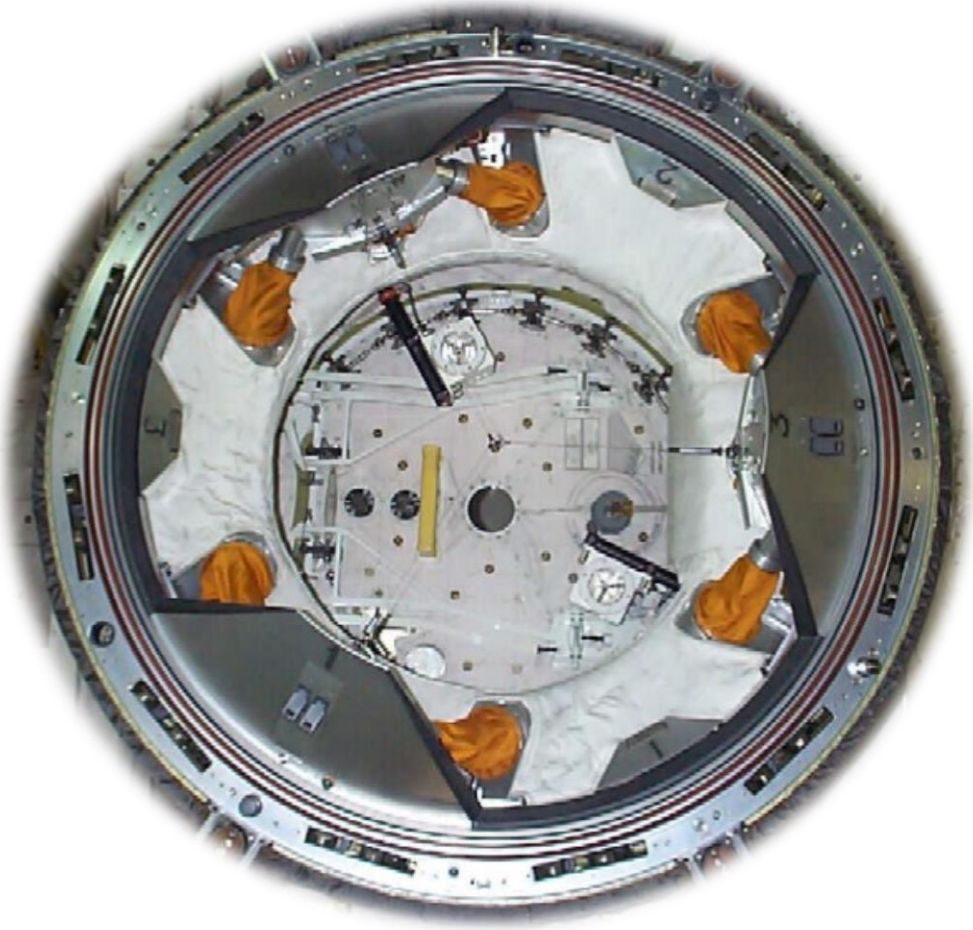
Orbiter “D” Hatch



Group #42

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Executive Summary

This document analyzes the hazards apparent when dealing with a hatch from a pressurized area to an unpressurized area (e.g. from a capsule/cabin into space). Specifically, this document looks at the NASA Orbiter “D” Hatch, which is used in the Orbital Docking System (ODS) and the airlock. This specific hatch has 17 latches and two-way pressure hatches. A two-way pressure hatch means that the pressure can be changed on either side of the hatch and the hatch will remain operable.

In the appendix will be the Hazard Report Forms for each of the ten hazards looks at for this project. It should be noted that the chosen scope of this project is to identify and analyze ten hazards of the Space Shuttle Orbiter “D” hatch with a focus on mechanical failures and how these failures would affect crew operations on the ground and on-orbit.

As noted above, a majority of the hazards are mechanical-related failures. This includes, but is not limited to, failure of the actuator, latches, and hinges.

Hazard Analysis

This section analyzes each of the hazards and how the hazards can be remedied through the use of controls and verifications. Due to the hatch’s main objective being the control of pressure in two environments to keep the crew safe, it should be noted that nearly all of these hazards have to do with the hatch being open/closed when the crew does not want it to be.

#1001 – Foreign Matter in Hatch Gaskets

Three causes were identified that could result in this hazard: gaskets not being properly cleaned, handled, or installed. Failure to perform these tasks properly begs for a problem to occur. These three causes are linked directly to each of the three controls listed: visual inspection, wipe down gasket surface, and replace the gasket entirely if needed. Each of these controls focus on inspecting the area for foreign matter and cleaning it away or replacement of the entire gasket if it is compromised.

To verify the controls, the following would need to be completed: visual inspection, physical inspection (e.g. to check for invisible-to-the-naked-eye material), and close hatch completely and test with a pressure reading to verify the seal.

If none of these control and verification combinations are sufficient to mitigate the problem, the consideration must be made to abort the mission and return to Earth.

#1002 – Latches Do Not Close

Four causes were identified that could result in this hazard: not properly being handled, maintained, or installed or foreign matter being present, which prevents closure of the latches. These four causes were linked to three controls: visual inspection prior to closure of hatch, removal of any foreign matter, or the replacement of the entire hatch itself.

To verify the controls, the following actions can be implemented: visual inspection, physical inspection, close hatch and use Simpson Meter to verify closure, or perform an EVA to visually/physically inspect both sides of the hatch during a closure attempt. This final verification may offer a unique perspective by allowing the participant to view the hatch from both sides, a luxury that is not offered from the safety of the airlock.

If none of these control and verification combinations are sufficient to mitigate the problem, the consideration must be made to abort the mission and return to Earth.

#1003 – Simpson Meter Failure

Six causes were identified that could result in this hazard. Four focus on the meter itself: the meter was not properly handled, maintained, or calibrated or had faulty batteries. These causes led to three distinctive controls: test the meter's accuracy with another circuit, install new batteries, or use a backup meter.

The other two causes focus on the wiring within the hatch: degradation of wiring or improper wiring overall. These then led to two separate controls: inspect and/or replace the wiring within the hatch itself.

To verify the controls, the following actions can be implemented: visual and physical inspection of the meter and the hatch and close hatch completely, using the primary and secondary meter for testing.

This is a low risk, low severity hazard. If none of these control and verification combinations are sufficient to mitigate the problem, perform a pressure check and ensure that there is no leak in the hatch. This will allow for the mission to continue for the foreseeable future.

#1004 – Damage to Gasket

Four causes were identified that could result in this hazard: the gasket is not properly handled or protected or is exposed to too much heat/cold or too much/too little moisture. These causes segue into five different controls: visual inspection prior to closure of the hatch, physical inspection to check for gasket integrity, keep gasket environment within operation range (i.e. in terms of moisture, temperature, and pressure), keep gasket covered when not in use, and replace the entire gasket if needed. These controls attack the problem at its source by identifying and removing any environmental or physically obvious issues with the gasket.

To verify the controls, three basic methods were identified: visual inspection, physical inspection, and close hatch entire and verify seal with Simpson Meter and leak check.

If no combination of the aforementioned controls and verifications work to remedy the situation, the consideration must be made to replace the entire hatch or complete all IVA activities and then abort the remainder of the mission and return to Earth.

#1005 – Warping of Hatch

Four causes were identified that could result in this hazard: the hatch was not properly handled, not properly protected, hatch experienced excessive amounts of stress, was affected by temperature/pressure change in the environment, or the manufacturer could have modified the materials or production process that had the potential to change the structures properties. Warping of the hatch could be potentially catastrophic; therefore, in-depth controls were identified to mitigate the issue. These controls are as follows: visual inspection prior to closure of the hatch, perform an EVA to observe both sides of the hatch during attempted closure, measure the distance from the hatch's body to the hatch's frame and taking note of all measurements (e.g. initial measurements being treated as nominal), perform a structural analysis on the hatch to locate new points of stress, and finally replace the entire hatch if necessary/possible.

Despite the in-depth controls, the verification methods are very simple: visual inspection, physical inspection, and close hatch and test the seal with the Simpson meter and a leak check.

If no combination of these controls and verifications remedy the issue, there is a serious problem and the integrity of the entire Orbiter may be at jeopardy. In light of that, an immediate abort of the mission may be necessary to bring the crew home safe.

#1006 – Misalignment of Latches

Three simple causes were identified that could result in this hazard: the latches were not properly installed, handled, or maintained. Three controls were also identified: visual inspection prior to closure of the hatch, attempt to realign via an EVA, and perform an analysis of the hatch to ensure it is not warped. Note that if it is warped, further procedures will be found under #1005 – Warping of Hatch.

To verify the controls, these methods should be implemented: visual inspection of the hatch, physical inspection of the hatch, and close the hatch complete and test with the Simpson meter and a leak check.

If no combination of these controls and verification remedy the situation, it becomes more likely that there is another problem entirely such as a warped hatch. However, if the situation cannot be remedied at all, the consideration must

be made to replace the hatch and/or abort the mission and return to Earth as soon as possible.

#1007 – Single Latch Failure

Five causes were identified that have the potential to result in this hazard: Latch is not properly aligned, has not been properly handled, has not been properly maintained, was manufactured improperly, or excessive stress could have been put on the singular latch. These controls were identified to mitigate the problem: visual inspection prior to closure of the hatch, replace the single latch, replace the entire hatch if needed, or contact the manufacturer to identify any changes in the fabrication/design/manufacturing process.

To verify these controls, the following action could be taken: visual inspection, physical inspection, and close the hatch and test with the Simpson meter and perform a leak test.

This occurrence has a low probability and medium severity level. Although this is still in the green, it should be taken care of as soon as it occurs. If not, this could result in the loss of “D” hatch operations.

#1008 – Actuator Failure

Three causes have been identified that could result in this hazard: excessive stress, exposed to an off-nominal environment (e.g. pressure or temperature), or a manufacturing mistake. Through these causes, the following controls were formed: visual inspection prior to closure of hatch, structural analysis on the actuator to identify if it was improperly designed, inspect internal working of the hatch to verify absence of foreign matter, complete breakdown and inspection of the actuator, contact manufacturer to inquire about changes in design/material/fabrication/manufacturing, or replace the actuator with a backup.

Although there are an abundance of controls for this hazard, the verification process is very simple. These actions include the following: visual inspection, physical inspection, and opening and closing the hatch completely to test the actuator in nominal operation conditions.

If none of these controls and verification rectifies the problem at hand, the hatch itself may have to be replaced in addition to using a different actuator. If that does not solve it, then a mission abort should be considered.

#1009 – Hatch Hinges Seize

Three causes were identified that could result in this hazard: the hinges become exposed to uncontrolled environment causing rusting, the structure becoming overstressed, or a manufacturing mistake. This led to four separate controls: visual inspection of the hinges, physical inspection for the structure and moving parts, replacing hatch/hinges if necessary, or perform an EVA to inspect both sides while attempt to close the hatch. These controls address the previously

mentioned causes as well as the possibility that separate hazards may be present like foreign material stopping the hatch from closing.

To verify these controls, the following actions should take place: visual inspection, physical inspection, and then close and open the hatch completely in addition to testing with the Simpson meter and performing a leak check.

#1010 – Hatch Glass Breaks

This hazard is one of the more dangerous ones analyzed in this document. The causes of this hazard are as follows: rapid heating/cooling or a blunt strike to the window. Analyzing these two hazards led to three distinctive controls: replace the hatch glass, replace the hatch, or seal the window on either side through use of a box patch. The box patch control would be used in the event of not having a replacement hatch or hatch glass available on-orbit. This is also an emergency fix that can occur during depressurization.

To verify these controls, the following actions should be taken: visual and physical inspection via EVA and close the hatch and then check for leaks via the pressure sensors on the flight deck.

Due to the potential for this hazard to cause a rapid decompression on-orbit, the crew should seriously consider returning to Earth immediately upon mitigating the hatch glass hazard.

Procedural Activities

H1001-C1 Visual Inspection of Hatch Gasket for Foreign Matter before Closeout

*****NOTE***** This procedure is to be conducted concurrently with H1004-C1

1) Gather supplies needed:
    a. Clean rag (2x per hatch)
    b. Bleach-free cleaner
    c. Flashlight
    d. Rubber gloves
    e. Extra gasket material
2) Don gloves
3) Ensure hatch is propped open and secured
4) Make a cursory inspection for obvious signs of particulate or residual matter on the gasket
    a. Note any discoveries
5) Activate and hold flashlight at an acute angle to the gasket and inspect the gasket for signs of glare strengthening or weakening along the entire gasket.
    a. Glare differential indicates the possible presence of a foreign substance on the gasket

b. Note any discoveries

6) Wipe 1x clean rag across the length of the gasket
    a. Inspect rag for evidence of foreign matter
    b. Note any discoveries
7) If foreign matter is discovered, proceed to H1001-C2; if no foreign matter is discovered, inventory equipment and close out procedure

H1001-C2 Gasket Cleaning

1) Take rag used to conduct wipe test in H1001-C1 and attempt to gently remove the foreign matter using a dry rag
    a. If successful, conduct H1001-C1 again
    b. If unsuccessful, proceed to step 2
2) Discard dry rag and apply non-bleach cleaner to rag then attempt to remove the foreign matter
    a. If successful, dry gasket with first rag and conduct H1001-C1 again
    b. If unsuccessful, conduct procedure H1001-C3

H1001-C3 Hatch Gasket Replacement

1) Gather materials required
    a. Screwdriver, Flat Head
    b. Wooden Block, 6”x1”x1”
    c. Rubber Mallet
    d. Large Shears
    e. Gasket Material
    f. Dry Erase Marker
    g. Dry, clean rag
2) Locate on existing gasket where the ends of the gasket material meet
    a. Mark the location on the hatch structure with Dry Erase Marker
3) Remove Gasket
    a. Gently work the head of the screwdriver into the gap between the ends of the gasket material
    b. With a lever action, dislodge one end of the gasket material and pull to remove
    c. Mark gasket on both sides as “OOC” [Out of Commission] to differentiate it from new gasket
4) Cut new gasket material
    a. Measure new gasket material approximately 1/8” longer than the old gasket (gasket shrinks with age)
    b. Mark a cutting line with dry erase marker
    c. Cut gasket ensuring that the cut on both edges of the gasket is exactly squared (i.e. diagonal cuts are not permitted)
5) Wipe dry erase marker residue from gasket material

6) Using the wooden block, push new gasket into groove, starting where the dry erase mark exists on the hatch frame
7) Using the wooden block, compress the gasket until it fits into the groove
8) Wipe the dry erase mark from hatch frame
9) Conduct a seal test in order to confirm that gasket is seated properly
    a. If seated improperly, open and secure hatch then adjust gasket as necessary
    b. If seated properly, inventory equipment and close out procedure

H1002-C1 Visual Inspection of Latches before closeout

*****Note***** This procedure is to be conducted concurrently with H1006-C1

1) Gather necessary materials
    a. Flashlight
    b. Clean, dry rag
2) Thoroughly inspect all latches for signs of wear, fatigue, or breakage
3) Wipe all latches with clean dry rag, note any discrepancies in inspection
4) Inventory equipment and close out procedure

H1002-C2 Removal of Foreign Matter from Latch Assembly

1) Gather necessary materials
    a. Alcohol-based solvent
    b. Clean, dry rags (3+)
    c. Rubber gloves
    d. Respirator with vapor cartridges
    e. Safety glasses
    f. Pliers, needle nose
    g. Rubber mallet
    h. Silicone lubricant
    i. Replacement small hardware, assorted
    j. Crescent wrench
2) Don safety gear (glasses, respirator, gloves)
3) Using needle nose pliers, remove cotter pin holding latch hinge in place
4) Using crescent wrench, disengage bolts that attach latch assembly to push-pull rods and remove latch hinge
5) Using clean rag, wipe latch hinge and all latch assembly parts free of debris and fluids
6) Douse clean rag in alcohol based solvent and thoroughly wipe each separate part of the latch assembly
7) Place parts in open air to dry
8) Apply silicone lubricant to gloved finger and apply to all friction surfaces (hinge, latch-hinge interface surface, etc.)

9) Reassemble latch assembly, reattach to push-pull arms, replace cotter pin in latch hinge
10) Test motion of latches
    a. If unsatisfactory, conduct H1007-C2
    b. If satisfactory, inventory equipment and close out procedure *info* - dispose of contaminated rags, gloves, and broken hardware IAW workplace HAZMAT guidelines.

H1002-C3 Hatch Replacement

1) Gather necessary materials
    a. Chain fall/pulley system
    b. Pliers, needle nose
    c. Hard hat
    d. Rubber gloves
    e. Replacement hatch and associated small hardware
    f. Safety observer
    g. Rubber mallet (as needed)
    h. Silicone lubricant
2) Don safety gear
3) Set chain fall/pulley system off orbiter and attach working end to hatch, take up all slack *info* - the weight of the hatch should be borne entirely by the chain fall/pulley.
4) Remove cotter pin in hinge axle
5) Remove hinge axle *info* - at this point, the hatch should be free of the orbiter structure
6) Heave around on chain fall/pulley to remove hatch
7) Lower replacement hatch onto orbiter structure
8) Lubricate inside of orbiter structure and replacement hatch hinge axle joint
9) Lubricate hinge axle
10) Replace hinge axle
11) Replace hinge axle
12) Test motion of the hatch
    a. If unsatisfactory, disassemble hinge and reassemble
    b. If satisfactory, inventory equipment and close out procedure

H1003-C1 Calibration of Simpson Meter on Test Circuit

1) Gather required materials
    a. Simpson Meter, primary
    b. Simpson Meter, secondary
    c. Test circuit w/power supply
    d. Electrical safety gloves
2) Connect power supply to test circuit
3) Connect secondary Simpson Meter to circuit, note results

4) Disconnect secondary Simpson Meter, connect primary Simpson Meter, note results
5) Compare results
    a. If results are different, conduct H1003-C2 then restart H1003-C1
    b. If results are the same
        i. Disconnect power supply from test circuit
        ii. Ground test circuit
        iii. Inventory equipment and close out procedure

H1003-C2 Battery Replacement for Simpson Meter

1) Gather necessary materials
    a. Simpson Meter
    b. Replacement batteries
2) Deactivate Simpson Meter
3) Remove batteries
4) Replace batteries
5) Activate Simpson Meter and conduct H1003-C1
6) Inventory equipment and close out procedure *info* - batteries must be disposed of IAW workplace HAZMAT regulations

H1003-C3 Inspection of Hatch Circuit Systems

1) Gather necessary materials
    a. Simpson Meter
    b. Screwdriver, Phillips-head
    c. Breakout box
2) Remove access panel and dust screen from door
3) Attach breakout box to electrical continuity test jack
4) Test resistance at points 3-4
5) Test resistance at points 5-6
    a. If resistance is >2 ohms, the hatch is open
    b. If resistance is <2 ohms, the hatch is closed
6) Compare test results to actual position of hatch
    a. If tests disagree with actual position, proceed to H1003-C4
    b. If tests concur with actual position
        i. Disconnect Simpson Meter from Breakout Box
        ii. Disconnect Breakout Box from electrical continuity test jack
        iii. Replace dust cover and access panel
        iv. Inventory equipment and close out procedure

H1003-C4 Hatch Replacement

******* Conduct procedure H1002-C3 *******

H1004-C1 Visual Inspection of Hatch Gasket for Damage

1) Gather necessary materials
    a. Flashlight
2) With the flashlight at a shallow angle to the gasket, gently press and stretch the gasket material, inspecting for any tears or holes in the gasket material
    a. If tears or holes are present, conduct procedure H1001-C3
    b. If no tears or holes are present, conduct procedure H1004-C2
    c. Inventory equipment and close out procedure

H1004-C2 Physical Inspection of Hatch Gasket for Damage

1) Gather necessary materials
    a. Flashlight
    b. Wooden Block, 6”x1”x1”
2) With the flashlight at a shallow angle to the gasket, use the edge of the block to stretch the gasket more strenuously than in previous procedure, inspecting for any tears or holes in the gasket material
    a. If tears or holes are present, conduct procedure H1001-C3
    b. If no tear or holes are present, inventory equipment and close out procedure

H1004-C3 Hatch Gasket Replacement

******* See Procedure H1001-C3 *******

H1004-C4 Gasket Storage and Protection Requirements

1) Gasket material must be stored in a cool, dry environment
2) Do not store gasket material with other petroleum products
3) Do not store gasket material with harsh solvents
4) Install gasket immediately upon removing from controlled environments
5) Cover with Kapton tape after installation

H1004-C5 Installation of Hatch Hood

***** This procedure should be considered only if hatch is exposed to greater risk of damage due to other operations in the vicinity *****

1) Gather necessary materials
    a. Hatch hood
    b. Attachment hardware
    c. Hard Hat
    d. Safety Glasses
    e. Chain fall/Pulley
2) Don safety gear
3) Attach hatch hood to chain fall and lift hatch hood off the ground
4) Maneuver hatch hood over hatch assembly and lower over hatch

5) Use small attachment hardware (zip ties, nuts and bolts, etc. as necessary) to secure hatch hood in place
6) Inventory equipment and close out operation

H1005-C1 Visual Inspection of Hatch for Warping

1) Gather necessary materials
    a. Spirit level
    b. Half sphere of chalk
    c. Non-bleach cleaner
    d. Clean dry rag
2) Close but do not seal hatch
3) Place spirit level with one end at the center of the hatch, note readings
4) Check in at least four different positions, noting deviations from level
5) Open hatch and secure
6) Conduct chalk test
    a. Rub flat surface of half sphere of chalk along gasket
    b. Close and seal hatch
    c. Open and secure hatch
    d. Inspect ring for broken segments
        i. If broken segments exist, conduct procedure H1004-C1 and H1004-C2
            1. If broken segments still exist, conduct H1005-C3
        ii. If no broken segments are present
            1. Dampen rag with non-bleach cleaner and wipe chalk from gasket and hatch collar
            2. Inventory equipment and close out procedure

H1005-C2 (Flight Rule 201.1005-2)

1) For crewmembers to attempt EVA, both conditions must be met
    a. EVA team is already in the airlock
    b. Safety of the EVA team is not endangered
2) EVA will be canceled if there is any evidence of debris on the exterior of the orbiter
3) If the EVA team is unable to reseal the hatch, EVA team will evacuate to ISS and shuttle will begin contingency deorbit

H1005-C3 Hatch Replacement

******* Conduct Procedure H1002-C3 *******

H1005-C4 Structural Analysis of Hatch and Hatch Collar for Warping

***** This procedure should only be considered if a warped hatch is discovered *****

1) Conduct stress and strain analyses on hatches and hatch collar to determine how and where hatches are likely to warp
2) Create redesign recommendations based upon analyses

3) Consider redesign

H1006-C1 Visual Inspection of Latch Alignment prior to Hatch Closeout

1) Gather necessary materials
    a. Wooden block, 6”x1”x1”
    b. Protractor
    c. Pencil
    d. Notepad
2) On wooden block, mark 90, 92.5 and 87.5 degrees using protractor on the long axis of the block, then draw a centerline down the length of the block, intersecting the 90 degree mark
3) Ensure hatch is open and secured
4) Place wooden block lengthwise on the hatch
    a. Align the centerline with the center of the latch hinge *info* - the angle described, between the hatch and the line that passes through the latch hinge and roller hinge should be approximately 90 degrees (perpendicular)
    b. Measure the deviation (□) from 90 degrees of the latch head’s roller hinge
        i. Note approximate deviation from 90 degrees for each individual latch in notepad
        ii. If □> +/- 2.5 degrees, latch is out of alignment
        iii. If □< +/- 2.5 degrees, latch is satisfactory
5) Adjust latches as necessary
    a. If latches are out of alignment, disassemble and reassemble with deviation from 90 degrees less than +/- 2.5 degrees
    b. If latches are aligned properly, inventory equipment and close out procedure

H1006-C2 (Flight Rule 201.1006-2)

1) For crewmembers to attempt EVA, both conditions must be met
    a. EVA team is already in the airlock
    b. Safety of the EVA team is not endangered
2) EVA will be canceled if there is any evidence of debris on the exterior of the orbiter
3) If the EVA team is unable to reseal the hatch, EVA team will evacuate to ISS and shuttle will begin contingency deorbit

H1006-C3 Hatch Warping Test

1) Gather necessary materials
    a. Metal bar equal in length to the hatch radius
    b. Spirit level
2) Close and seal hatch

3) Place metal bar with one end over the center of the hatch, place spirit level on top of bar
4) Rotate bar 360 degrees around the hatch, noting the position of the spirit level
    a. If spirit level deviates more than 2mm from center, the hatch is warped
        i. Proceed to H1007-C3
    b. If spirit level does not deviate more than 2mm from center, the hatch is not warped
        i. Open and secure hatch
        ii. Inventory equipment and close out procedure

H1007-C1 Visual Inspection of Latches prior to Hatch Closeout

******* Conduct Procedure H1002-C1 *******

H1007-C2 Replacement of Single Latch

1) Gather necessary materials
    a. Alcohol-based solvent
    b. Clean, dry rags (3+)
    c. Rubber gloves
    d. Respirator with vapor cartridges
    e. Safety glasses
    f. Pliers, needle nose
    g. Rubber mallet
    h. Silicone lubricant
    i. Replacement latch and small hardware, assorted
    j. Crescent wrench
2) Don safety gear (glasses, respirator, gloves)
3) Using needle nose pliers, remove cotter pin holding latch hinge in place
4) Using crescent wrench, disengage bolts that attach latch assembly to push-pull rods and remove latch hinge
5) Remove latch
6) Using clean rag, wipe new latch hinge and all latch assembly parts free of debris and fluids
7) Douse clean rag in alcohol based solvent and thoroughly wipe each separate part of the latch assembly
8) Place parts in open air to dry
9) Apply silicone lubricant to gloved finger and apply to all friction surfaces (hinge, latch-hinge interface surface, etc.)
10) Reassemble latch assembly, reattach to push-pull arms, replace cotter pin in latch hinge
11) Test motion of latches
    a. If unsatisfactory, conduct H1007-C2

b. If satisfactory, inventory equipment and close out procedure *info* - dispose of contaminated rags, gloves, and broken hardware IAW workplace HAZMAT guidelines.

H1007-C3 Hatch Replacement

******* Conduct Procedure H1002-C3 *******

H1007-C4 Fabrication Information for Latch Assembly

1) Contact manufacturer for fabrication specifications of latch assembly components

H1008-C1 Visual Inspection of Actuator prior to Hatch Closeout

1) Gather necessary materials
    a. Alcohol-based solvent
    b. Clean, dry rags (3+)
    c. Rubber gloves
    d. Respirator with vapor cartridges
    e. Safety glasses
    f. Pliers, needle nose
    g. Rubber mallet
    h. Silicone lubricant
    i. Replacement actuator and small hardware, assorted
    j. Crescent wrench
2) Don safety equipment
3) Open and secure hatch
4) Observe actuator assembly, inspect for signs of exterior wear
5) Proceed to H1008-C1.1

H1008-C1.1 Disassembly and Inspection of Actuator Assembly

2) Disassemble the actuator assembly into components
3) Visually inspect each component for wear, cracking, and fatigue
    a. If wear, cracking or fatigue exists, replace part
    b. Proceed to H1008-C1.2

H1008-C1.2 Inspection and Cleaning of Internal Parts of Actuator Assembly

1) Using a dry clean cloth, wipe each individual component clean
2) Dampen a clean cloth with alcohol-based solvent and wipe each component
3) Set components out in open to dry
4) Apply silicone lubricant to finger and spread over all components that experience friction
5) Reassemble actuator assembly
6) Test actuator action on open hatch
    a. If test fails, disassemble and reassemble

        i. If that fails, proceed to H1008-C3
    b. If test is successful, inventory equipment and close out procedure

H1008-C2 Structural Analysis of Actuator to Identify Flaws

***** This procedure should only be conducted if a problem or series of problems are identified *****

1) Conduct multi-disciplinary analyses on actuator assembly to identify potential failure points
2) Compile recommendations for improvement of actuator design
3) Recommend modifying actuator

H1008-C3 Actuator Replacement

1) Gather necessary equipment
    a. Alcohol-based solvent
    b. Clean, dry rags (3+)
    c. Rubber gloves
    d. Respirator with vapor cartridges
    e. Safety glasses
    f. Pliers, needle nose
    g. Rubber mallet
    h. Silicone lubricant
    i. Replacement actuator and small hardware, assorted
    j. Crescent wrench
2) Don safety equipment
3) Open and secure hatch
4) Disconnect actuator assembly from push-pull rods
5) Disassemble, remove, and discard actuator assembly
6) Disassemble replacement actuator
7) Conduct procedures H1008-C1.1 and H1008-C1.2
8) Inventory equipment and close out procedure *info* - dispose of contaminated rags IAW applicable workplace HAZMAT guidelines

H1009-C1 Visual Inspection of Hatch Hinges

1) Gather necessary materials
    a. Flashlight
2) Inspect hatch hinge assembly for any anomalous condition that may exist
3) Proceed to H1009-C2

H1009-C2 Physical Inspection of Hatch Hinges

1) Gather necessary materials
    a. Dry clean rag
    b. Flashlight
    c. Hard hat

d. Safety observer

2) Pass a dry clean rag over each part of the hatch hinge, checking for foreign matter in the hinge assembly
3) Test the hatch hinge by opening and closing (do not seal) the hatch
    a. If test is unsatisfactory, proceed to H1009-C3
    b. If test is satisfactory
        i. Open and secure hatch
        ii. Inventory equipment and close out procedure

H1009-C3 Hatch Hinge Replacement

***** Note: because two of the three major components of the "D" hatch are inseparable from the hatch or the orbiter structure, the only part of the hinge that can be replaced is the axle. Replacing other portions would require extensive structural work on the orbiter or hatch. *****

1) Gather necessary equipment
    a. Hard hat
    b. Safety glasses
    c. Gloves
    d. Silicone lubricant
    e. Pliers, needle nose
    f. Chain fall/pulley system
    g. Replacement hinge parts
    h. Safety observer
2) Attach chain fall/pulley system to hatch assembly
    a. Heave around on chain fall until no weight is on hinge assembly
3) Remove cotter pin from hinge axle, remove hinge axle, discard old axle *Caution* - remove one at a time to prevent hatch from swinging freely
4) Apply lubricant to finger and rub on replacement hinge axle
5) Reassemble hinge axle, replace cotter pin in hinge axle
6) Test motion of hatch by opening and closing hatch (do not seal)
    a. If test is unsuccessful, disassemble and reassemble
    b. If test is successful
        i. Open and secure hatch
        ii. Slack and release chain fall/pulley system
        iii. Remove hatch from chain fall/pulley
        iv. Inventory equipment and close out procedure

H1009-C4 (Flight Rule 201.1009-4)

1) For crewmembers to attempt EVA, both conditions must be met
    a. EVA team is already in the airlock
    b. Safety of the EVA team is not endangered
2) EVA will be canceled if there is any evidence of debris on the exterior of the orbiter

3) If the EVA team is unable to reseal the hatch, EVA team will evacuate to ISS and shuttle will begin contingency deorbit

H1010-C1 Hatch Glass Panel Replacement

1) Gather necessary materials
    a. Replacement glass panel
    b. Replacement window gaskets
    c. Crescent wrench (2x)
2) Ensure hatch is open and secured
3) Complete a danger tag for the hatch *rationale* - it is impossible to test the seal on the porthole mount until the leak test before launch. Completing a danger tag in the program's tag out log will ensure that pad technicians will test the seal at that location
4) Disassemble the porthole mount
5) Remove glass panel and gaskets
6) Replace the gaskets, with the glass panel between the two
7) Reassemble porthole mount
8) Inventory equipment and close out procedure

H1010-C2 Hatch Replacement

******* Conduct Procedure H1002-C3 *******

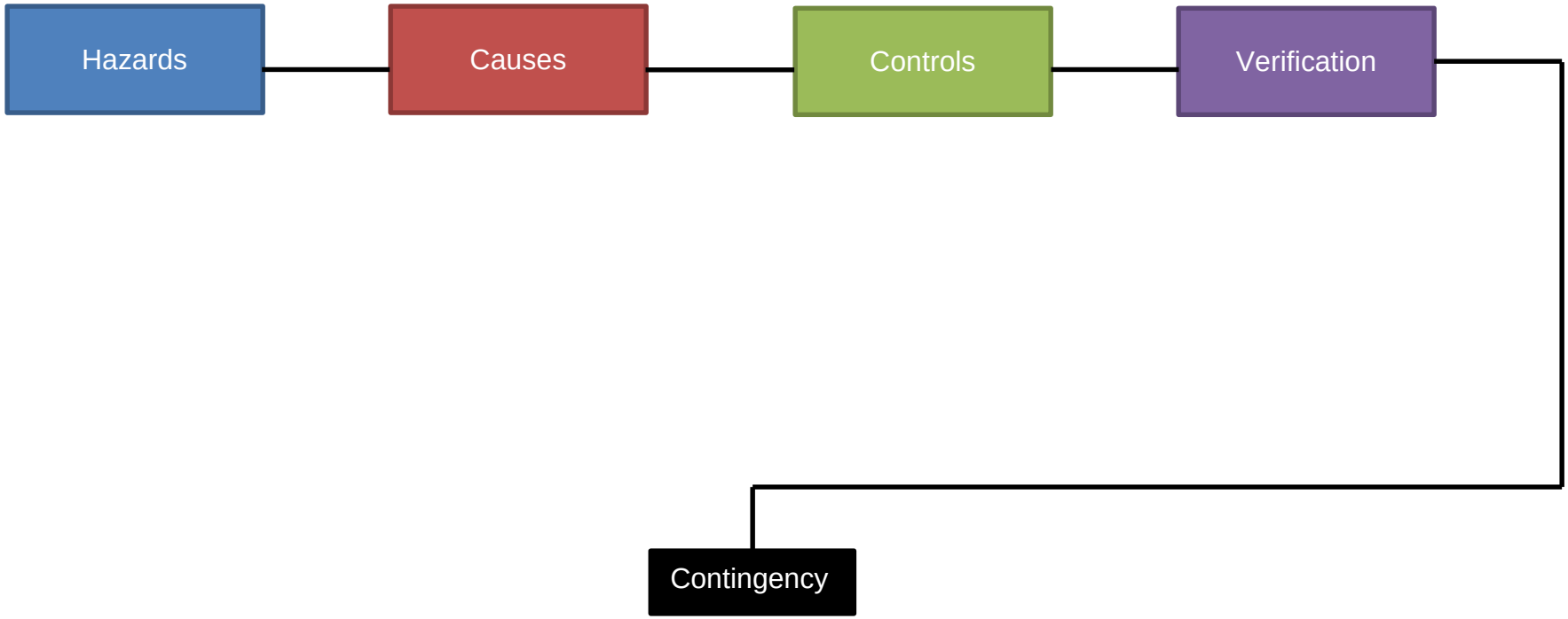
H1010-C3 Emergency Pressure Hull Patching – No Heat Loading

******* This patching procedure is for use only on portions of the spacecraft that experience no aerodynamic heating on re-entry. ***

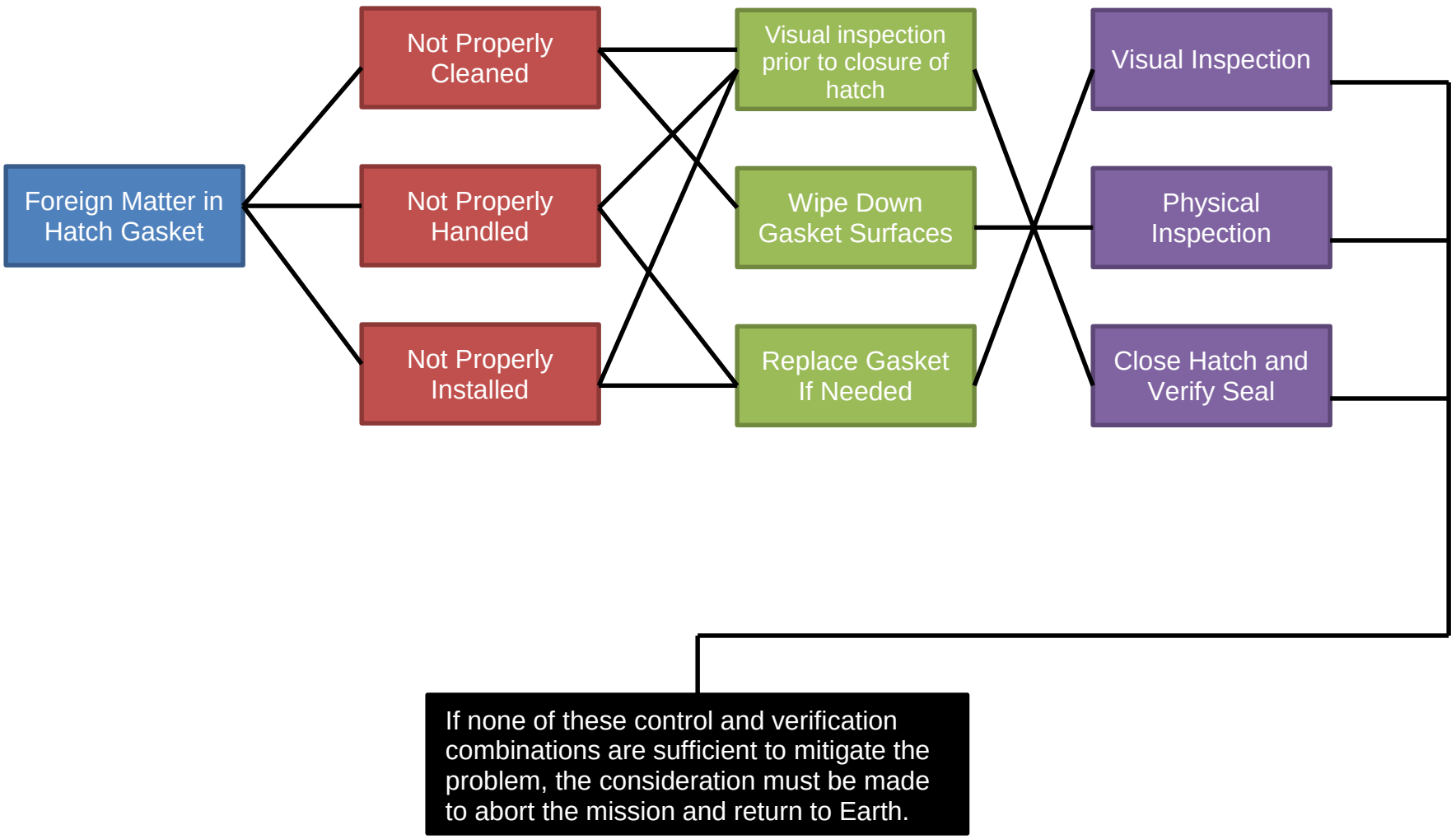
1) Gather necessary equipment
    a. Bucket/box patch
    b. Crescent wrench
2) Loosen the self-locking pressure nut on top of the bucket/box patch to within one inch of the top of the J- or L-bar
3) Slide the J- or L-bar through the hole *Note* - make sure that the repairman firmly grips the end of the bar in order to maintain positive control of the patch.
4) Slide the bucket over the hole
5) Tighten the nut nearest the bucket first, then tighten the second nut to lock it in place
6) Tighten the patch until a firm seal is formed
7) Monitor airlock pressure from crew compartment
    a. If pressure continues to drop, continue tightening patch, prepare to evacuate affected portion of spacecraft
    b. If pressure stabilizes and normalizes, inventory equipment and close out procedure

Mapping of Hazards to Procedures

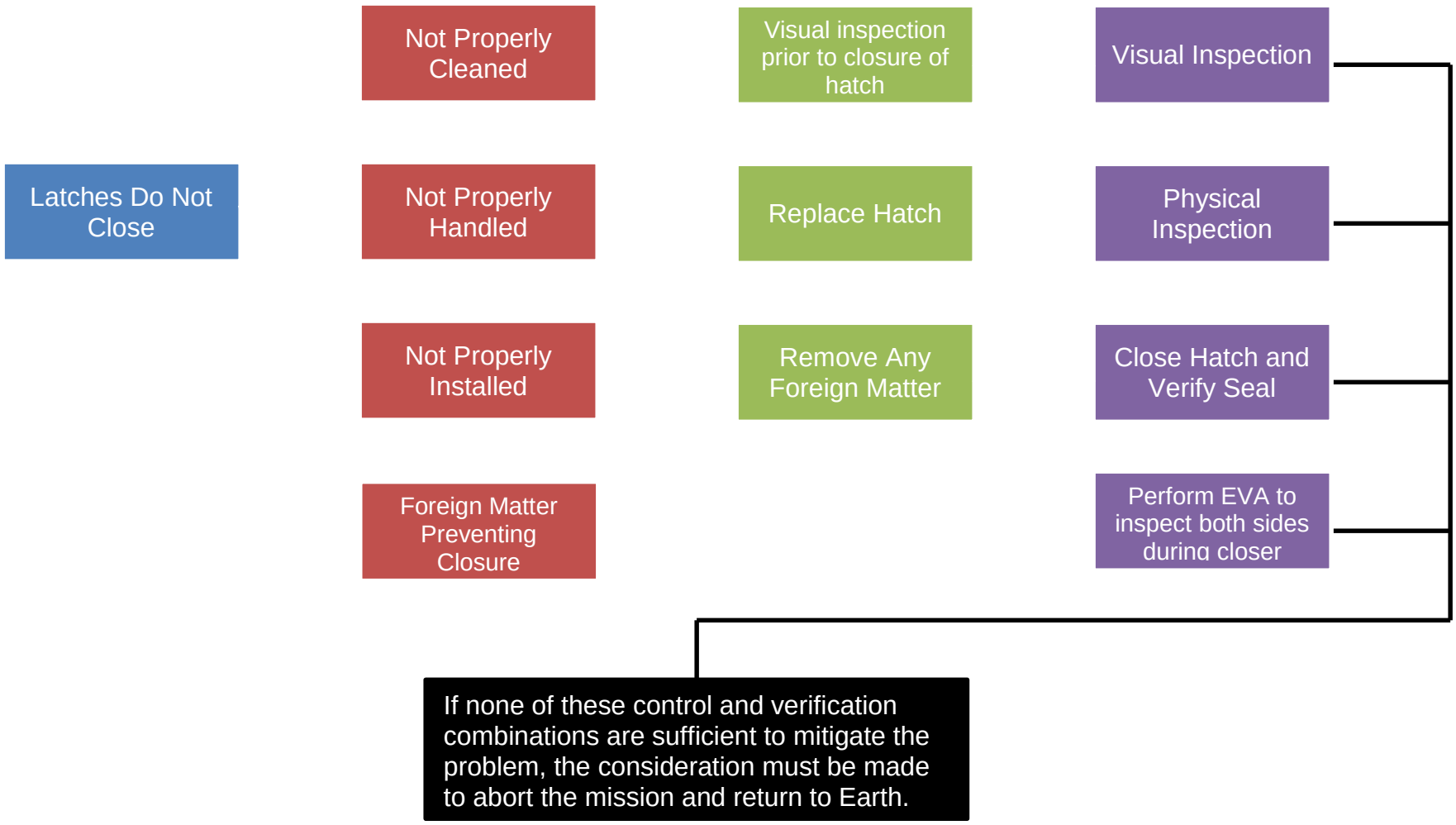
Guide



#1001 – Foreign Matter in Hatch Gaskets

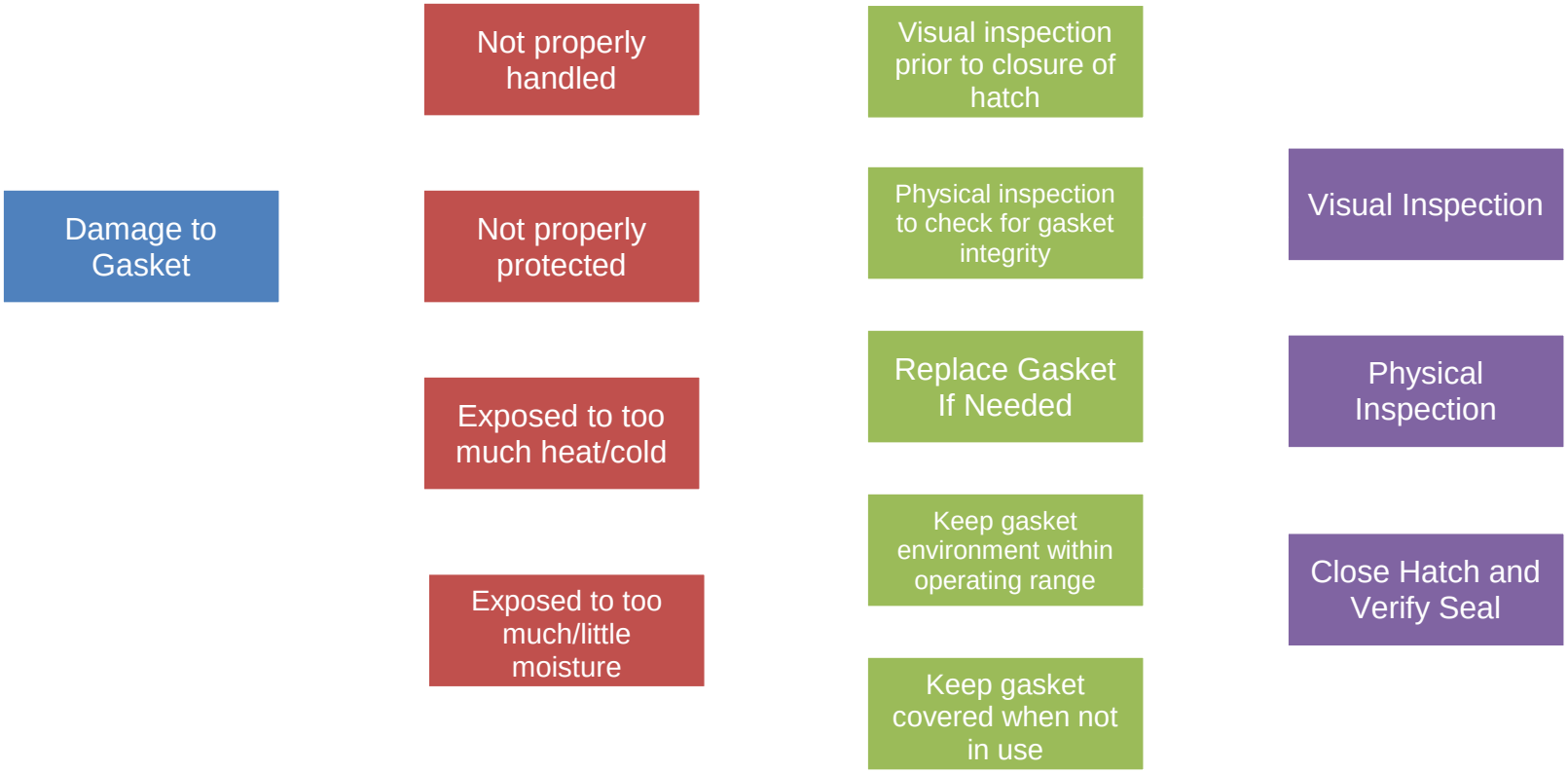


#1002 – Latches Do Not Close

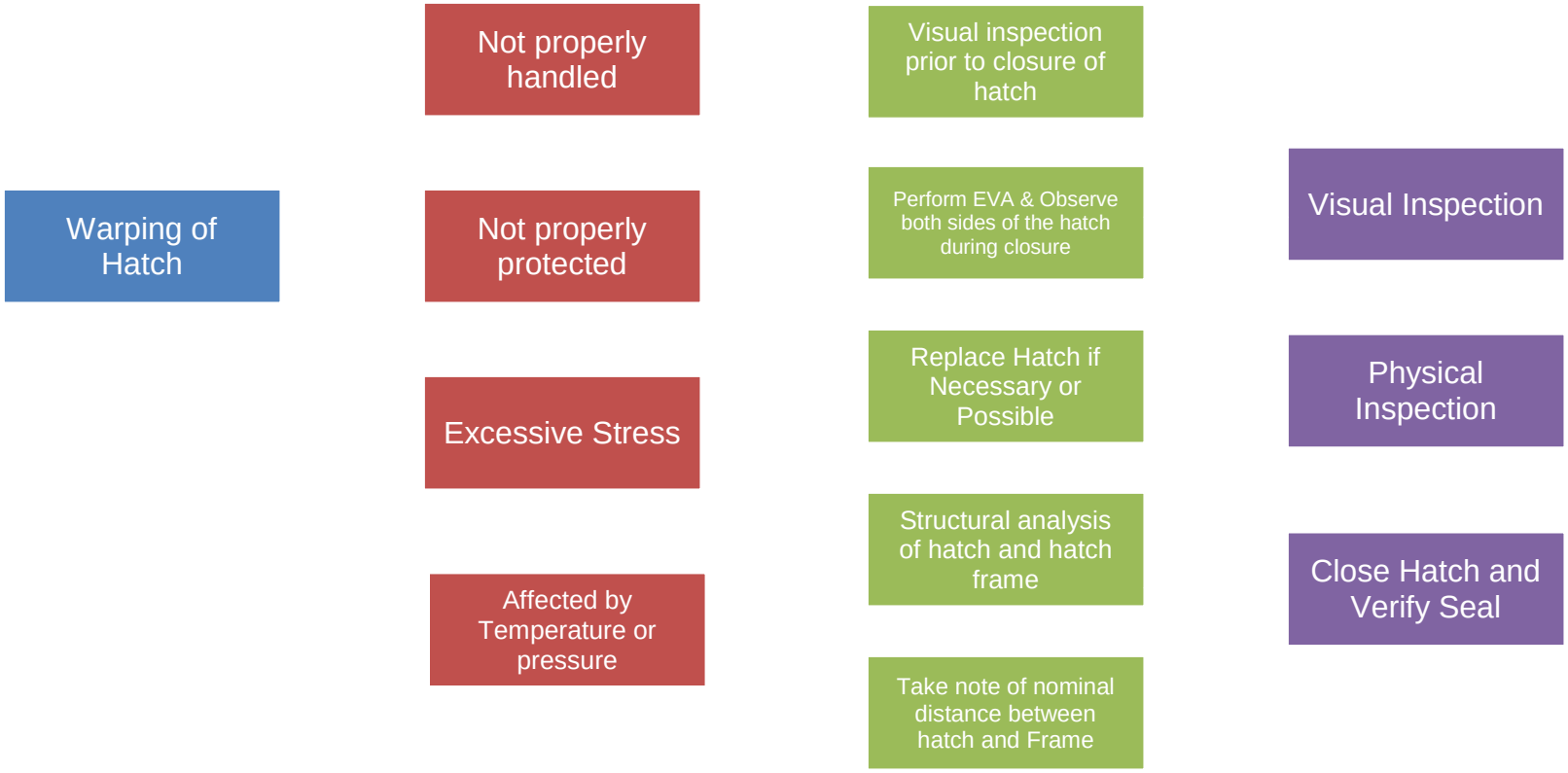


#1003 – Simpson Meter Failure

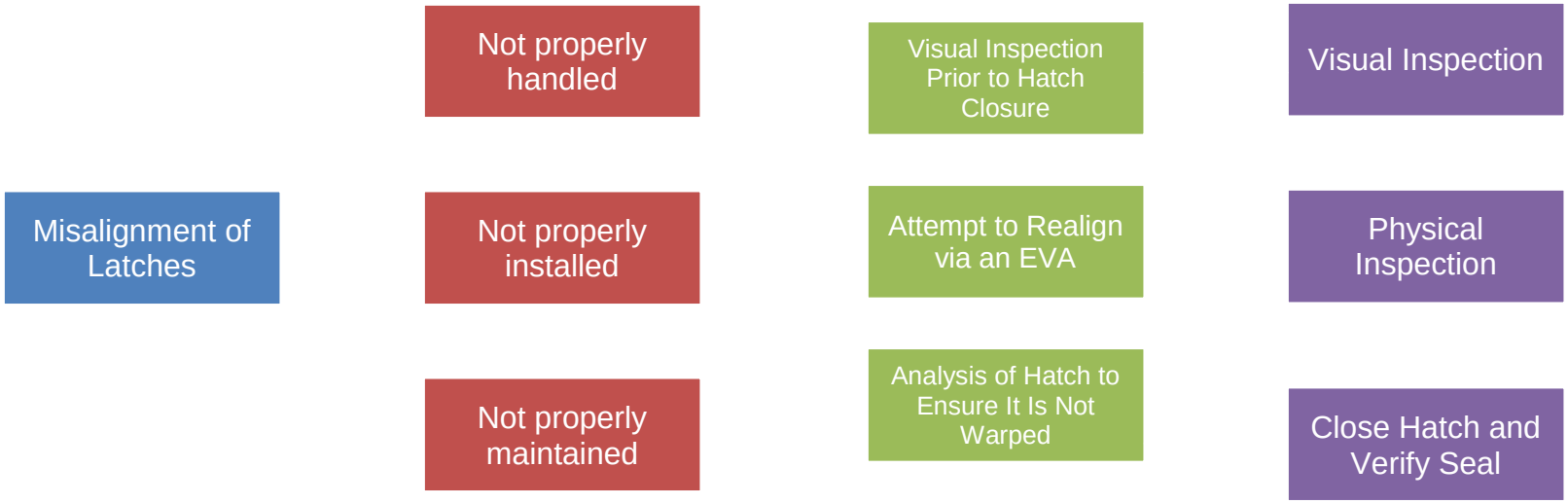
#1004 – Damage to Gasket



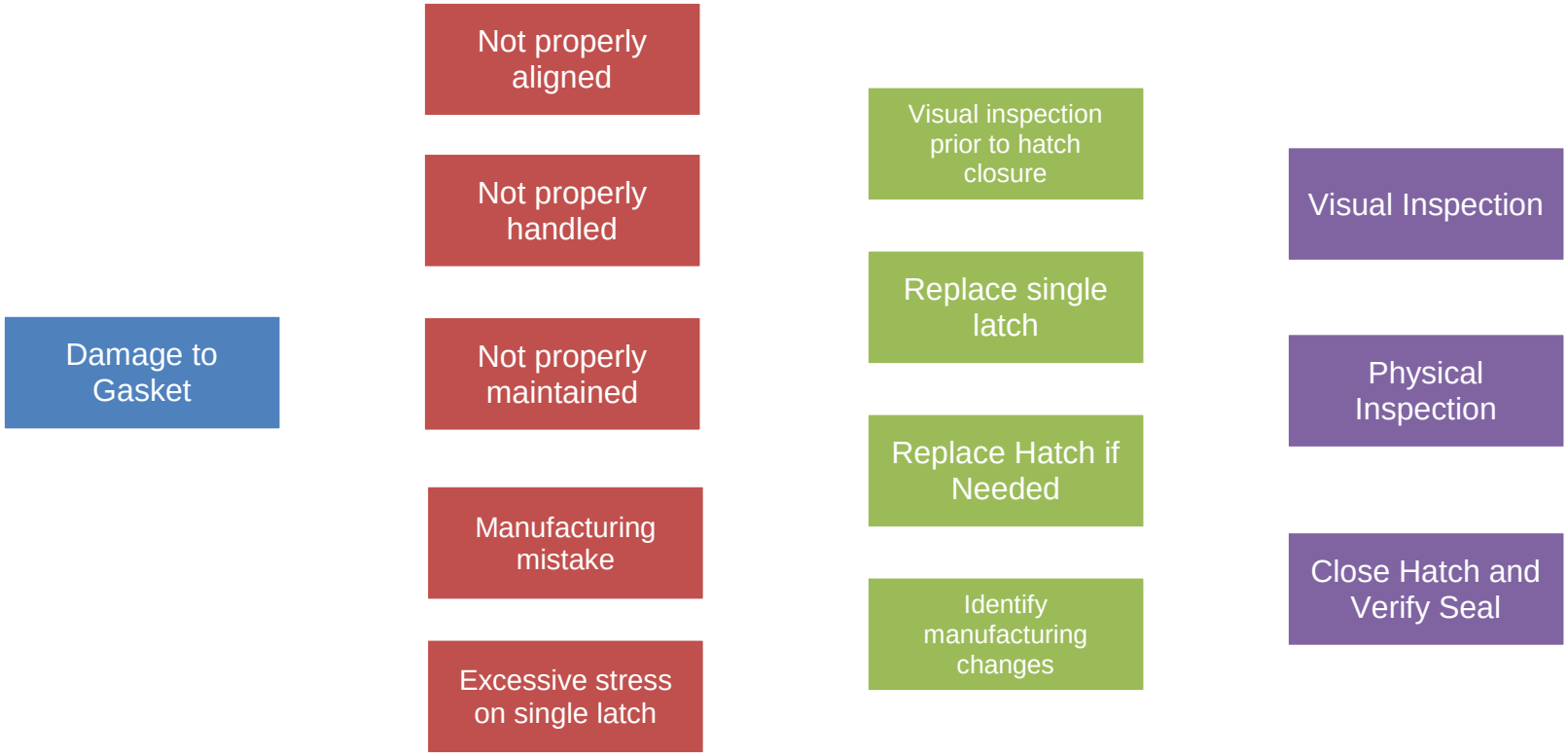
#1005 – Warping of Hatch



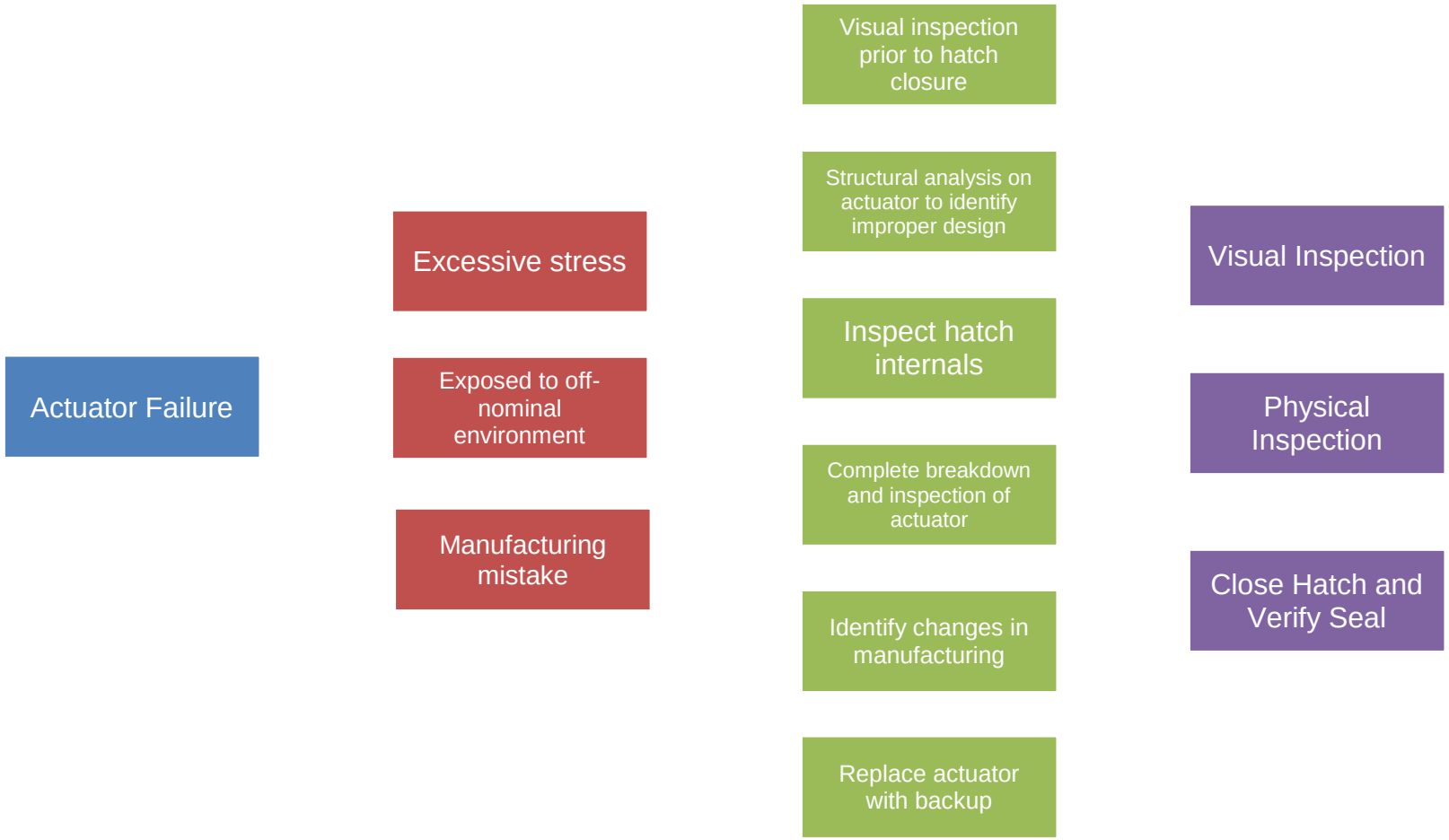
#1006 – Misalignment of Latches



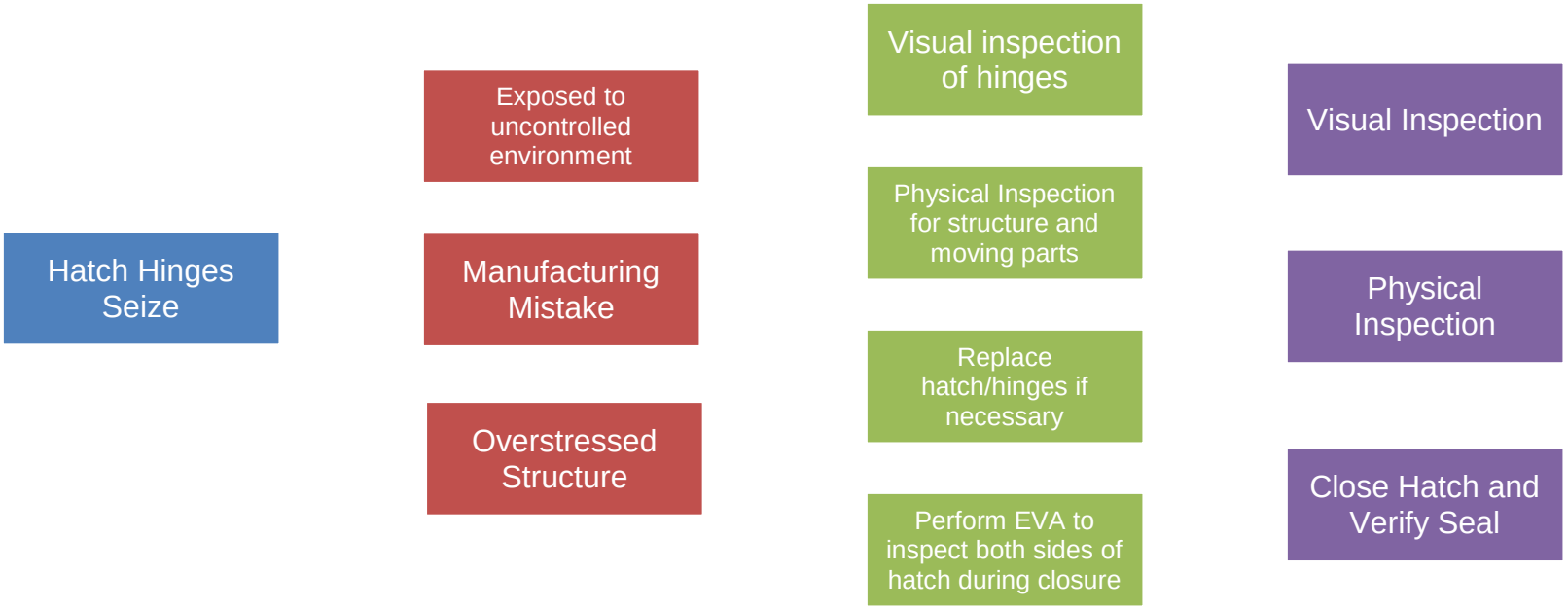
#1007 – Single Latch Failure



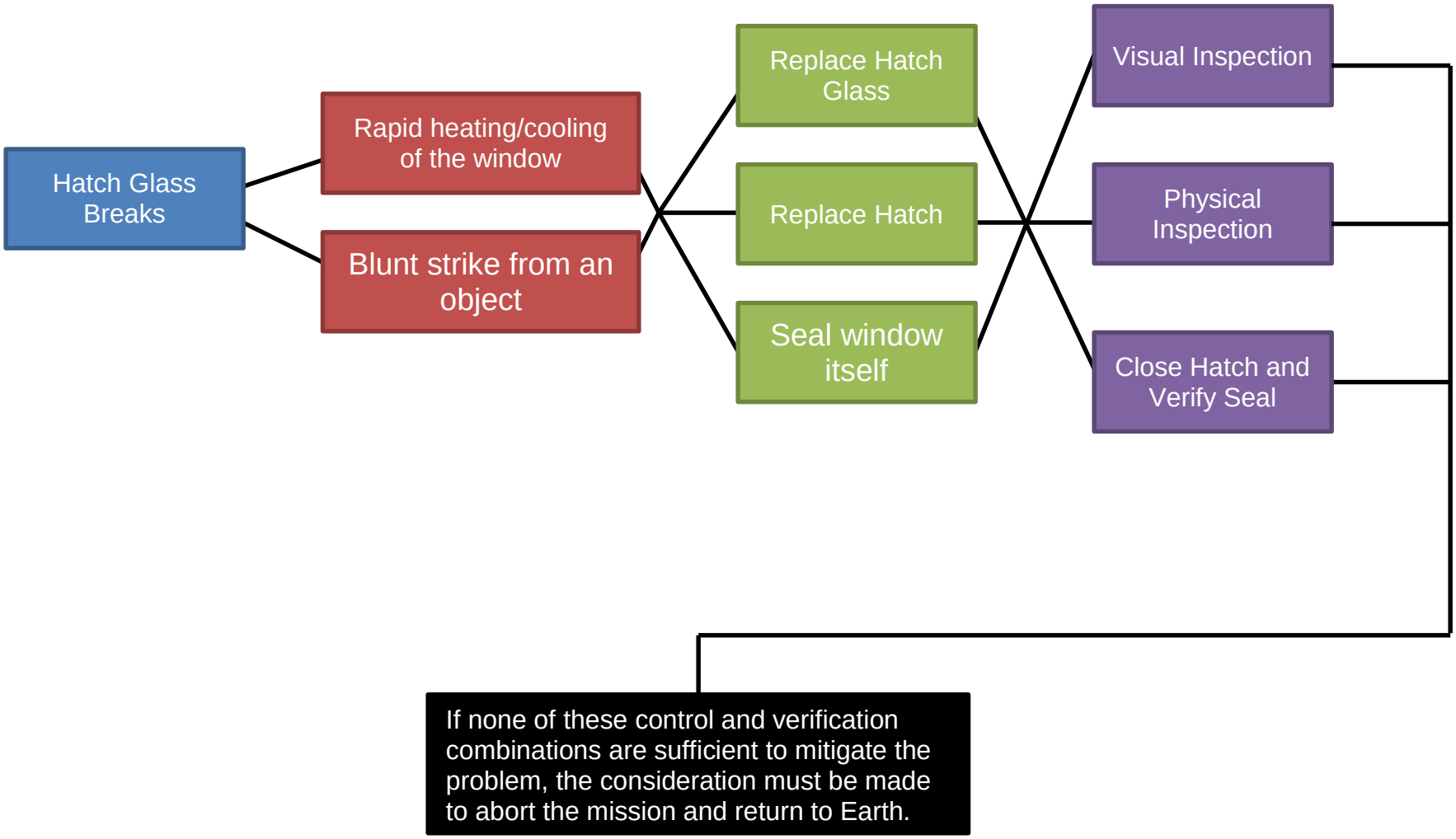
#1008 – Actuator Failure



#1009 – Hatch Hinges Seize



#1010 – Hatch Glass Breaks



Appendix

#1001 – Foreign Matter in Hatch Gaskets

1. **Hazard Title**: Foreign Matter in Hatch Gaskets
   Hazard #: 1001

2. **Hazard Condition Description**:

Foreign matter has been detected in the hatch gaskets, removing the ability to create a perfect seal.

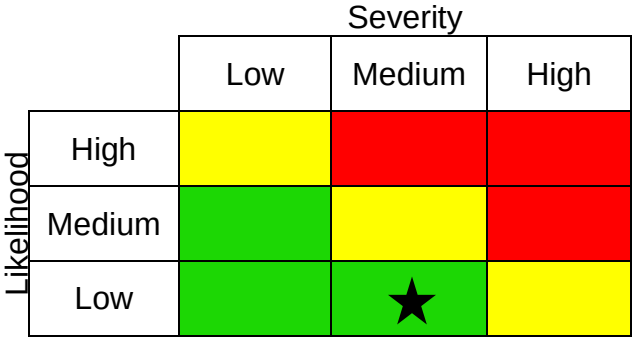
3. **Causes (Summary)**:
   a. Not properly cleaned
   b. Not properly handled
   c. Not properly installed

4. **Hazard Interfaces**:

This affects the ability to pressurize/depressurize the airlock. This has the potential to remove all capability of EVAs and may require the immediate abort of a mission.

5. **Mission Phase(s)**
   a. Launch Processing __x__
   b. Launch _____
   c. Ascent _____
   d. On-Orbit Operations __x__
   e. Entry _____
   f. Landing _____
   g. Post Mission __x__

Risk Management Matrix



Severity: Low

Likelihood: Medium

Hazard Controls:

Control 1: Visual inspection prior to closure of hatch

Control 2: Wipe down gasket surfaces

Control 3: Replace gasket if needed

Method for Verification of Control:

Verification 1: Visual inspection

Verification 2: Physical inspection

Verification 3: Close hatch and verify seal

Contingency: The gaskets must create a perfect seal. If a perfect seal is not present, gaskets must be replaced entirely. If that is not an option, the mission must be scrubbed/aborted until the problem can be remedied. If on-orbit and all controls and verifications have failed, finish IVAs and return to Earth.

#1002 – Latches Do Not Close

1. **Hazard Title**: Latches Do Not Close
   Hazard #: 1002

2. **Hazard Condition Description**:

A mechanical failure has stopped the latches from being able to close properly.

3. **Causes (Summary)**:
   a. Not properly handled
   b. Not properly maintained
   c. Not properly installed
   d. Foreign matter preventing closure

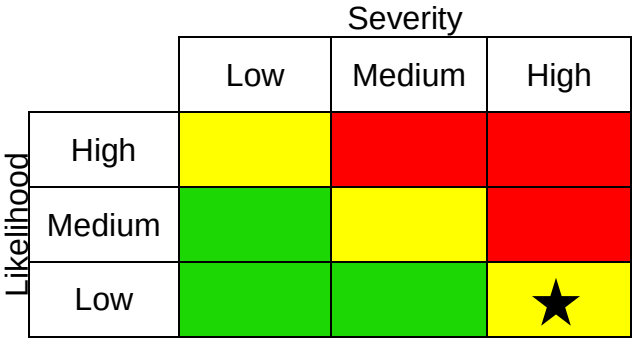
4. **Hazard Interfaces**:

This affects the ability to pressurize/depressurize the airlock. This has the potential to remove all capability of EVAs and may require the immediate abort of a mission. In addition, depending on when this happens during a mission, the Orbiter could be permanently stuck to the ISS or the hatch could be left open.

5. **Mission Phase(s)**
   a. Launch Processing __x__
   b. Launch _____
   c. Ascent _____
   d. On-Orbit Operations __x__
   e. Entry _____

f. Landing _____
g. Post Mission __x__

Risk Management Matrix



Severity: High

Likelihood: Low

Hazard Controls:

Control 1: Visual inspection prior to closure of hatch

Control 2: Remove any foreign matter

Control 3: Replace hatch

Method for Verification of Control:

Verification 1: Visual inspection

Verification 2: Physical inspection

Verification 3: Close hatch and verify closure through use of Simpson Meter

Verification 4: Perform EVA to visually/physically inspect both sides of the hatch during closure attempt

Contingency: If all controls and verifications have failed, finish IVAs and return to Earth.

#1003 – Simpson Meter Failure

1. **Hazard Title**: Simpson Meter Failure
   Hazard #: 1003

2. **Hazard Condition Description**:

Simpson Meter shows inaccurate reading when all other sign point to the opposite.

E.g. Meter reads as the hatch being closed when the hatch is obviously open.

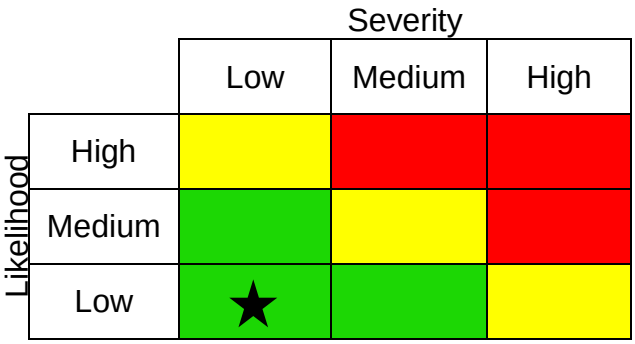
3. **Causes (Summary)**:
   a. Not properly handled
   b. Not properly maintained
   c. Not properly calibrated
   d. Faulty batteries
   e. Improper wiring within hatch
   f. Degradation of wiring within hatch

4. **Hazard Interfaces**:

This malfunction affects this mission by creating an unsure environment of whether or not the hatch is properly closed. In addition, if this meter is malfunctioning, what caused it to malfunction and could that cause have affected other mechanisms in the Orbiter.

5. **Mission Phase(s)**
   a. Launch Processing __x__
   b. Launch _____
   c. Ascent _____
   d. On-Orbit Operations __x__
   e. Entry _____
   f. Landing _____
   g. Post Mission __x__

Risk Management Matrix



Severity: Low

Likelihood: Low

Hazard Controls:

Control 1: Test meter's accuracy with another circuit

Control 2: Install new batteries

Control 3: Use backup meter

Control 4: Inspect circuit system of the hatch itself

Control 5: Replace hatch circuitry or replace hatch

Method for Verification of Control:

Verification 1: Visual inspection

Verification 2: Physical inspection

Verification 3: Close hatch and verify proper closure

Contingency: Backup meter should remedy the problem. If the inaccurate reading is still present, the hatch itself will need to be inspected for proper wiring.

#1004 – Damage to Gasket

1. **Hazard Title**: Damage to Gasket
   Hazard #: 1004

2. **Hazard Condition Description**:

Gasket(s) have been damaged through use or degradation of material.

3. **Causes (Summary)**:
   a. Exposed to too much heat/cold
   b. Exposed to too much/little moisture
   c. Not properly handled
   d. Not properly protected

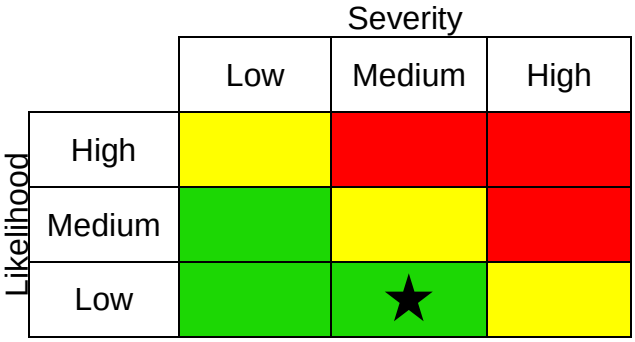
4. **Hazard Interfaces**:

Gaskets are vital to creating an airtight seal. Without the gaskets being in peak condition, a leak can form, endangering the crew.

5. **Mission Phase(s)**
   a. Launch Processing __x__
   b. Launch _____
   c. Ascent _____
   d. On-Orbit Operations __x__
   e. Entry _____
   f. Landing _____

g. Post Mission __x__

Risk Management Matrix



Severity: Medium

Likelihood: Low

Hazard Controls:

Control 1: Visual inspection prior to closure of hatch

Control 2: Physical inspection to check for gasket integrity

Control 3: Replace gasket if needed

Control 4: Keep gasket environment within operating range (e.g. temperature, moisture, pressure)

Control 5: Keep gaskets covered when not in use

Method for Verification of Control:

Verification 1: Visual inspection

Verification 2: Physical inspection

Verification 3: Close hatch and verify seal

Contingency: The gaskets must create a perfect seal. If a perfect seal is not present, gaskets must be replaced entirely. If that is not an option, the mission must be scrubbed/aborted until the problem can be remedied. If on-orbit and all controls and verifications have failed, finish IVAs and return to Earth.

#1005 – Warping of Hatch

1. **Hazard Title**: Warping of Hatch
   Hazard #: 1005

2. **Hazard Condition Description**:

Hatch has warped to the point of not being able to close/open. If the hatch is warped while closed, a perfect seal it most likely impossible, creating a leak.

3. **Causes (Summary)**:
   a. Not properly handled
   b. Not properly protected
   c. Excessive stress
   d. Affected by temperature/pressure

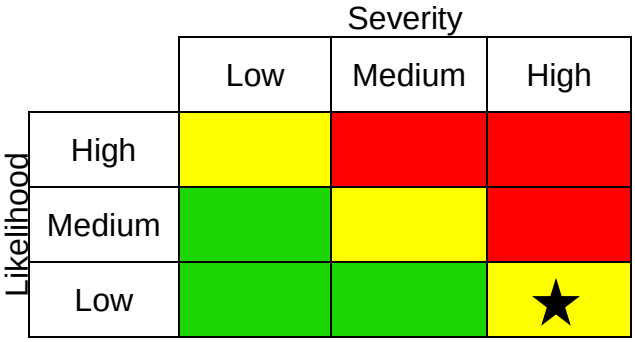
4. **Hazard Interfaces**:

Warping could have occurred on the hatch or the wall surrounding the hatch. This can cause new stress loads to be experienced, compromising the integrity of the Orbiter.

5. **Mission Phase(s)**

a.	Launch Processing	__x__
b.	Launch	__x__
c.	Ascent	__x__
d.	On-Orbit Operations	__x__
e.	Entry	__x__
f.	Landing	__x__
g.	Post Mission	__x__

Risk Management Matrix



Severity: High

Likelihood: Low

Hazard Controls:

Control 1: Visual inspection prior to closure of hatch

Control 2: Perform EVA to observe both sides of the hatch during attempted closure

Control 3: Replace hatch if necessary/possible

Control 4: Structural analysis of the hatch and the wall the hatch is attached to

Control 5: Take note of nominal measurements between the hatch's body and the hatch's frame.

Method for Verification of Control:

Verification 1: Visual inspection

Verification 2: Physical inspection

Verification 3: Close hatch and verify seal

Contingency: If on-orbit and all controls and verifications have failed, finish IVAs and return to Earth.

#1006 – Misalignment of Latches

1. **Hazard Title**: Misalignment of Latches
   Hazard #: 1006

2. **Hazard Condition Description**:

Latches are not properly lined up, thus making closure of the hatch impossible.

3. **Causes (Summary)**:
   a. Not properly installed
   b. Not properly handled
   c. Not properly maintained

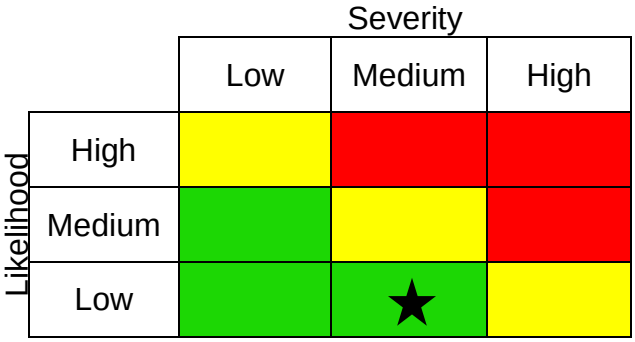
4. **Hazard Interfaces**:

The airlock cannot be used until the hatch is closed. If the latches are misaligned, it has the potential to cause damage to the latch housing.

5. **Mission Phase(s)**
   a. Launch Processing __x__
   b. Launch _____
   c. Ascent _____
   d. On-Orbit Operations __x__
   e. Entry _____
   f. Landing _____

g. Post Mission __x__

Risk Management Matrix



Severity: Medium

Likelihood: Low

Hazard Controls:

Control 1: Visual inspection prior to closure of hatch

Control 2: Attempt to realign via an EVA

Control 3: Analysis of hatch to ensure it is not warped

Method for Verification of Control:

Verification 1: Visual inspection

Verification 2: Physical inspection

Verification 3: Close hatch and verify seal

Contingency: If on-orbit and all controls and verifications have failed, finish IVAs and return to Earth.

#1007 – Single Latch Failure

1. **Hazard Title**: Single Latch Failure
   Hazard #: 1007

2. **Hazard Condition Description**:

A single latch has had a mechanical failure, stopping the hatch from being able to close properly.

3. **Causes (Summary)**:
   a. Not properly aligned
   b. Not properly handled
   c. Not properly maintained
   d. Manufacturing mistake
   e. Excessive stress on single latch

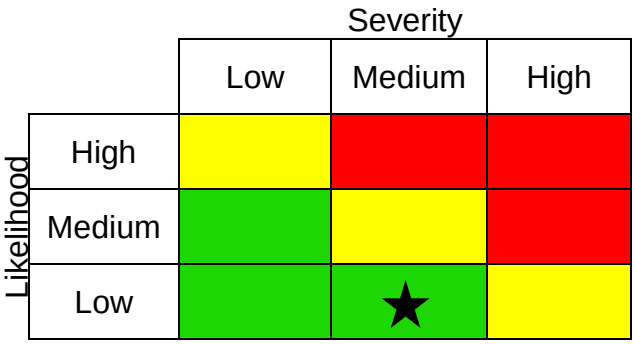
4. **Hazard Interfaces**:

A single latch failing can affect the integrity of the seal of the hatch. It is possible for the hatch to appear closed, but to not have a perfect seal due to one of the latches failing.

5. **Mission Phase(s)**

a.	Launch Processing	__x__
b.	Launch	_____
c.	Ascent	_____
d.	On-Orbit Operations	__x__
e.	Entry	_____
f.	Landing	_____
g.	Post Mission	__x__

Risk Management Matrix



Severity: Medium

Likelihood: Low

Hazard Controls:

Control 1: Visual inspection prior to closure of hatch

Control 2: Replace single latch

Control 3: Replace hatch if needed

Control 4: Contact manufacturer to identify any manufacturing changes

Method for Verification of Control:

Verification 1: Visual inspection

Verification 2: Physical inspection

Verification 3: Close hatch and verify seal with Simpson Meter

Contingency: The latches are vital to creating a perfect seal on the hatch. If all of the parts are not working in concert with one another, the crew will not be safe. If on-orbit and all controls and verifications have failed, finish IVAs and return to Earth.

#1008 – Actuator Failure

1. **Hazard Title**: Actuator Failure
   Hazard #: 1008

2. **Hazard Condition Description**:

The actuator has failed by either breaking or becoming warped.

3. **Causes (Summary)**:
   a. Excessive stress
   b. Exposed to off-nominal environment
   c. Manufacturing mistake

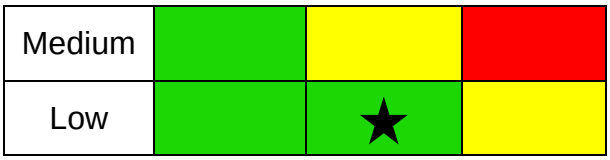
4. **Hazard Interfaces**:

The actuator allows for the hatch to be properly closed by moving the latches into a locked position. Failure of the actuator would remove all ability to close/open the hatch.

5. **Mission Phase(s)**
   a. Launch Processing __x__
   b. Launch _____
   c. Ascent _____
   d. On-Orbit Operations __x__
   e. Entry _____
   f. Landing _____
   g. Post Mission __x__

Risk Management Matrix

		Severity		
		Low	Medium	High
Likelihood	High			



Severity: Medium

Likelihood: Low

Hazard Controls:

Control 1: Visual inspection of actuator prior to closure of hatch

Control 2: Structural analysis on the actuator to identify if it was improperly designed

Control 3: Inspect internal workings of the hatch, verifying absence of foreign matter

Control 4: Complete breakdown and inspection of the actuator

Control 5: Contact manufacturer to inquire about changes in design/material/fabrication/manufacturing

Control 6: Replace actuator with backup

Method for Verification of Control:

Verification 1: Visual inspection

Verification 2: Physical inspection

Verification 3: Open and close hatch completely, verifying nominal operations

Contingency: The actuator allows for the opening and closing of the hatch. If the actuator fails, an entire mission can be at jeopardy. Having a second actuator on hand should remedy any issues. If on-orbit and all controls and verifications have failed, finish IVAs and return to Earth.

#1009 – Hatch Hinges Seize

1. **Hazard Title**: Hatch Hinges Seize
   Hazard #: 1009

2. **Hazard Condition Description**:

The hinges on the hatch allow the hatch to be opened/closed and operable. If the hinges were to seize, it had the potential jeopardize the mission.

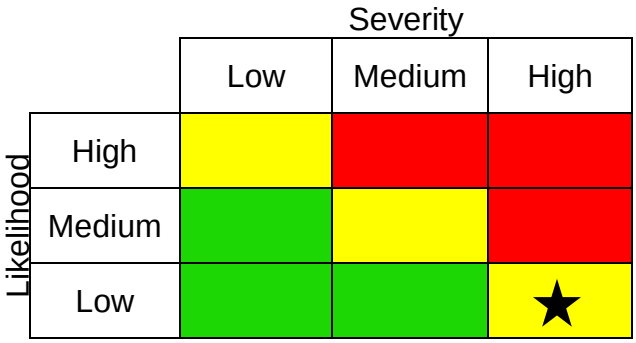
3. **Causes (Summary)**:
   a. Exposed to uncontrolled environment causing rusting
   b. Manufacturing mistake
   c. Overstressed structure

4. **Hazard Interfaces**:

With the hinges seized, the hatch cannot be moved, and thus the airlock may become inoperable. In addition, this could create a problem when needing to leave the International Space Station if the hatch cannot be closed.

5. **Mission Phase(s)**
   a. Launch Processing __x__
   b. Launch _____
   c. Ascent _____
   d. On-Orbit Operations __x__
   e. Entry _____
   f. Landing _____
   g. Post Mission __x__

Risk Management Matrix



Severity: Low

Likelihood: High

Hazard Controls:

Control 1: Visual inspection of hinges

Control 2: Physical inspection for structure and moving parts

Control 3: Replace hatch/hinges if necessary

Control 4: Perform EVA to inspect both sides while attempting to close the hatch

Method for Verification of Control:

Verification 1: Visual inspection

Verification 2: Physical inspection

Verification 3: Close and open hatch completely, verifying full operable motion

Contingency: If the all on-orbit controls and subsequent verifications fail, abort mission and return to Earth.

#1010 – Hatch Glass Breaks

1. **Hazard Title**: Hatch Glass Breaks
   Hazard #: 1010

2. **Hazard Condition Description**:

The window in the hatch has cracked or broken, compromising the integrity of the seal created by the hatch.

3. **Causes (Summary)**:
   a. Rapid heating/cooling of the window
   b. Blunt strike from an object

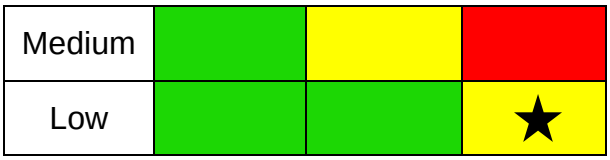
4. **Hazard Interfaces**:

The hatch glass breaking affects the integrity of the airlock, making it useless.

5. **Mission Phase(s)**
   a. Launch Processing __x__
   b. Launch __x__
   c. Ascent __x__
   d. On-Orbit Operations __x__
   e. Entry __x__
   f. Landing __x__
   g. Post Mission __x__

Risk Management Matrix

		Severity		
		Low	Medium	High
Likelihood	High			



Severity: High

Likelihood: Low

Hazard Controls:

Control 1: Replace hatch glass

Control 2: Replace hatch

Control 3: Seal window on either side, removing line-of-sight, but creating a vacuum.

Method for Verification of Control:

Verification 1: Visual and physical inspection via EVA

Verification 2: Close hatch and check for leaks through pressure sensors on the flight deck

Contingency: If all controls and verifications have failed, complete IVAs and then return to Earth.