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EMERGENCY EGRESS REQUIREMENTS FOR SPACE STATION FREEDOM

Prepared By:	Paul S. Ray
Academic Rank:	Assistant Professor
University and Department:	The University of Alabama Industrial Engineering Tuscaloosa, Alabama
NASA/MSFC:	
Division Branch:	Systems Safety Engineering Project Safety Engineering
MSFC Colleague:	Mark G. D'Agostino Richard Siler
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Introduction

There is a real concern regarding the requirements for safe emergency egress from the Space Station Freedom. The possible causes of emergency are (a) depressurization due to breach of the station hull by space debris, meteoroids, seal failure, or vent failure, (b) chemical toxicity, and (c) a large fire.

The original considerations including nodes at the end of international modules, egress aids, zoning of equipment and clear isles have been discarded in favor of the current specification requiring time of egress not to exceed three minutes. However, the tasks required for safe emergency egress in three minutes were not fully analyzed and the requirement has been recently used to 'avoid' design instead of making it safer.

Objectives

The objectives of the current study were to (a) Identify the tasks required to be performed in emergencies, (b) establish time required to perform these tasks, and (c) review the human-equipment interface in emergencies.

Assumptions

The study has been based on the following assumptions that resulted from previous studies:

1. Space Station Configuration established in PDR/5-4/GRFX-07/17/90.

2. Hatch Operation is manual.

3. All hatches remain open during normal operation.

4. Crew members can maintain a translation speed of one meter per second in the induced airflow caused by a 4 inch diameter hole in the station hull.

5. Probable translation speed range is from 0.75 to 2.0 ft/second depending on translation path restrictions. These values are based on the Skylab experience and empirical data obtained from the Astronauts.

6. Aisle passages are unobstructed at the onset of an emergency exit.

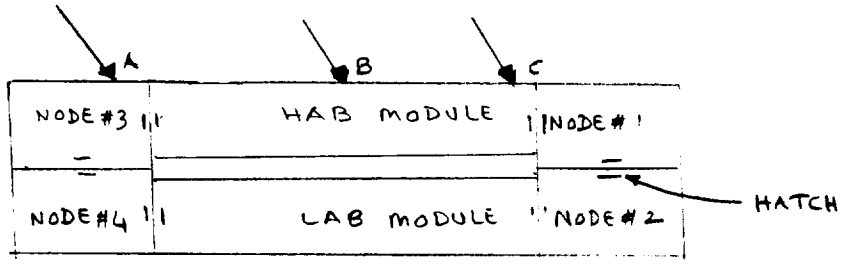
Emergency Egress Tasks

The emergency egress tasks consist of:

1. Perceiving the emergency warning
2. Recognizing the voice synthesized advice
3. Translating to safe area
4. Closing the hatches on both sides of the affected element

Assessment of the Emergency Egress Times

Emergency egress times were estimated for three unfavorable situations. Each scenario begins with all crew members located at the Habitation (Hab) module, while an emergency occurs in (a) Node #3, (b) at the mid-length, and (c) at one end of the Hab.



Sketch of the Space Station Configuration

The estimated times for the three cases were:

Case	Egress time (sec)
A	166
B	102
C	194

In case 'C', egress may be accomplished in 178 seconds if the hatch between Node #1 and Node #2 is closed instead of the one between Node #1 and the Hab module. But in this case Node #1 will be lost in addition to the Hab module.

Human-Equipment Interfaces in Emergencies

The emergency interface equipment identified are:

1. Hatch
2. Hatch Cover Plate Handle
3. Hand Crank for securing hatch cover plate
4. Pressure Gauge
5. Mobility Aids
6. Foot Restraints

Appropriate design specifications for these elements have been suggested to insure improved human performance of the emergency egress tasks. These specifications relate to human factors considerations and operational safety. The principal specifications are given below:

1. Hatch: The railings of the hatch operating mechanism should be enclosed.

2. Handle: The handle should be designed for power grip of a gloved hand and be of circular cross section.
Recommended dimensions:
Diameter = 1.5 inches
Length = 5.5 inches
Clearance = 2.0 inches

3. Hand Crank: Crank Arm = 8.0 inches
Crank Handle:
Diameter = 1.5 inches
Length = 2.0 inches
Operation at both sides of the Cover Plate should be decoupled

4.Pressure Gauge: Recommended Specifications:
Graduation Range = 1-15 psia
Graduation Interval = 1 psia
Graduation Mark = 5 psia
Conform to Specification No. MIL-M-18012B

5. Mobility Aids: Fixed Handrails and Kick Surfaces should be provided at suitable locations and for Hatch operation in emergencies.

6. Restraints: Foot Restraints are to be provided for Hatch operation in emergencies.
Recommended Dimensions :
Length = 8.25 - 11.5 inches
Breadth = 4.5 inches
Adjustable to fit different foot widths
Portable, and
Lockable on the floor

Summary

The study observations are summarized as follows:

1. A fixed time value specified for egress has shifted focus from the basic requirements of safe egress.

2. In some situations the crew members may not be able to complete the emergency egress tasks in three minutes without sacrificing more than half of the station.

3. Increased focus should be given to the Human Factors aspects of the station design.

Recommendations

1. Emergency Egress requirements for the Space Station should be directly linked to the following basic needs of safe egress before:

    A. Incapacitation due to low ambient pressure,
    B. Contamination from toxic chemicals, or
    C. Suffocation from smoke caused by fire.

2. A Flashing Display in Grid system should be evaluated as an alternative to the Voice Synthesizer for directing crew members in emergencies. This alternative appears to have some potential for reducing egress time and will also eliminate the masking effect of noise on the message.

3. Suggested specifications for emergency equipment should be considered for inclusion in the design of the Space Station.

4. The following procedures and design considerations should be finalized at an early date:

    A. Appropriate locations for suitable mobility aids and Restraints.
    B. Protective clothing and their stowage locations.
    C. Egress procedures and aids for single node attachments (PLM, ESA, JEM).
    D. Emergency decontamination procedures and facilities.

5. Ability of the crew members to perform emergency egress tasks should be experimentally verified under micro-gravity conditions for different sizes of hull penetration i.e. different induced air flow rates.