective maintenance tasks were identified. It is estimated that a total of 360 manhours/year will be required to cover all these tasks. During 50 percent of maintenance duration, one or more racks will be tilted on the aisle for access, causing partial blockage of the egress path. Typically, a tilted rack will be flat on an aisle and will reduce the egress path from 80 inches x 80 inches to 80 inches x 40.3 inches, as shown in figure 3. However, the reduced opening is adequate for emergency egress inside a module as illustrated in figure 6.

Although the egress path is blocked during hatch maintenance, the probability of an emergency during hatch maintenance is extremely low. A rigorous preventive maintenance is recommended to minimize the breakdown of hatch mechanism.

Safety and Emergency Egress During Assembly Phase MB-6

A total of 17 stages have been planned for assembling the Station in space. From MB-6, the Station will be occupied by humans at least for short periods. As such, safety and emergency provisions are required beginning this assembly stage.

Most of the assembly operations consist of hazardous Extravehicular Activities (EVA). A catastrophic emergency may arise due to puncture of an EVA suit (4). It is recommended that all sharp edges must be rounded or capped. In case of any emergency situation during this assembly operation, the crewmembers should translate to the docked Orbiter and de-orbit. For safe assembly operation, handholds and attachments are required on all modules and nodes. All EVA tools should also be tethered. A safe EVA operation procedure should be developed and used for training of EVA crewmembers.

During an emergency at MB-6, the worst emergency scenario consists of an accident at Node 2 and all four crewmembers located in the lab cannot translate through the damaged Node 2 to the Orbiter. In this case, crewmembers should close the lab hatch, isolate the lab, and wait for rescue by Orbiter.

Reference:

1. International Standard Payload Rack (ISPR) Neutral Buoyancy Simulation (NBS) Quick Look Report, Boeing Defense and Space Group, Doc: 2-H8W1-LCK-442, June 26,1992

2. Maintainability Allocations, Predictions and Analyses, Report C, Boeing Defense and Space Group, Doc: D683-10483-1, March 30, 1992

3. MPLM Phase B Safety Analysis, Alenia Spazio SPA, Doc: MPLM-RP-AI-002, January 17, 1992

4. Safety Assessment Report for MB-6, Draft 1, Boeing Defense and Space Group, Doc: D683-46007-1, July 23, 1992