

2009 ASTRONAUT GLOVE CHALLENGE RULES

OCTOBER 1, 2008 V. 3.0



1 CHALLENGE DETAILS

1.1 Overview

The 2009 Astronaut Glove Challenge is designed to promote the development of glove joint technology, resulting in a highly dexterous and flexible glove that can be used by astronauts over long periods of time for space or planetary surface excursions.

The CHALLENGE is intended to promote the development of a highly dexterous and flexible glove resulting in a monetary award to the winning Team(s).

The CHALLENGE will be conducted by Volanz Aerospace Inc. (hereinafter referred to as "Volanz") in a format that brings all competitors to a single location for a "head to head" competition to determine the winning Team(s). Each Team will be required pass a series of minimum performance requirements (as specified in section 2.3) and perform a variety of tasks as outlined in section 2.4. Teams will be scored on their performance. The Team(s) that earns the highest score will be the winner.

1.2 Definitions Specific to Challenge

- a. Baseline Glove - The Glove currently certified for use by NASA on the International Space Station, the Phase VI EVA Glove.
- b. Burst Test – The unpowered, bladder and bladder-restraint portion of the Glove will be capped and pressurized with water until it bursts to measure the value of the burst pressure.
- c. Comfort Glove - A commercially-available, seamless, disposable, protective glove liner that provides a layer between the hand and the bladder-restraint glove. An example of a manufacturer of Comfort Gloves for medical purposes includes PARADERM. Non-medical Comfort Gloves are commercially available at stores such as REI.
- d. Competitor - The Team member that will be performing the Dexterity and Flexibility Test.

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- e. Dexterity and Flexibility Test - For this test, conducted in the Glove Box, the Competitor will insert the full Glove (consisting of the thermal micrometeoroid garment (TMG) layer (outer glove unpressurized layer), and the unpowered, bladder and bladder-restraint portion) of the Glove into the Glove Box. The Competitor will perform thirty (30) minutes of hand exercises (e.g., pinching and gripping), and other manipulation dexterity tests and tasks that will be scored based on performance.
- f. Glove - For this CHALLENGE, the Glove includes the thermal micrometeoroid garment (TMG) layer of the Glove (outer glove unpressurized layer), and the unpowered, bladder and bladder-restraint portion of the space suit that covers the hand of an astronaut up to and including the wrist joint and permits the control and manipulation of objects outside the suit with functional similarity to that of the human hand. The Glove must have a normal layout (i.e. four (4) fingers and a thumb).



4000 Series Glove Assembly

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- g. Thermal micrometeoroid garment (TMG) - is the outer layer of a space suit (For this CHALLENGE, we are only concerned with the Glove). The TMG has three functions: to insulate the suit occupant and prevent heat loss, to shield the occupant from harmful solar radiation, and to protect the astronaut from micrometeoroids, which could puncture the suit and depressurize it. For this year's CHALLENGE, Glove heaters, used in spacesuit gloves to keep astronauts' hands warm, and any other electronic components, are not part of this year's CHALLENGE.



Phase VI Glove Assembly

- h. Glove Box - The vessel, depressurized to a minimum of four point three (4.3) psid below atmospheric pressure, in which the Dexterity and Flexibility Test will be conducted.

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- i. Joint Force Test – For this series of tests, the Glove will be capped and pressurized to four point three (4.3) psid to measure the following Glove forces: Wrist flexion, wrist extension, wrist abduction, wrist adduction, and flexion of each finger and thumb individually and together. Each Glove will be tested twice, once with the thermal micrometeoroid garment (TMG) layer of the Glove (outer glove unpressurized layer), and the unpowered, bladder and bladder-restraint portion attached, and once with just the unpowered, bladder and bladder-restraint portion of the Glove. Both scores will be added together to determine the winner of the Joint Force Test.
- j. Structural Pressure Test – For this test, the unpowered, bladder and bladder-restraint portion of the Glove will be capped and pressurized to six point six (6.6) psid for a period of five (5) minutes. If the Glove internal pressure is no less than six point one (6.1) psid after five (5) minutes, then the Glove will pass the Structural Pressure Test.
- k. Score - A mathematical function combining the results of the Joint Force Test, the Dexterity and Flexibility Test, and the Burst Test. A Score will only be calculated for those Gloves that pass the Minimum Performance Requirements in Section 2.3.

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2 CHALLENGE RULES

2.1 Overview

Technical specifications and drawings not already covered in this Agreement about the Glove, the Functional Task, and any other CHALLENGE details will be provided by Volanz to the Team at time of registration. These technical specifications may be subject to future updates by Volanz at its sole discretion.

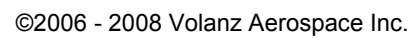
2.2 Gloves

Team must provide either two (2) complete identical Gloves (i.e. two (2) identical right or left Gloves at the competitor's sole discretion) or one (1) pair (a left Glove and a right Glove) sized to fit the Competitor's hands with the hardware interfaces as specified in the Minimal Performance Requirements. In addition, each Team must provide an additional complete working glove mockup that will be utilized by Volanz for educational and promotional purposes. This additional glove will become the property of Volanz, and will not be returned. Proprietary technology and high cost materials may be substituted in the glove mockup, as long as a complete glove is provided, and all substituted materials are identified. Please note: Volanz Aerospace Inc is a 501c3 non-profit educational corporation, and this Glove will be considered a contribution for tax purposes.

2.3 Minimum Performance Requirements

All Competitors' Gloves will be tested to ensure that they meet the minimum requirements specified in this section. Any Glove that fails to meet these requirements is disqualified from further formal participation in the Competition. The minimum physical properties and/or characteristics that the Gloves must possess before competing in the CHALLENGE are:

- A. The Gloves will incorporate interface hardware to the Glove Box and blanking plate as shown in the following technical drawings:



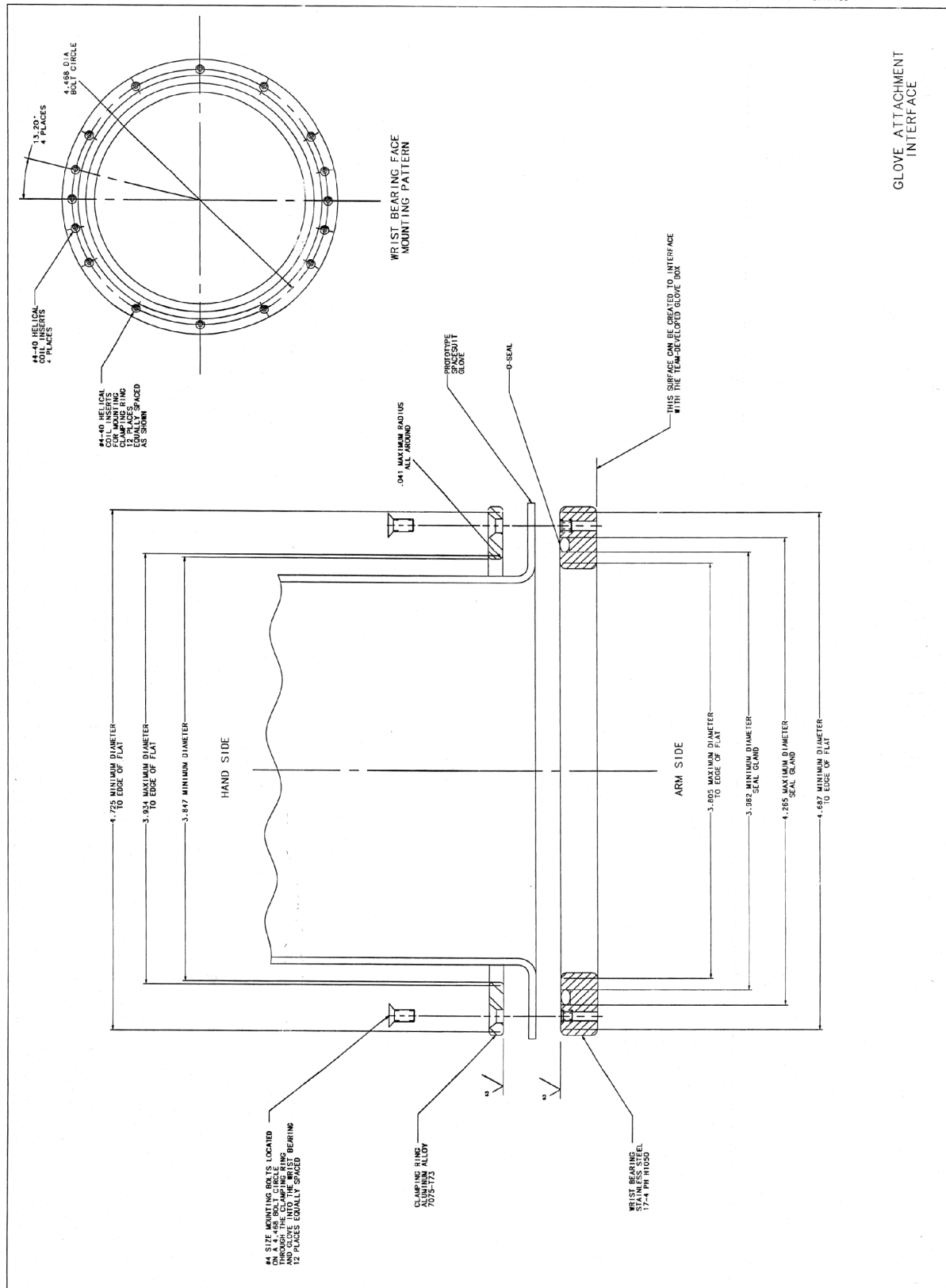
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- B. Wrist area opening of the glove must accommodate the ninety-fifth (95th) percentile male wrist size.
- C. The range of motion of each digit must be between forty-five (45) and seventy-five (75) degrees.
- D. The range of motion of the wrist is specified in the following chart:

	B e n d i n g R a n g e f r o m N e u t r a l P o s i t i o n
W r i s t F l e x i o n	4 5 °
W r i s t E x t e n s i o n	4 5 °
W r i s t A b d u c t i o n	3 0 °
W r i s t A d d u c t i o n	3 0 °

- E. The minimum length of the unpowered, bladder and bladder-restraint portion of the Glove, that covers the hand of an astronaut up to and including the wrist joint, without the pressure interface, measured from the top of the middle finger must be at least twenty point six five (20.65) cm.
- F. The thermal micrometeoroid garment (TMG) layer of the Glove (outer glove unpressurized layer) must extend below the top of the pressure interface sufficiently to cover the interface while the glove is in use.
- F. The maximum operating pressure must be at least five point three (5.3) psid.
- G. The maximum failure pressure must be at least five point five (5.5) psid.
- H. The normal operating pressure must be four point three (4.3) +/- zero point one (0.1) psid.
- I. The proof pressure must be at least eight point zero (8.0) psid. The Glove must experience no damage when submitted to this pressure.
- J. The unpowered, bladder and bladder-restraint portion) of the Glove must pass a Structural Pressure Test.

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- K. Weight of the unpowered, bladder and bladder-restraint portion of the Glove, without the interface hardware, must not exceed four hundred (400) grams.
- L. Weight of the thermal micrometeoroid garment (TMG) layer of the Glove (outer glove unpressurized layer) must not exceed **yyy (yyy)** grams (1.5 times the average weight of the unpowered Phase VI Glove).
- M. The TMG must be able to withstand a temperature range from -120 degrees Celsius (-185 F) to +113 degrees Celsius (235 F).
- N. TMG (Thermal micrometeoroid garment) Evaluation - The TMG is the outer layer of a space suit (For this CHALLENGE, we are only concerned with the Glove). Glove heaters, used in spacesuit gloves to keep astronauts' hands warm, and any other electronic components, are not part of this year's CHALLENGE.

This is the first year that the TMG is required for participating in the CHALLENGE. The TMGs provided must be capable of protecting an Astronaut's hands while operating in Space (such as at the International Space Station).

For this Year, Teams must provide Two (2) TMGs and a sample of the TMG material with the layers identified. A separate Key must be provided that describes the function of each layer. A paper describing the TMG functionality must be provided 30 calendar days prior to the competition. Each Team will make a presentation (of no more than 15 minutes duration) to a special judging team that will evaluate the capabilities of the provided TMG. A printed copy of the presentation must be provided to the Judges before the Team presentation is made. At the request of the Team, presentations will be held in a private location, and Judges will sign a non-disclosure statement. Teams must also provide a publically-distributable TMG presentation (in PowerPoint 2003 format) to Volanz that can be used for educational and promotional purposes.

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The Judges will evaluate the Team's TMG according to the following criteria:

- Did the Team provide the requested materials specified in section 2.3 L of the official rules?
- Does the TMG meet the requirements outlined in section 2.3 L, M, and N of the official rules?

For this year's CHALLENGE, the Judges will be looking specifically at the rationale and reasonableness behind the submitted TMG design. After the evaluation is completed, the Judges will assign a Pass/Fail score to each Team's TMG.

O. Gloves must successfully meet all Minimal Performance Requirements in order to further compete in the CHALLENGE.

2.4 Challenge Testing

The goal of the CHALLENGE is to produce a glove with minimal joint torques to minimize fatigue of the astronaut during EVA. All Gloves that meet the minimum performance requirements of section 2.3 will be tested.

The Gloves will undergo a series of tests, and receive a Score based on the results of each test. The Team with the highest Score that exceeds the Score of the Baseline Glove will win the CHALLENGE. The following sections (2.5 – 2.8) describe the tests to be conducted:

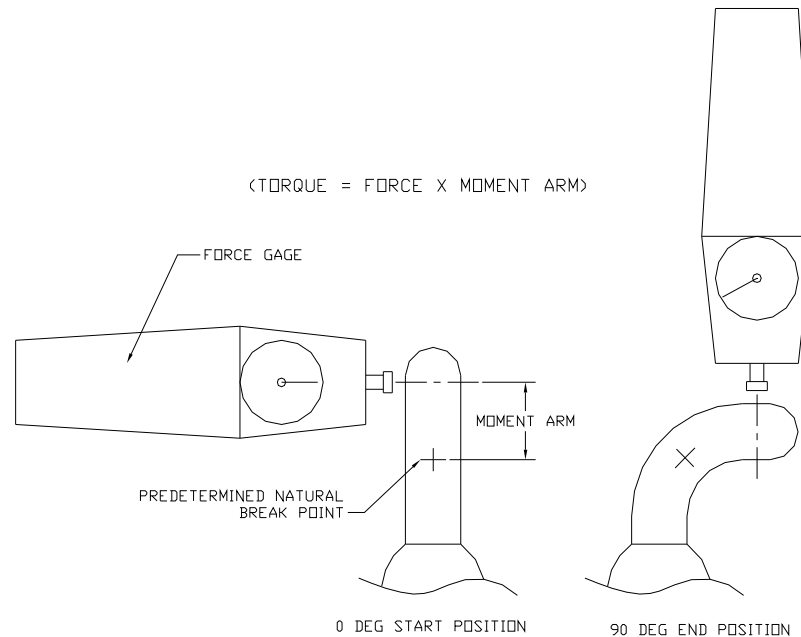
2.5 Joint Force Test

The goal of the Joint Force Test is to produce a glove with minimal joint torques to minimize fatigue of the astronaut during EVA. The following tests will be performed with the glove pressurized to 4.3 psid:

- A. Range of Motion will be determined by visual observation on a drawn scale or grid background
- B. A common test operator will be used to minimize variability from entering the test
- C. Force measurements can be performed in push or pull mode, string may be used to facilitate pulling
- D. Torque will be calculated by multiplying the measured force (ounces) by the distance (inches) to the bending portion of the joint being measured

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Typical Finger Joint Force Measurement

A low score on this test is indicative of a low torque glove design. The Joint Force test will measure the torque required to flex various glove joints through the nominal range of motion as compared to the Phase VI Glove. The Gloves will be scored according to the following procedure:

		Bending Range from Neutral Position	Measured Force	X	Measured Distance to Break Point	=	Joint Torque	Average for each grouping
Group 1	Wrist Flexion	45°	oz.	X	in.	=	oz. in.	oz. in.
	Wrist Extension	45°	oz.	X	in.	=	oz. in.	
Group 2	Wrist Abduction	30°	oz.	X	in.	=	oz. in.	oz. in.
	Wrist Adduction	30°	oz.	X	in.	=	oz. in.	
Group 3	Pinky Finger Flexion	45° - 75°	oz.	X	in.	=	oz. in.	oz. in.
	Ring Finger Flexion	45° - 75°	oz.	X	in.	=	oz. in.	
	Middle Finger Flexion	45° - 75°	oz.	X	in.	=	oz. in.	
	Index Finger Flexion	45° - 75°	oz.	X	in.	=	oz. in.	
Group 4	Thumb Flexion	45° - 75°	oz.	X	in.	=	oz. in.	oz. in.

Joint Torque Score = Summation of Joint Torque for each group =

To calculate a final score, an average for each grouping (Wrist Flexion/Extension, Adduction/Abduction, Finger Flexion, and Thumb Flexion) is determined and then these scores are totaled. The Glove with the lowest score, while exceeding the current Phase VI glove, will win the Joint Force Test.

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Each Glove will be tested two (2) times. Test #1 will consist of the thermal micrometeoroid garment (TMG) layer (outer glove unpressurized layer), and the unpowered, bladder and bladder-restraint portion) of the Glove, and Test #2 will consist of only the unpowered, bladder and bladder-restraint portion) of the Glove. The results for Test#1 will count for 25% of the score, and the results for Test#2 will count for 75% of the score. The two scores for each glove will be added together (as specified above) in order to determine the winner of this test.

If a Glove is unable to complete these 2 tests, it will receive zero (0) points, and will be disqualified from further formal participation in the Competition. If a successfully tested Glove does not exceed the current Phase VI Glove, it will receive zero (0) points.

2.6 Dexterity and Flexibility Test

For this test, conducted in the Glove Box, the Competitor will insert the full Glove (consisting of the thermal micrometeoroid garment (TMG) layer of the Glove (outer glove unpressurized layer), and the unpowered, bladder and bladder-restraint portion of the Glove) into the Glove Box. The Competitor will perform thirty (30) minutes of hand exercises (e.g., pinching and gripping), and other manipulation dexterity tests and tasks that will be scored based on performance.

- A. All Judges will examine the Competitor's hand that will be inserted into the glove. The Judges shall make note of all pre-existing wounds, abrasions, and the condition of all nails, and mark them on a hand chart. A photo of the hand shall be made before and after the test.
- B. During the last minute of each sequence the subject will remove their hand from the glove and allow it to be examined and photographed by the judges.
- C. The Competitor's hand must be examined after every 10 minutes of exercise to determine if any new injury exists.

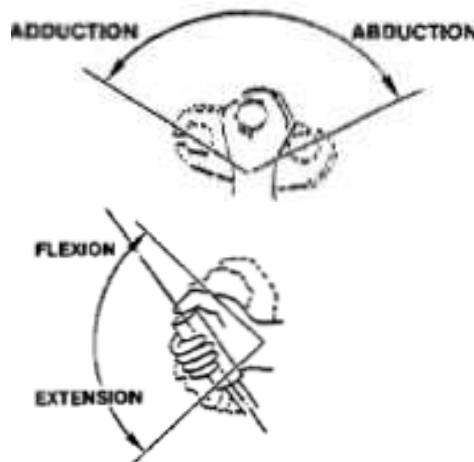
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D. The Dexterity Test will be conducted according to the following procedure:

- a. The Dexterity Test shall be divided into six five-minute sequences.
- b. Each 5-minute sequence shall consist of 4 minutes of cycling and 1 minute of hand observation.
- c. The following motions shall be completed, in order, within each 4 minute cycling period:
 - 25 Cycles of wrist flexion/extension
 - 25 cycles of wrist adduction/abduction
 - 25 cycles of hand clenching
 - Clench fist as tightly as possible followed by extending fingers to a flat palm fingers out position
 - 25 cycles of thumb to finger touch
 - Thumb to pinky finger
 - Thumb to ring finger
 - Thumb to middle finger
 - Thumb to index finger



- d. Testing shall be performed in a glove box with 4.3 psid across the glove and a team member performing the cycling

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- E. An injury is defined as:
 - a. Bleeding
 - b. Cuts
 - c. Abrasions
 - d. Swelling
 - e. Loss/Partial Loss of Nail(s)
 - f. Broken Hand
 - g. Any other condition requiring medical attention
- D. Serious Redness or Irritation on the hand shall be examined to determine if continuing the test would result in a more serious injury.
- E. If the Competitor appears to be in any sort of distress, the test shall be immediately stopped, and the Competitor's hand examined.
- F. If any injury or unsafe condition caused by the Competitor's Glove is detected by the Competitor or any of the judges, the test will be immediately stopped, and the Dexterity and Flexibility Test score will be zero (0) points.
- G. If, immediately after the Dexterity and Flexibility test is completed, the Glove shows no sign of wear or failure, and if the Competitor's hand displays no new signs of bleeding cuts or abrasions, hematoma, or any other signs of injury caused by the Glove, the Dexterity and Flexibility Test score will receive their full points. Otherwise, the Dexterity and Flexibility Test score will be zero (0) points.

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2.8 Burst Test

The burst test is a measure of the strength capability of the glove. For this test, the unpowered, bladder and bladder-restraint portion of the Glove will be capped and pressurized with water (tested hydrostatically) until it bursts to measure the value of the burst pressure. The following procedure will be followed:

- A. The procedure involves pressurizing the gloves at a rate of approximately 1 psi per minute.
- B. One test operator will be used to assure consistency.
- C. Teams are allowed to install their glove onto the test equipment.
- D. Burst pressure will be determined as the pressure at which the glove no longer allows pressure increase.
- E. Small water seepage is acceptable as long as the glove doesn't lose pressure.
- F. When the glove no longer supports increasing pressure or loses pressure the glove will consider to have burst.

If a Glove is unable to complete this test, it will receive zero (0) points, and will be disqualified from further formal participation in the Competition. If a successfully tested Glove does not exceed the current Phase VI Glove, it will receive zero (0) points.

2.9 Scoring and Prizes

The Team with the highest Score that **exceeds** the Score of the Baseline (Phase VI) Glove will win the CHALLENGE. The following procedure will govern the scoring of the CHALLENGE:

- A. The Score is a mathematical function combining the results of the Joint Force Test, the Dexterity and Flexibility Test, and the Burst Test. The weighting factors on these three test results will be point four (.4), point four (.4), and point two (.2) respectively, which add up to a total of 1.0.
- B. Any Team that is unable to complete any test(s), will be ineligible to win or receive a prize from this competition.

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- C. In order to win a prize, Teams must (at a minimum), exceed the score of the Baseline (Phase VI) Glove in one or more of the Tests, while equaling the score of the Baseline Glove in all other tests. Any Team that fails to meet the criteria outlined above will not be eligible to win or receive a prize from this competition.
- D. Teams that successfully complete a particular test (Joint Force Test, the Dexterity and Flexibility Test, and the Burst Test) that meets the criteria outlined in Section 2.8 of the rules, will receive the following points based upon their test ranking:

Place	Points
1	4
2	3
3	2
4 (and lower)	1

In the case of a tie, each Team tied will receive the same score. For example, if 2 teams tie for first place on a particular test, they would each receive 4 points. The third place team would receive 2 Points. A Team must (at a minimum) tie the Baseline (Phase VI) Glove in order to receive any points for that test.

Points for each test would be multiplied by the weighting factor specified in Section 2.8 – A for that particular test, to determine the Team score for that test.

- E. The scores for all three tests will be added together to come up with a final score. The Team with the highest numeric score shall be declared the winner of the CHALLENGE.
- F. In case of a tie between two (2) or more Teams, the following tie breaker formula shall apply (in the following order):
- Joint Force Test Winner
 - Burst Test Winner
 - Dexterity and Flexibility Test Winner

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- G. Among the Teams tied for first place, the first Team to win the first tiebreaker will be declared the winner of the CHALLENGE. In case of a tie, the same rule will apply for the second and third tiebreaker. If after three (3) tiebreakers there is still a tie, all Teams tied for first place will be declared the winner. In this case, the Prize will be equally divided between all Teams tied for first place.
- H. The Team(s) with the highest score in the Joint Force Test, while at least tying the Baseline (Phase VI) Glove in all other tests, will be declared the Joint Force Test Winner. In case of a tie on the Joint Force Test, the winning Teams will share the prize equally.
- I. Prizes will be awarded for overall First Place and Second Place in the CHALLENGE, and the winner of the Joint Force Test.
- J. The decision of the judges is final.**

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3 SAFETY

During the course of this competition, high pressure devices are in use. Safety is our first priority. Please be careful. Safety rules are important, and the competition will be held again next year, so always take the time to stop and think before you act. Volanz Aerospace Inc. will tolerate no unsafe behavior at the event.

The competition will have one or more safety officers. All safety related matters ultimately fall within the responsibility of the safety officer. At any given time, a specific person will be designated as a safety officer, and this person will have full discretion and authority to instruct any other person in the competition. Failure to follow the instructions of the safety officer is a Code-of-Conduct violation, and is grounds for disqualification as specified in section 4.0.

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4 CODE OF CONDUCT

Each Team must adhere to the following code of conduct. Any violation of the rules is immediate grounds for disqualification:

- a. Upon arrival at the competition site, each Team will leave a cleanup/damage cash deposit of \$200 with Volanz Aerospace Inc., to be conditionally refunded within 7 days of the end date of the competition, upon compliance with the guidelines below.
- b. Teams must clean up after themselves, pick up all of their hardware, and not damage property. Clean up costs will be deducted from the deposit, plus a 100% penalty.
- c. Arguing with Volanz Aerospace Inc. personnel, judges, and NASA participants in anything other than a private forum can result in immediate disqualification of the Team, irrespective of the root cause of the disagreement.
- d. Disobeying instructions by Volanz Aerospace Inc. personnel or judges will result in immediate disqualification of the Team.
- e. Unsportsmanlike conduct such as hindering the performance of other Teams, violence, or harassment is grounds for immediate disqualification.
- f. Any Team disqualified for a Code-of-Conduct violation will forfeit the cleanup/damage deposit, and may not be permitted to participate in further competitions.

**The 2009 Astronaut Glove Challenge Rules are
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