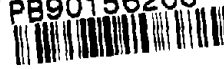


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# **Advanced Guidelines for Performance Testing of Two-Legged Longwall Shields**

By Thomas M. Barczak

**UNITED STATES DEPARTMENT OF THE INTERIOR**  
**Manuel Lujan, Jr., Secretary**

**BUREAU OF MINES**  
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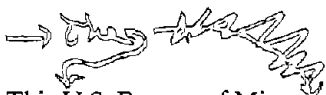
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### UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

|         |                  |                     |                                  |
|---------|------------------|---------------------|----------------------------------|
| cyc/min | cycle per minute | kip/in <sup>2</sup> | kip per square inch              |
| in      | inch             | pct                 | percent                          |
| in/min  | inch per minute  | psi                 | pound per square inch            |
| in/cyc  | inch per cycle   | psi/min             | pound per square inch per minute |
| kip/min | kip per minute   |                     |                                  |

# ADVANCED GUIDELINES FOR PERFORMANCE TESTING OF TWO-LEGGED LONGWALL SHIELDS

By Thomas M. Barczak<sup>1</sup>



## ABSTRACT

This U.S. Bureau of Mines report is intended to assist coal mine operators in the selection of longwall supports by providing advanced guidelines for performance testing and standardized test documentation to facilitate support comparisons. These advanced guidelines culminate in a series of proposed tests to evaluate (1) support resistance characteristics, (2) stiffness characteristics, (3) leg mechanics, (4) stability, (5) load transfer mechanics, and (6) structural integrity. The Bureau has conducted extensive studies on shield mechanics to identify boundary conditions that induce loading in support components, which is often not included in current testing techniques. This report discusses influential parameters that affect support behavior and provides insight into how components are loaded and what conditions produce the most severe loading. Testing philosophies and techniques in both active and static frames are discussed. Proper methods for determining support resistance are described and instrumentation requirements for advanced performance testing are provided. ←

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## INTRODUCTION

This report provides advanced guidelines for performance testing of longwall support structures. It is intended to assist coal mine operators in evaluating support systems prior to purchase. It may also be of interest to other researchers and support manufacturers when considering support responses relative to design requirements.

The most productive and often most profitable underground coal mines in the United States are longwall mines. The decision to pursue longwall mining requires considerable capital investment and 5 to 8 years of reserves to depreciate the large capital expense required for equipment purchases (1).<sup>2</sup> The major equipment costs are the powered roof supports, representing about 60 pct of the required capital investment. In 1988 dollars, the median purchase cost of longwall roof supports was \$50,000 per support or approximately \$6.3 million for a single longwall face of average length (663 ft). The control of ground provided by these roof support structures is usually the determining technical factor in whether the operation is successful.

Longwall supports are used to provide a temporary working space for personnel and machinery during the extraction of a coal panel. Their primary purpose is to provide stability of the face area. In doing so, they must interact with the strata to resist relative motion between the roof and floor as the strata tries to reestablish a stable configuration. More specifically, the support must function to (1) control vertical (roof-to-floor) convergence and (2) maintain stability against horizontal displacements resulting from strata activity.

Because their operation is essential to successful mining, mine operators frequently require performance testing of longwall supports by equipment manufacturers prior to accepting delivery of the supports for underground installation. These tests generally involve cycle testing by vertical load application under a variety of canopy and base contact configurations to evaluate the potential for structural failure from fatigue loading. Despite these precautionary evaluations, support failures still occur underground on supports that proved satisfactory in the laboratory and often at loads less than the rated support capacity (2). Obviously these laboratory tests do not always accurately simulate in-service load conditions.

The U.S. Bureau of Mines has conducted extensive research on shield mechanics to develop improved support testing methods that will reduce the risk of support failure when in underground service. This research was conducted in the Bureau's mine roof simulator (fig. 1).<sup>3</sup> The simulator is capable of simulating underground loading by providing controlled vertical and horizontal displacements or forces to full-size longwall supports.

These research studies have advanced the state-of-the-art in roof support performance testing by evaluation of boundary conditions that induce loading in support components, which is normally ignored in testing. More specifically, advancements in support testing have been made by (1) evaluation of horizontal constraint of the support structure prior to load application, (2) distinguishing component responses for applied vertical shield displacements from component responses for applied horizontal shield displacements, (3) quantification of the effects of horizontal displacement applied in both the face-to-waste and waste-to-face direction, (4) evaluation of the effects of leg mechanics on support response, (5) identification of canopy and base contact combinations that produce maximum loading in specific support components, and (6) comparison of component response and critical loading for symmetric and unsymmetric contact configurations.

A format for standardized longwall support performance testing and test documentation is provided in this report. Currently, performance evaluation programs differ from manufacturer to manufacturer. As a result, a direct comparison of support performance is difficult. A standardized documentation reporting format that will support development of a common data base in order to make more meaningful support comparisons is provided in this report. Standardized testing and documentation will also enable an industrywide historical data base of support performance to be developed. This historical data base would be a source of reference to industry personnel when purchasing new equipment. Such a reference will help operators select supports that are most compatible to their needs with minimum cost of testing and with minimum risk of failure.

The scope of the guidelines presented in this report is limited to evaluation of the mechanical behavior, structural response, and structural integrity of the support. Procedures for evaluation of support compatibility with other equipment and evaluation of operating functions are not included in these guidelines. The scope is also limited to two-leg shield supports because the Bureau has not evaluated four-leg shields. While the mechanics of four-leg shields differ considerably from two-leg shields, many of the issues discussed, in particular load application techniques, apply to both support types. It is assumed that the reader has a basic understanding of support mechanics. Two Bureau of Mines Reports of Investigation (RI) are recommended as reference material: RI 9188 (2) "Vertical and Horizontal Load Transferring Mechanisms in Longwall Shield Supports," and RI 9220 (3), "Two-leg Longwall Shield Mechanics."

This report begins with a definition of terminology to avoid any confusion in the meanings of terms used. This is followed by a brief discussion of performance testing goals. Next, several important considerations in performance testing are discussed in detail: Load application considerations, contact configuration and initial load conditions, and instrumentation requirements. Also included

<sup>2</sup>Italic numbers in parentheses refer to items in the list of references preceding the appendixes at the end of this report.

<sup>3</sup>Testing was conducted by personnel of Boeing Services International (BSI), Pittsburgh, PA, under the direction of Carol L. Tassillo, operations engineer, BSI.

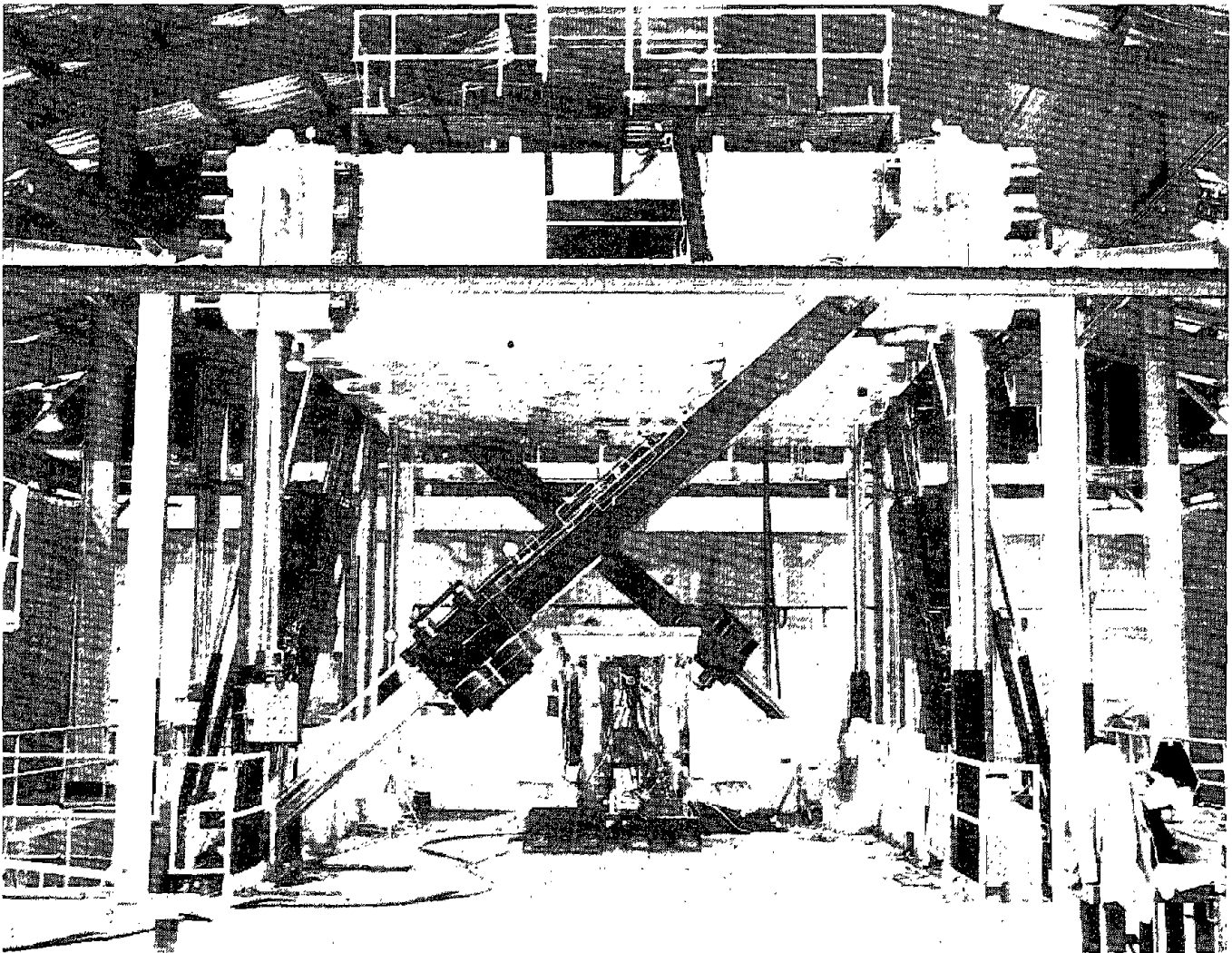


Figure 1.—U.S. Bureau of Mine's mine roof simulator.

are less influential parameter considerations such as height effects, contact stiffness effects, and load rate considerations. A discussion of shield mechanics and component responses for several boundary conditions and loading considerations is also provided. The report concludes with

a suggested program plan for advanced performance evaluation of longwall support structures. Proposed tests are documented on a standardized reporting form to illustrate the ability of the form to concisely convey test information.

## DEFINITION OF TERMINOLOGY

The two-dimensional diagram of a two-legged shield support (fig. 2) illustrates the major shield components. These components are identified as the canopy, base, caving shield, front links, rear links, and leg cylinders. Reference will also be made to the caving shield-lemniscate assembly, which includes the caving shield and link components. A brief definition of other terminology

used in subsequent discussions of support performance testing is also provided in this section. Because this terminology may not be consistent throughout the industry, it is important that these terms be understood to avoid any misinterpretations.

Probably the most unfamiliar and perhaps ambiguous is the term "constraintment." Constraintment is defined as

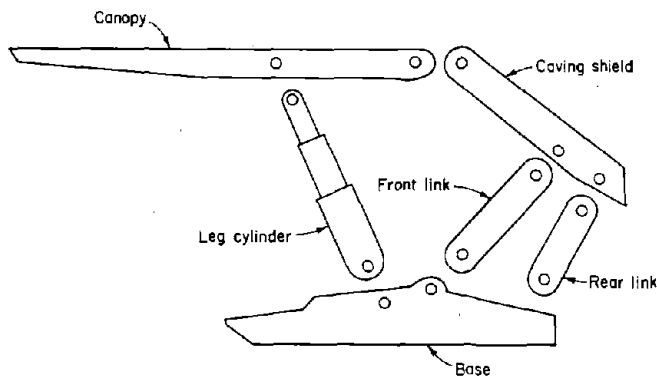


Figure 2.—Two-dimensional diagram of a two-leg longwall shield.

forced restriction, and is used in the context of support performance testing to indicate an initial shield condition, where the canopy and/or base is horizontally constrained prior to load application by forced horizontal displacement of the canopy relative to the base. Constraint is a means to remove rigid-body translational freedom in the numerous joints of the shield structure to allow the caving shield-lemniscate assembly to fully participate in the shield's load transfer mechanics. The following are definitions of the specialized terminology used in this report.

**Constraint.**—Forced restriction (of the canopy relative to the base).

**Configuration, contact.**—Combination of vertical and horizontal contacts on canopy and base through which forces or displacements are applied to the support structure.

**Configuration, constrained shield.**—Shield configuration in which the canopy is displaced horizontally relative to

the base prior to load application to remove rigid-body translational freedom in the pin joints to allow the caving shield-lemniscate assembly to fully participate in the shield's load transfer mechanics.

**Configuration, restrained shield.**—Shield configuration in which horizontal contact restricts horizontal displacement of the canopy or base.

**Displacement, horizontal, face-to-waste.**—Face-to-waste horizontal translation of the canopy relative to the base; i.e., the canopy is displaced towards the gob.

**Displacement, horizontal, waste-to-face.**—Waste-to-face horizontal translation of the canopy relative to the base; i.e., the canopy is displaced towards the face.

**Displacement, vertical.**—Convergence of the canopy relative to the base by roof-to-floor or floor-to-roof displacements.

**Face.**—Pertaining to the area in front of the supports.

**Load frame, active.**—A load frame in which one or both platens are capable of controlled force or displacement.

**Load frame, static.**—A load frame in which the platens remain stationary and are intended only to react loads applied by an active support specimen.

**Load application, active.**—Externally applied loading by an active load frame to a passive roof support structure.

**Load application, passive.**—Loads generated through reactions developed in a static load frame by hydraulic pressurization of the support leg cylinders.

**Loading, force-controlled.**—Forces applied to a roof support structure are controlled and the support canopy and base are free to displace until equilibrium is attained.

**Loading, displacement-controlled.**—Displacements applied to a roof support structure are controlled and the support reactions vary.

**Restraint.**—Contact that restricts displacement in one direction or more.

**Waste.**—Caved material behind the supports. Synonymous with gob.

## PERFORMANCE TESTING GOALS

The performance testing program should determine the suitability of a support to its intended application. Hence, the primary goal of a performance testing program is to simulate as closely as possible the various loading conditions that occur underground. However, actual underground loading conditions are not predictable from current strata mechanics analyses and are generally not well defined even in existing mines. Therefore, knowledge of shield mechanics is necessary to develop a testing program that will explore the full capabilities of the supporting system for a wide range of hypothetical loading conditions. While the performance testing program cannot ensure successful operation, it should minimize the risk of failure by accurately defining the capabilities of the support and conditions, if any, that will cause failure.

The tests should be standardized so that they can be duplicated if necessary. All parameters that affect support

behavior should be addressed in the testing program. Test results should be clear and well documented. It is important that loading mechanisms are correlated to support response so that unanticipated problems that might occur after the support is put into service can be better defined. This philosophy will also provide insight into design improvements for next generation supports or support designs for other applications.

This report addresses these needs by providing for a comprehensive evaluation of shield supports. Considerations in performance testing are discussed in detail and standardized tests are documented that include evaluation of the following areas of performance: (1) support resistance characteristics, (2) stiffness characteristics, (3) leg mechanics, (4) stability, (5) load transfer mechanics, and (6) structural integrity.

## CONSIDERATIONS IN SUPPORT PERFORMANCE TESTING

This section discusses several considerations in performance testing. The intent is to provide an overview of the various things one must consider when evaluating a long-wall support. Included in these discussions are load application considerations, contact configurations and initial load conditions, influential parameter considerations that affect shield response, and instrumentation requirements.

### LOAD APPLICATION CONSIDERATIONS

Some fundamental decisions must be made regarding how the support structure is loaded. The primary goal of the test program is to simulate as closely as possible the loading conditions the support will encounter in underground service. This section discusses active versus passive load application, force-controlled versus displacement-controlled loading, vertical versus horizontal loading, and static versus cyclic loading.

#### Active Versus Passive Load Application

A decision must first be made as to whether the shield loading tests will be conducted in an active or passive load frame. An active load frame is one in which the load platens of the test frame are displaced to provide loading to a passive roof support structure. The Bureau's mine roof simulator (fig. 1) is an active load frame that can apply controlled vertical and horizontal forces or

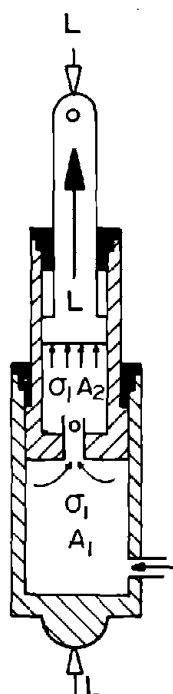
displacements. In contrast, a static frame remains passive and support loads are generated by pressurization of the support's hydraulic leg cylinders.

Active load application in an active frame is the most desirable because it more closely simulates the behavior of the strata and support response when in underground service. In underground operation, the shield is set against the roof by pressurization of the leg cylinders to a nominal pressure. The support then reacts loads in response to strata convergence. This loading is duplicated in an active load frame, where the support is set in the frame at the designated setting pressure and controlled displacements are applied by the load frame. Generating loads only by pressurization of the legs in a static load frame does not permit controlled displacement of the canopy relative to the base. As a result, shield mechanics cannot be controlled. This limits the load conditions that can be evaluated.

If tests are conducted in a static frame, the following recommendations should be considered:

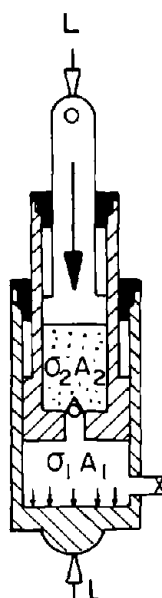
Tests should be conducted at less than full first stage leg extension on shields with double telescoping leg cylinders. Leg force can be reduced by as much as 50 pct when the first stage of the leg cylinder is fully extended by active leg pressurization. The mechanics of the leg cylinder operation that produce this effect are illustrated in figure 3. Basically, the effective area of the leg cylinder

#### LEG EXTENSION



$$\text{Leg force (L)} = \sigma_1 A_2$$

#### LEG CONVERGENCE



$$\text{Leg force (L)} = \sigma_1 A_1$$

#### KEY

- L Leg force
- Trapped fluid
- Pressure application
- $A_1$  Area of 1st stage
- $A_2$  Area of 2d stage
- $\sigma_{1,2}$  Cylinder pressure

Figure 3.—Leg mechanics.

is reduced as the applied pressure is acted against the smaller upper cylinder piston area, as opposed to leg convergence where fluid trapped in the leg acts on the larger area of the lower cylinder. Therefore, even if the leg is actively pressurized to yield pressure, the effective leg force will be half that it would be if the same pressure was achieved by convergence of the leg cylinder. The reduced leg force would result in considerably lower loading of the support components and may lead to erroneous evaluations of the support's structural integrity. As illustrated in figure 3, this behavior will not occur when the first stage is not fully extended.

**Leg pressures should be higher than in-service yield pressure.** In a static load frame where the leg cylinders are pressurized to cause leg extensions, leg cylinder seal friction and friction in the numerous pin joints of the structure oppose leg forces, which causes a reduction in support resistance (see figure 4). Friction effects are likely to be on the order of 3 to 5 pct of the total support resistance, but can reach 10 pct under some (unsymmetrical) load conditions. Therefore, leg pressures should exceed yield pressure by 10 to 20 pct when tested in a static frame to achieve leg forces and component loadings comparable to in-service operation where the friction effects are reversed.

**Zero horizontal load tests should be conducted.** Zero horizontal load tests should be conducted, by placing rollers on the canopy and/or under the base as illustrated in figure 5, to develop maximum stresses in the caving shield and lemniscate links and to assess shield stability. Without external horizontal restraint on the canopy and base, the caving shield-lemniscate assembly must resist the horizontal component of the leg force to maintain shield stability. Also, the line of action of the resultant force in the absence of horizontal shield forces produces maximum bearing pressure on the toe of the base.

#### Force-Controlled Versus Displacement-Controlled Loading

Two methods of load application are generally available: one is to control the forces acting on the shield and the other is to control the displacements imposed on the support structure. The preferred method of load application is by controlled displacement of the canopy relative to the base because convergence of the strata underground more closely simulates displacement control.

Another reason why displacement control is preferred is because the shield components react loads in proportion to the component stiffness and relative displacements. Controlling the displacement of the canopy relative to the base provides a better control of component loading than controlling the external force acting on the shield. For example, there could be vertical and horizontal forces acting on the shield canopy and base that do not produce horizontal displacements and therefore will not produce significant loading in the caving shield-lemniscate assembly. Shield response to horizontal loading will be described in subsequent discussions of shield mechanics.

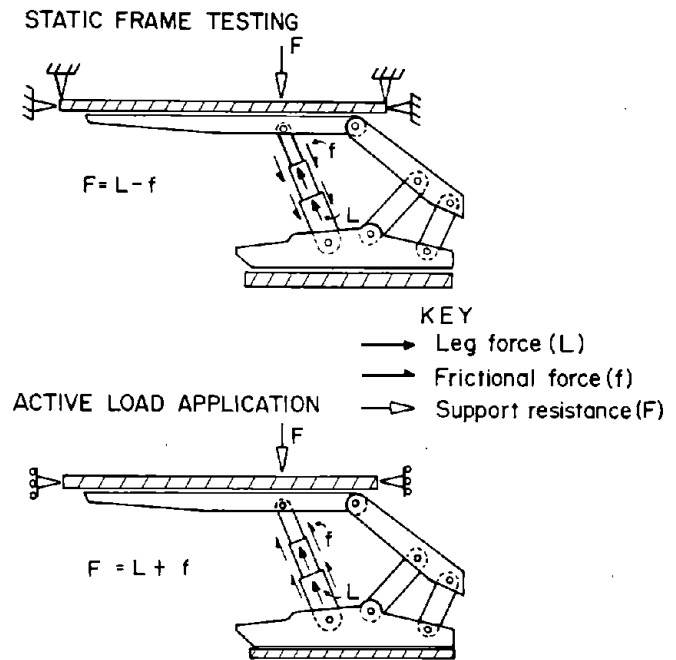


Figure 4.—Friction considerations in shield testing.

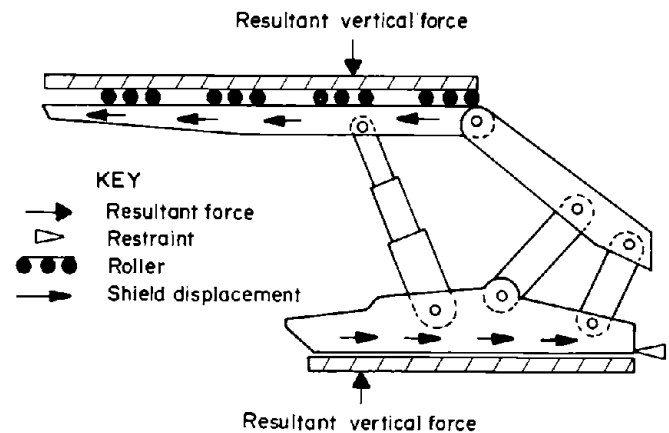


Figure 5.—Zero horizontal load shield tests.

Force control allows the shield (components) to displace uncontrollably until the required force equilibrium is attained. Hence, force control can produce varying results in terms of load transfer and subsequent component loading. Because of these variations in results, displacement control is the preferred loading method.

### Vertical Versus Horizontal Loading

Shield supports are designed to provide resistance against both vertical and horizontal loading as illustrated in figure 6. More specifically, once the shield is set against the roof in an equilibrium configuration, it may be subjected to various combinations of vertical displacement,

face-to-waste horizontal displacement, and waste-to-face horizontal displacement as illustrated in figure 7. Component responses and developed stress magnitudes are significantly different for each of these load applications and all three should be imposed on the support structure during performance testing, individually and in combinations.

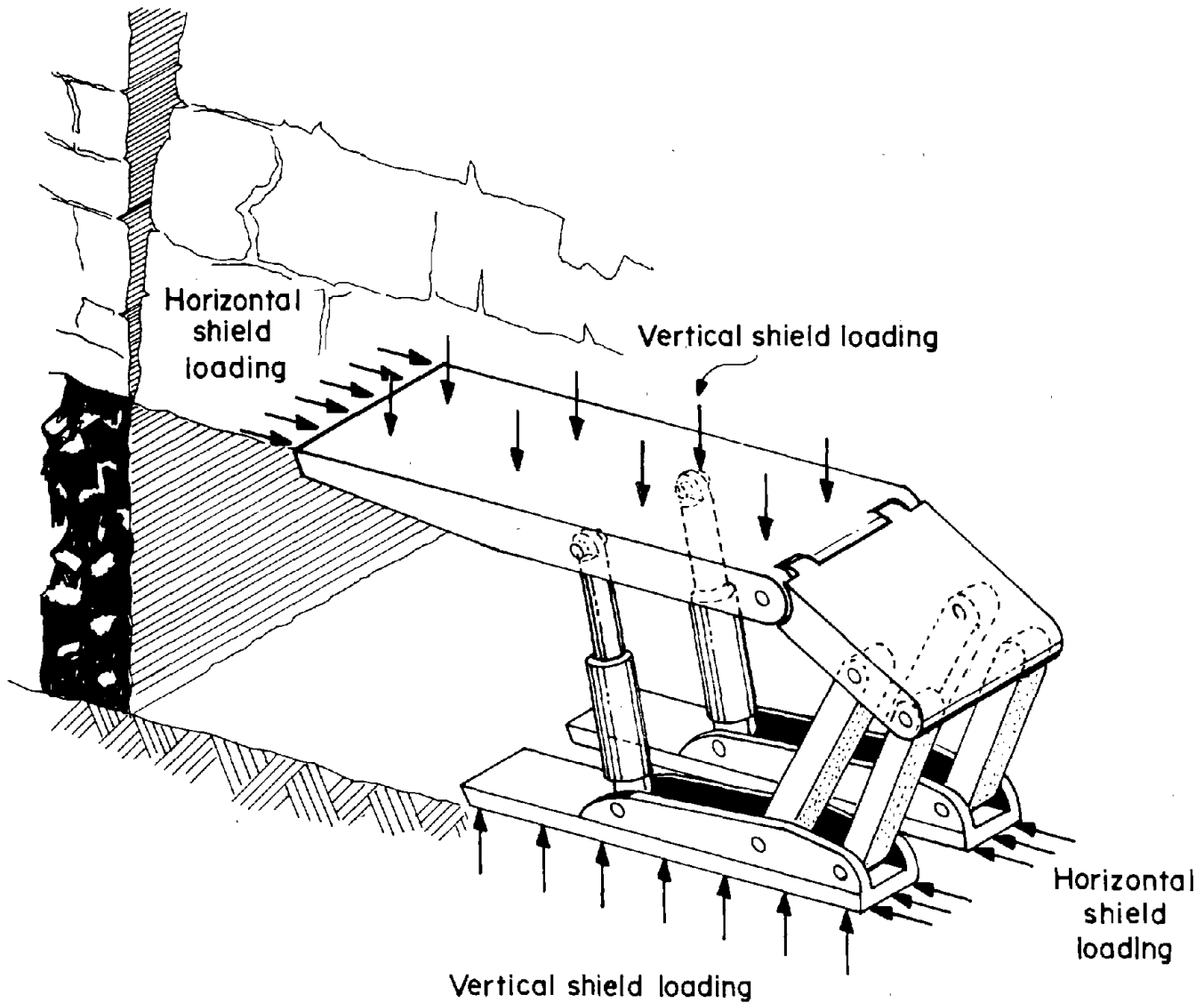


Figure 6.-In situ horizontal and vertical loading of shield support.

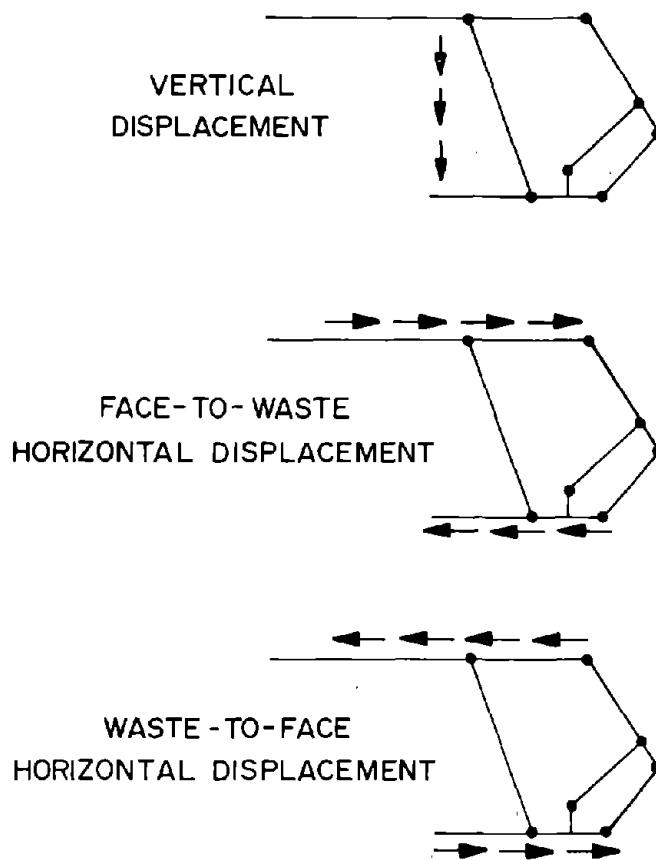


Figure 7.-Shield displacement possibilities.

Figure 8 illustrates generalized load transfer mechanics for a two-leg shield depicting load development in the legs and caving shield assembly. The caving shield-lemniscate assembly has very little vertical stiffness and will not develop much loading from vertical displacements. However, the caving shield does have considerable horizontal stiffness and will develop significant loading from horizontal displacements, provided the displacement is sufficient to overcome rigid-body translational freedom in the pin joints.

Generalized component responses for vertical, face-to-waste horizontal, and waste-to-face horizontal displacements are illustrated for the leg cylinders and lemniscate links in figure 9. As seen in the figure, the behavior of these components is dependent upon the direction of the imposed shield displacement. Because these loading mechanisms are different, each displacement should be considered in the performance test program.

Vertical and horizontal displacements or forces should be applied independently and in combination with one another after the shield is set at normal operating pressures. Because vertical loading will help maintain stability, it is recommended that vertical displacement (loading) be

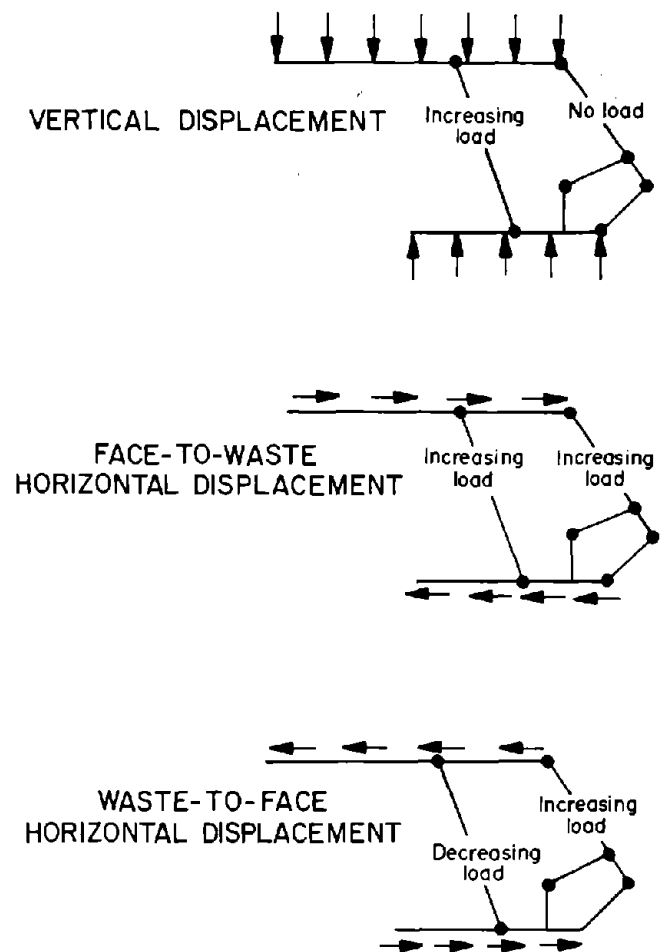


Figure 8.-Generalized load transfer mechanics for two-leg shield support.

applied first, followed by either waste-to-face or face-to-waste horizontal displacement (loading) for combined load cases.

Loading should be applied until one of four conditions is met: (1) leg pressure reaches yield pressure, (2) leg pressure is reduced to below setting pressure, (3) material yield is approached in one or more components, or (4) the shield becomes physically unstable or the contact configuration is altered from canopy or base instability. The magnitude of the displacement depends upon the vertical and horizontal stiffness of the support structure (4). For most shields, 0.5 in of vertical displacement should be sufficient to reach shield (leg) capacity, assuming displacements are applied after setting the shield with 2,500-to-3,500 psi leg pressure. The required magnitude of horizontal displacement depends upon the translational freedom in the numerous pin joints of the structure. Some shields may require as much as 0.75 in of horizontal displacement before appreciable stresses are developed in the caving-shield lemniscate assembly.

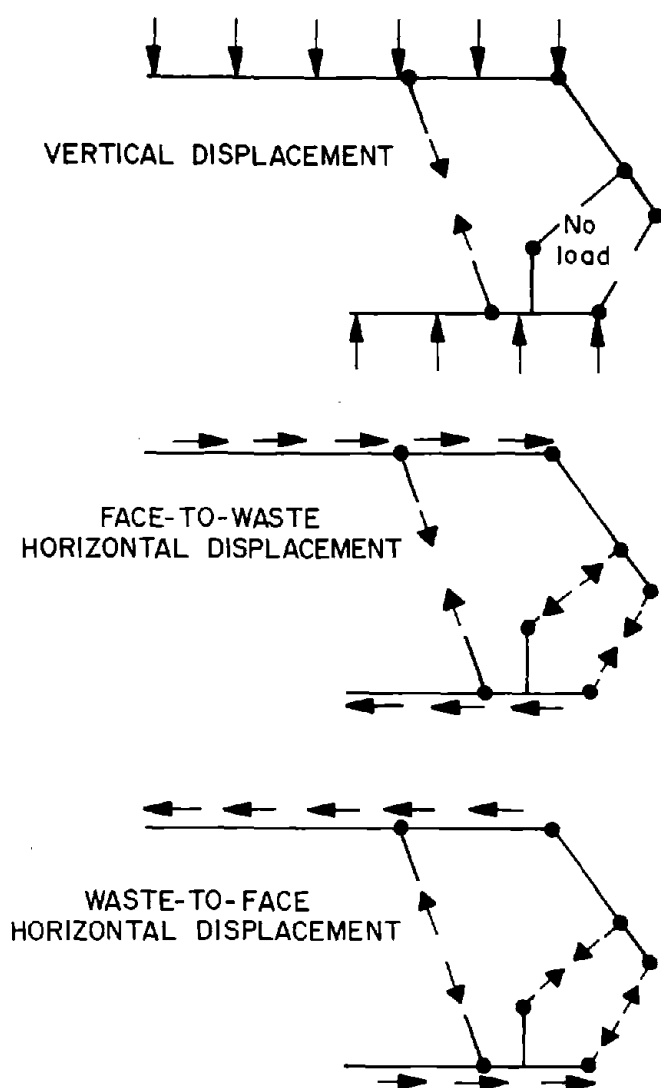


Figure 9.—Generalized component responses for two-leg shield support.

### Static Versus Cyclic Tests

Performance test requirements described in this report apply equally well to both static tests and cyclic tests. Both static and cyclic tests should be conducted. Static tests should be conducted first to evaluate basic load transferring mechanisms and component responses under precisely controlled loading. Preferably, these tests should be conducted in an active load frame. Cyclic tests can be time consuming and are often conducted in static load frames because of the time required to conduct the tests. The primary objective of cyclic tests is to evaluate fatigue failures. Both static tests and cyclic tests should evaluate boundary conditions that produce different loading mechanisms in each support component. Cyclic tests should be conducted under conditions that produce maximum

changes in strain and maximum strain magnitudes. The number of cycles should approximate the expected service life of the shield. Typically, 10,000 cycles of each load case are evaluated.

### CONTACT CONFIGURATIONS AND INITIAL LOAD CONDITIONS

Shield response is largely dependent upon contact configurations and initial load conditions. Contact configuration describes the combinations of vertical and horizontal contacts on the canopy and base through which forces or displacements are applied to the support structure. The goal of the testing program should be to utilize contact configurations that produce maximum loading in each of the support components.

Initial conditions describe the shield configuration and test procedures prior to controlled load application. Initial conditions often dictate how the shield will respond and thus are critical to performance testing. The most important initial condition consideration is horizontal constraint.

### Constrained Load Conditions

Constraint is a term used to define forced horizontal restriction of the shield canopy and base that reduces or eliminates freedom in the numerous pin joints of the shield structure. Pin freedom, as conceptually illustrated in figure 10, can be seen by physical inspection of the shield. In the laboratory, constraint is achieved by horizontal displacement of the canopy relative to the base prior to vertical or horizontal load application. In an underground environment, constraint may be achieved by advancement of the shield while under partial contact with the roof or if the canopy tip or base toe strikes a protrusion during advancement.

Tests conducted in the Bureau's mine roof simulator indicate that for unconstrained configurations, the caving shield-lemniscate assembly is not likely to appreciably participate in the shield load transfer mechanics. Hence, when the shield is unconstrained, the vertical and horizontal capacity is controlled by the leg forces.

The effect of constraint is to lock up the structure so that the caving shield-lemniscate assembly participates in providing support resistance. Even in a constrained configuration, vertical stiffness of the caving shield-lemniscate assembly is small compared to leg stiffness and most of the vertical load will be taken by the leg cylinders. Horizontally, load resistance provided by the caving shield-lemniscate assembly can equal or exceed the resistance provided by the legs in constrained configurations. Therefore, higher stresses will be developed in constrained configurations than in unconstrained configurations and stresses will be a maximum when the canopy is displaced horizontally relative to the base. The caving shield and lemniscate links will show the most increase in loading, but all components will be exposed to higher stresses in constrained load cases.

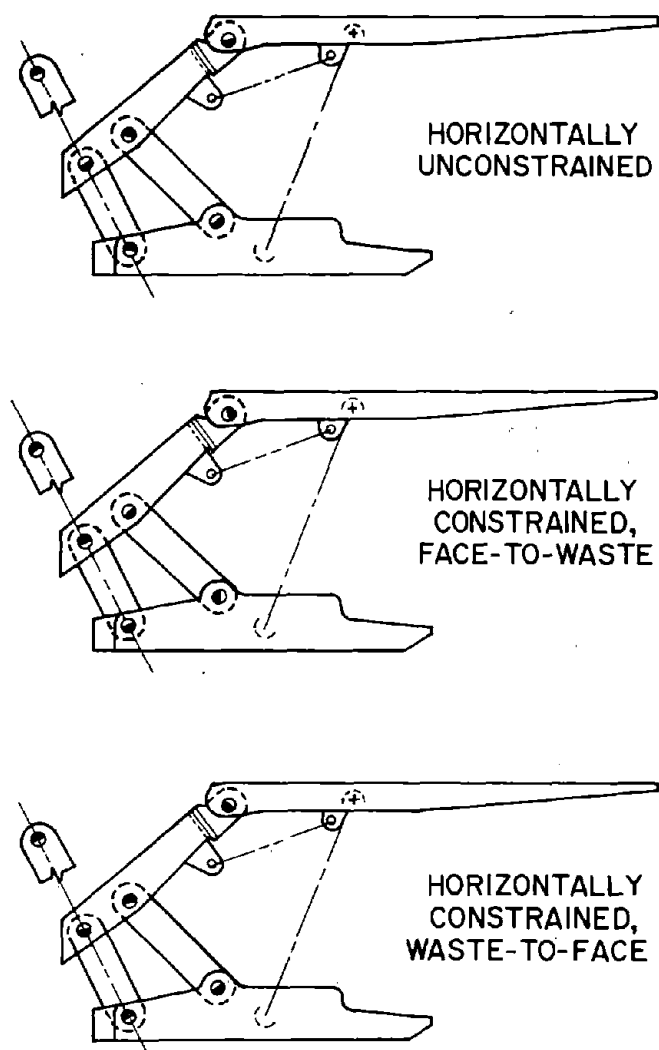


Figure 10.—Conceptual illustration of freedom in pin joints of shield structure. Light area of pin joint is area of freedom; dark area is point of contact.

### Symmetric Contact Configurations

Figure 11 depicts symmetric canopy and base contacts typically employed by support manufacturers. Each canopy and each base contact illustrated in figure 11 can be examined in combination as shown in the matrix in figure 12. However, a goal of the test program should be to minimize the number of tests without sacrificing information on the safety and integrity of the support. Combinations that do not produce significantly different responses from another combination can be eliminated from the test program. The Bureau's research into shield load transfer mechanics provides insight into component responses for canopy and base contact combinations. This section discusses general considerations in symmetric contact shield behavior.

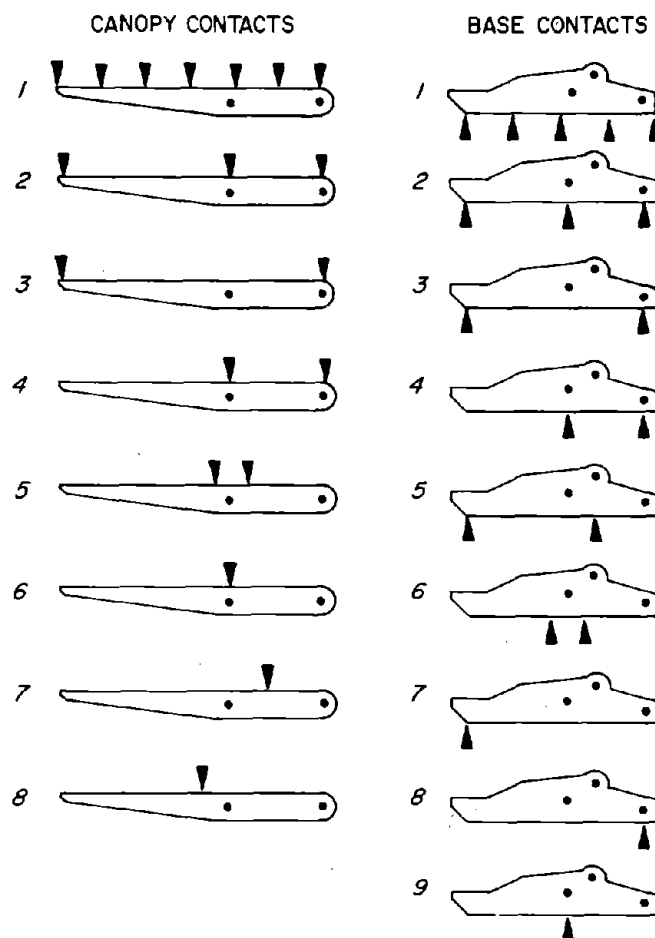


Figure 11.—Symmetric canopy and base contacts.

Proposed contact configurations for advanced performance testing are identified in the "Critical Load Test Configurations" section.

Canopy contacts mostly influence the behavior of the canopy; while the behavior of the base, caving shield, and lemniscate links is more sensitive to base contacts. Therefore, selective canopy contacts can be examined, but several base contacts need to be tested to evaluate all possible loading mechanisms. Furthermore, the caving shield-lemniscate assembly has very little vertical stiffness (for horizontally unconstrained shield configurations). Almost all of the load on the canopy, regardless of the contact configuration through which the load is applied, will be transmitted by the leg cylinders to the base. Therefore, loading of the base and caving shield-lemniscate assembly is largely independent of the canopy contact configuration, and any canopy contact can be selected in combination with specific base contacts to evaluate all component responses except the canopy.

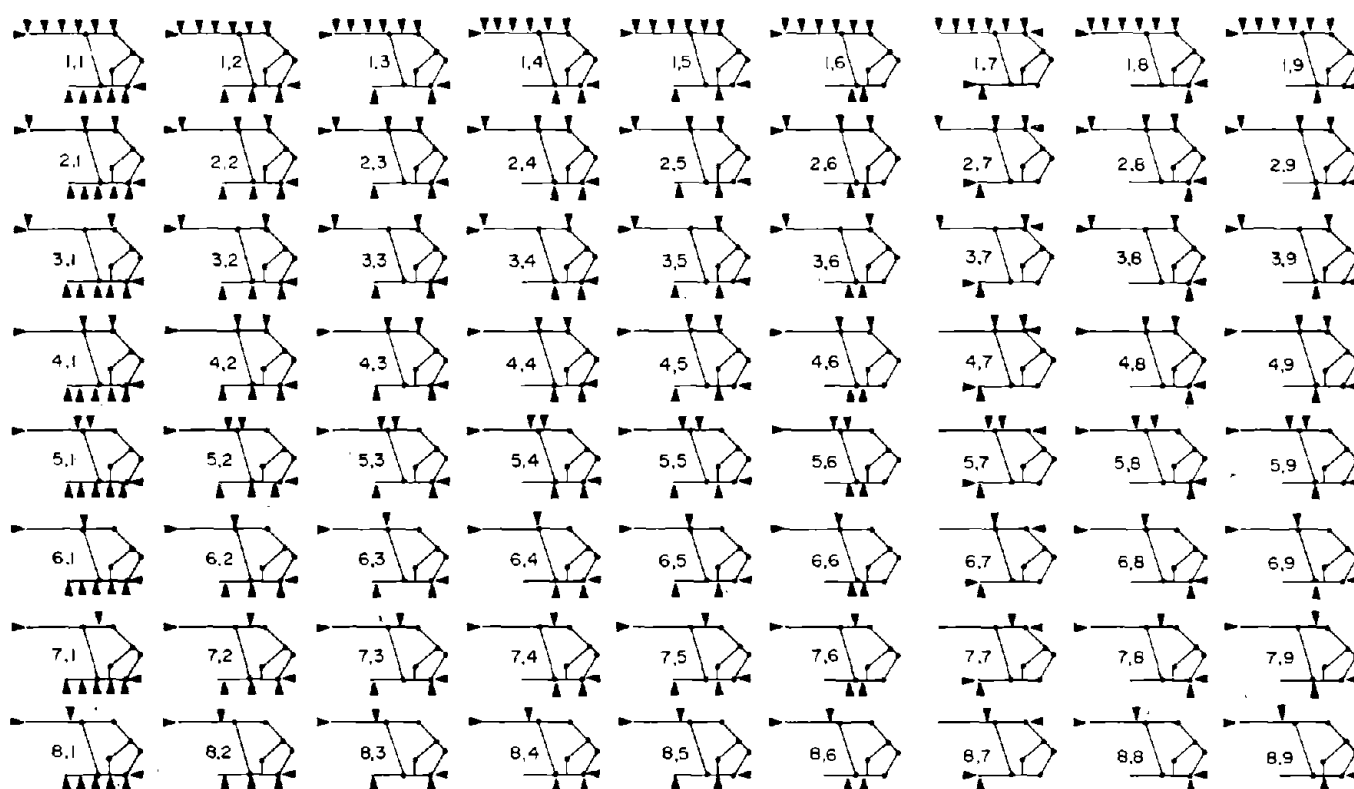


Figure 12.-Matrix of symmetric canopy and base contact combinations. Numbers refer to contacts shown in figure 11.

Full canopy contact is suggested as a standard simply because it is presumed that this configuration is most likely to occur underground. A more conservative selection for the standard canopy contact is concentrated load application at the leg location. Contact at the leg location will maximize base activity by maximizing load transfer through the leg cylinders. Likewise, canopy responses are largely independent of base contact configurations, and a full base contact can be used to evaluate worst case canopy contacts.

### Unsymmetric Contact Combinations

In addition to the symmetric contact configurations previously discussed, unsymmetric contact configurations should be evaluated separately in the test program. These contact configurations promote the development of out-of-plane stresses within the support components. Figure 13 depicts typically employed unsymmetric canopy and base contacts, which can also be examined in combination to provide a multitude of test configurations.

In the discussion of symmetric canopy and base contact combinations, it was indicated that canopy contact primarily affects only the behavior of the canopy. For configurations with unsymmetric canopy contact, the canopy can

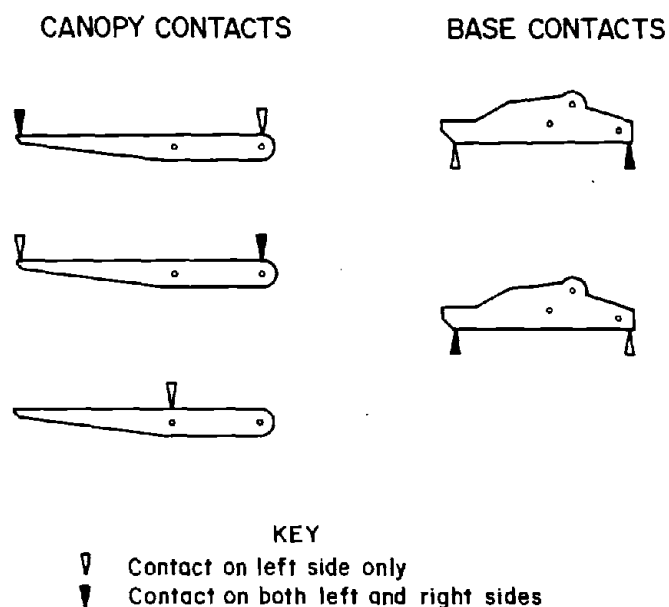


Figure 13.-Unsymmetric canopy and base contacts.

also influence the behavior of the caving shield and the lemniscate links. In two-leg shield design with split-base designs, unsymmetric base contact (as shown in figure 13) is actually a misnomer in that the contacts do not produce out-of-plane stress development in the base. The two base units act as individual members and influence the behavior of the shield consistent with the mechanics of the more dominant base contact.

In terms of critical loading, component responses, with the exception of the canopy, are likely to be dominated by the base configuration. Unsymmetric canopy contact will produce slightly larger canopy strains than symmetric contact, but the influence of the unsymmetric canopy contact on the caving shield is likely to be dominated by the base contact in all but full-base contacts. The dominance of the base contact configuration in the behavior of the caving shield, lemniscate links, and base members also makes worst-case symmetric base contacts more critical than unsymmetric base contacts. This suggests that in terms of critical shield loading, only symmetric contacts need to be investigated, but because load transferring mechanisms are also criteria for the selection of performance tests, unsymmetric contacts should be investigated. Specific unsymmetric contact configurations proposed for advanced performance testing are identified in the "Critical Load Test Configurations" section.

## OTHER PARAMETER CONSIDERATIONS

Load application, contact configuration, and constraint are the most important parameters to consider in performance testing of shield supports. However, there are several other parameters that can be considered, including height effects, contact material stiffness, and load rate effects.

### Height Effects

Generally, lower shield heights will produce lower stresses in the support structure than identical boundary conditions at higher shield heights. This suggests that shields should be tested at heights slightly higher than anticipated for underground service.

The increase in component loading at higher shield heights can be attributed to the increased stiffness of the shield with decreasing shield heights (5). Because the shield stiffness is greater, the same loads will produce less displacement which results in less strain development per unit load. The difference in strains between low and high shield heights is dependent upon the change in stiffness for different shield geometry configurations. Strain changes of 10 to 15 pct are possible for maximum changes in shield height (geometry).

### Contact Stiffness Effects

It has been established that shield responses are largely dependent upon canopy and base contact configurations, but the interaction of the support with the strata is also

dependent upon the physical properties of the strata (5). Generally, stiffer contact materials will produce higher localized stresses at the contact locations.

In laboratory tests conducted in a relatively rigid test frame, the resulting stress in the support structure is also strongly influenced by the rotational stiffness of the contact material. For example, contact by a 6- by 6-in concrete or steel block will produce up to several hundred percent larger strains in the support structure than will contact by a round steel bar. The steel and concrete blocks, because of the cross sectional area contacting the canopy or base, produce additional bending strains in the support structure. Steel blocks provide good contact stability and a conservative assessment of component loading, hence, they are the recommended contact material.

The canopy is likely to be most affected by material contact stiffness considerations its bending strength is generally weaker than that of the base. It is expected that the effect of the rotational stiffness of the strata will be less pronounced than the laboratory results because the strata are assumed to be less rigid than the laboratory test frame.

## Load Rate Considerations

Some tests have suggested a load rate effect on shield strain profiles (5), but no conclusive data have been obtained thus far. Until more evidence of rate effects are documented, it is suggested that displacement rates of 0.1 in/min be utilized in shield performance testing. There is also some evidence to suggest that slower cycle rates are more critical than faster cycle rates, but again the evidence is inconclusive at this time.

## INSTRUMENTATION REQUIREMENTS

The support should be instrumented to determine (1) basic component responses and nominal stress development, (2) areas of stress concentration, (3) load transfer mechanics, and (4) changes in support geometry. Specific instrumentation for each of these requirements is suggested as follows.

### Basic Component Responses

Figure 14 depicts instrumentation to monitor basic component responses and nominal stress development. Strain gages are used to assess structural deformations and pressure transducers are used to monitor hydraulic component responses as illustrated in figure 14. This instrumentation will provide a fundamental description of the shield structural response and basic design integrity. Load application should be terminated prior to any strain gage indication of material yield to ensure elastic recovery of the shield, unless destructive testing is desired. Again, this instrumentation is intended only to determine nominal component stress development. It does not necessarily ensure the structural integrity of the support as it is not intended to identify stress concentrations. However, any

indication of component yielding by this instrumentation, excluding hydraulic component response, should be viewed as indication of unacceptable support design.

### Stress Concentrations

It is usually impractical to put enough strain gages on a support to assess stress concentrations in all areas of the support structure. Localized regions of high stress are often dictated by abrupt changes in the geometry of the structure, and therefore are somewhat shield specific. Areas of concern might include leg sockets, hinge pin clevises, and regions around holes. Triaxial gauges should be used if the state of stress is not apparent in these regions. Photoelastic plastic can also be employed to

provide a more generalized picture of stress concentrations. The plastic produces colored fringes when viewed under polarized light in response to stress profiles of the underlying structure.

A primary concern in the evaluation of stress concentrations is the promotion of crack growth from fatigue loading. Hence, an important consideration in evaluating structural integrity of the support is to identify inherent flaws in the structure. This can be done by ultrasonic techniques or X-ray detection. Knowledge of the stress intensity factors for the component steel should be acquired and used in conjunction with the nominal stress development measurements to assess fatigue related failures.

### Load Transfer Mechanics

Some indication of load transfer within the support structure is desirable for evaluation of imposed loading and support responses to performance testing. The most critical requirement is to assess load transfer between the canopy and caving shield assembly. This is best achieved by replacing the canopy-caving shield hinge pin with an instrumented pin that is instrumented with strain gages in two orthogonal axes to determine vertical and horizontal force reactions. These pins are commercially available and can be configured to a specific shield design. Figure 15 shows an instrumented pin used by the Bureau. Ideally, knowledge of load transfer at all joints within the structure is desired to provide a complete picture of load transfer. If instrumented pins are not available, then the lemniscate links should be instrumented with strain gages to assess load transfer to the caving shield-lemniscate assembly.

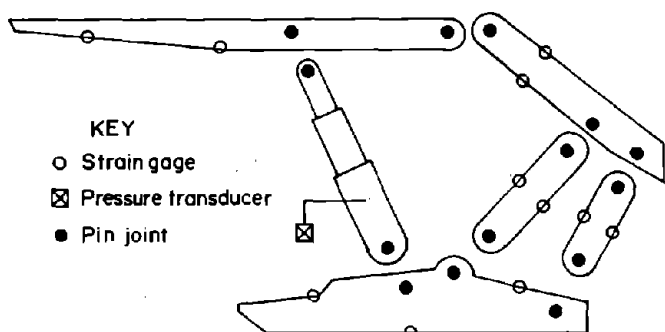


Figure 14.-Instrumentation to monitor basic component responses.

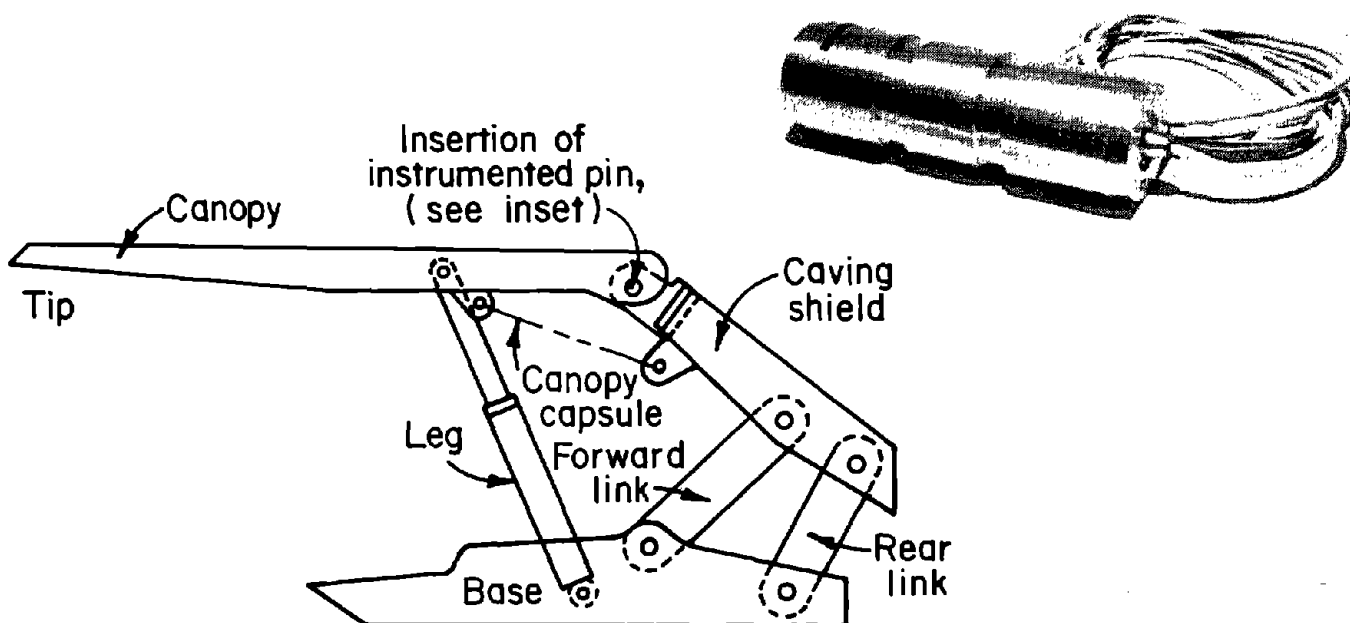


Figure 15.-Instrumented vertical and horizontal load sensing pin.

### Changes in Support Geometry

Appendix A provides a computer program for determining the spatial coordinates of a shield geometry for a specified shield height. The program is written in Fortran and can be run on any IBM compatible computer.<sup>4</sup> In addition to this mathematical model, the following physical changes of geometry of the support structure should be monitored during testing.

*Displacement of canopy relative to the base.*—Vertical and horizontal displacement of the canopy relative to the base should be monitored. If these displacements cannot be accurately determined from load frame information, then the support should be instrumented to monitor leg closure and leg rotation as shown in figure 16 and 17, respectively. Vertical and horizontal displacements are determined as follows:

$$\delta_v = \Delta L \sin \theta + L \Delta \theta \cos \theta \text{ and}$$

$$\delta_h = \Delta L \cos \theta + L \Delta \theta \sin \theta,$$

where  $\delta_v$  = vertical displacement,

$\delta_h$  = horizontal displacement,

$\Delta L$  = leg closure,

$\Delta \theta$  = change in leg angle,

$L$  = initial leg length,

and  $\theta$  = initial leg angle.

<sup>4</sup>Reference to specific products does not imply endorsement by the U.S. Bureau of Mines.

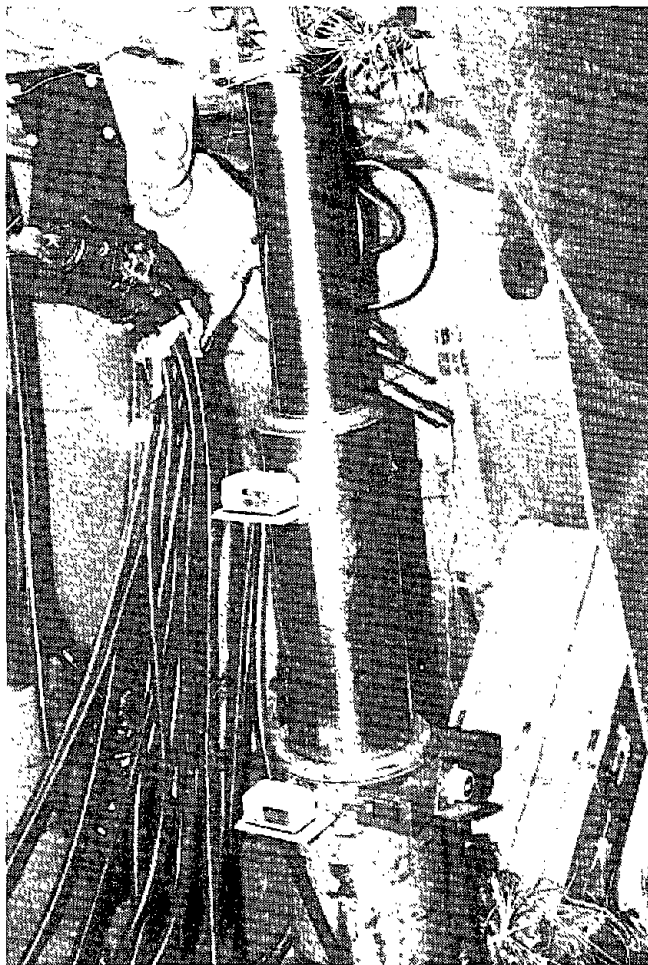


Figure 16.—Monitoring leg closure using wire-pull displacement transducers.

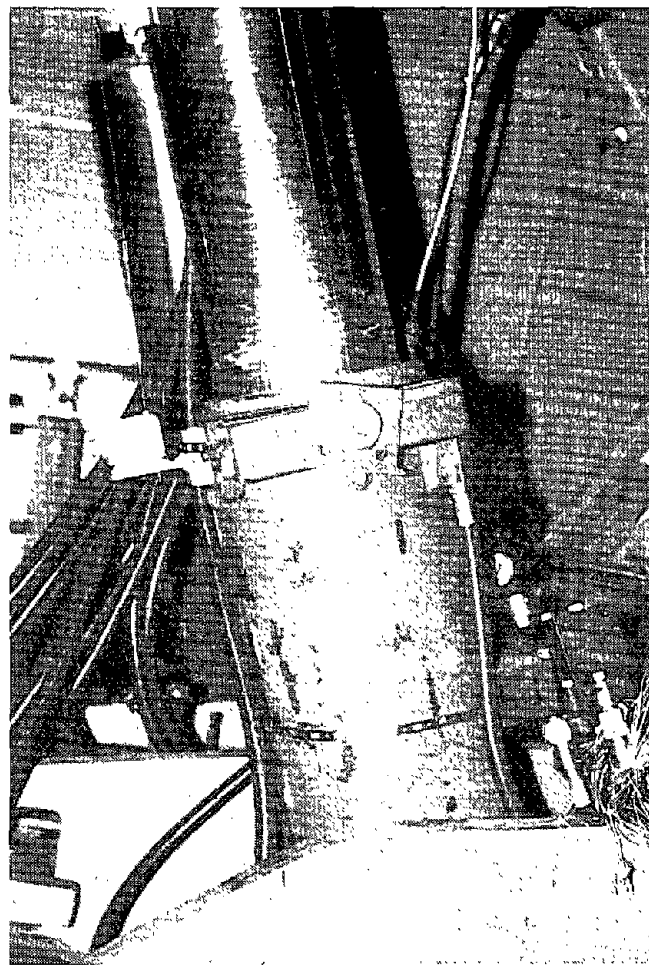


Figure 17.—Inclinometer used to measure leg rotation.

*Leg cylinder compression.*—Leg closure should be monitored by a wire-pull displacement transducer. In multiple stage leg designs, closure of each stage should be measured independently as illustrated in figure 16.

*Leg cylinder rotation.*—Leg cylinder rotation with respect to the plane of the canopy should be measured. Figure 17 depicts a small analog inclinometer that can be used for such measurements.

*Plane of reference of canopy relative to the base.*—Measurements should be taken to monitor

orientation of canopy relative to the base. This orientation can be determined from inclinometers such as those described for leg orientation measurements.

*Shield height.*—Initial shield heights should be recorded prior to each test. This measurement does not require any specialized instrumentation; any common measuring tape should be adequate. Changes in shield height during testing can be determined from leg orientation and leg closure measurements.

## DESCRIPTION OF SHIELD MECHANICS AND COMPONENT RESPONSES

A discussion of component responses is essential to the identification of critical contact configurations and load conditions. Appendix B describes component responses and loading mechanisms for several load conditions and contact configurations. The mechanics of the support structure as described in the diagrams in appendix B should be understood to properly interpret test results for each load case evaluated. Specific component responses for symmetric contact configurations are described in the following sections. General responses for unsymmetric contact configurations are described separately.

### CANOPY RESPONSES

Bending will produce maximum stresses in the canopy structure because the canopy acts primarily as a cantilevered beam. Maximum bending will occur when tip loading is a maximum, which occurs with two-point canopy contact with the contacts at the ends of the canopy as shown in canopy contact 3 in figure 11. Maximum stresses will occur just ahead of the leg connection or near the beginning of the tapered section of the canopy. Because the canopy structure is fairly stiff in the region between the leg connection and the caving shield hinge, loads applied to the canopy structure in this region (canopy contacts 4, 5, and 7, figure 11) will produce minimal bending.

Canopy contacts 4 and 7 in figure 11 are designed to transfer load through the caving shield, however, the caving shield has little vertical stiffness and most of the load for these configurations will be carried by the leg cylinders. Because the canopy is stiff in this region, minimal stresses will be developed in the canopy for these contact configurations.

Overall, the canopy can be considered to be weakest in bending strength and strongest in axial and shear strength. Axial loading is likely to be fairly small and is produced by (1) horizontal components of the leg forces when the canopy tip is restrained, (2) resistance provided by the caving shield-lemniscate assembly, (3) applied horizontal

loading (displacement) to the canopy tip, or (4) by gob loading on the caving shield. Shear responses are likely to occur in the canopy structure for loads applied away from the leg connection, since these loads must be transmitted to the leg cylinder for transferral to the base structure.

In summary, maximum stresses in the canopy structure are produced from two-point canopy contact with a horizontally restrained canopy tip.

### BASE RESPONSES

Maximum stresses in the base structure will also be developed from bending. However, base structures are designed with a larger cross sectional area and are considerably stiffer than canopy structures. Therefore, bases are less likely to deform from bending and will develop smaller stresses than the canopy structure for similar contact configurations and load conditions.

Two loading mechanisms are responsible for producing base bending. The most critical configuration occurs when the base is standing on its toe as illustrated in base contact 7 in figure 11. In this configuration, the rear lemniscate links act (in tension) to pull the base up and maintain equilibrium while the leg force acts in compression to push the base back down. Maximum stresses will be developed in the toe region of the base structure or under the leg connection for this contact configuration. Significant base bending can also be produced by simply supporting the base at its ends (base contact 3, figure 11) in the same manner as with the two-point canopy contact configuration. In this configuration, maximum stresses are likely to occur more towards the leg connection. Because the base has a smaller cross section near its toe than at the leg connection and since the rear link introduces an additional moment in the base structure, standing the support on its toe is likely to be the most critical contact configuration for the base structure. Horizontal restraint at the toe of the base may also be required to maintain base stability in this configuration.

## LEMNISCATE LINK RESPONSES

Lemniscate links are primarily axially loaded members. Some bending can be induced in the link structures from pin friction, pin eccentricity, or from "curved" link designs where the line of action of the pins is not in line with the centroid of the member; however, in most cases bending forces are likely to be small.

There are three primary mechanisms that induce significant stresses in the link members: Base bending, horizontal displacement of the canopy relative to the base structure, and one-point base contacts that promote instability of the base members. Without one of these conditions, link loading is likely to be very small since the caving shield-lemniscate assembly has very little vertical stiffness (4).

Maximum link loading will occur when the base is standing on its toe (base contact 7, figure 11). In this configuration, horizontal stability is provided to the base and canopy by the caving shield-lemniscate assembly, causing considerable strains to be developed in the lemniscate links. Tensile stresses are developed in the rear links and compressive stresses in the front links for vertical shield displacements. Significant link loading can also be caused by single point base contact at the rear of the base (base contact 8, figure 11), where the front link also acts to maintain stability of the base. In this configuration, tensile stresses are likely to be developed in the front links and compressive forces in the rear links.

Two-point base contact (base contact 3, figure 11) will also produce link loading, but because bases are generally stiff members, the bending in the base is relatively small and it is not likely to be sufficient to cause critical loading in the link structures. Theoretically, horizontal displacement of the canopy relative to the base can produce critical loading of the link structures, but in practice rigid-body translation in the pin joints usually prevents the caving shield-lemniscate assembly from developing its full stiffness before the capacity (leg yield pressure) of the shield is reached. Horizontal constraint of the shield prior to load application will reduce freedom in the pin joints and enhance link loading under all load conditions.

## CAVING SHIELD RESPONSES

The caving shield is also most likely to be subjected to maximum loading from bending. As seen in the free-body diagram in figure 18, the caving shield is acted upon by hinge pin forces at the canopy joint and by the lemniscate link forces. The direction of these applied forces vary depending upon contact configuration and applied shield loading as seen in appendix B. Link forces must always be opposite one another to maintain stability of the caving shield. Aside from stress concentrations developed at the joint clevises and geometric discontinuities, maximum stresses are likely to be developed in the section between the front link and the canopy hinge.

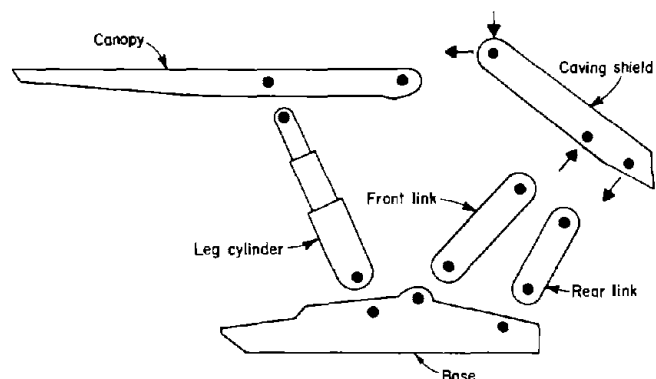


Figure 18.—Free-body diagram for caving shield.

Contact configurations that produce maximum link loading (base contacts 3 and 7, figure 11) will also produce maximum loading in the caving shield. Therefore, maximum caving shield loading requires relative horizontal displacement in the joints of the caving shield-lemniscate assembly and will be enhanced by horizontal constraint.

## LEG RESPONSES

Leg cylinders will be axially loaded in compression for all load cases, assuming some vertical loading on the shield. Horizontal displacement can produce some bending in the leg cylinders if friction is developed in the leg socket and the horizontal displacement is not resisted by the caving shield-lemniscate assembly. Actual bending is likely to be relatively small. Face-to-waste horizontal displacement of the canopy relative to the base increases leg pressures while waste-to-face horizontal displacement will reduce leg pressures.

The leg is the dominant load transferring member for most load cases. Hence, there is not a specific contact configuration for critical load evaluation of the legs. Canopy contact 5 and base contact 6 in figure 11 are designed to induce maximum shear stresses in the leg socket area of the canopy and base, respectively, which is often an area of concern and failure. Because the legs are capable of relieving load by bleeding off internal hydraulic pressure, leg cylinders rarely fail structurally. Seal leakage is usually the most common failure of leg cylinders. Another critical concern is the ability of the yield valves to sufficiently displace hydraulic fluid to relieve leg pressures under high rates of convergence. Such convergence tests are discussed in the "Standardized Performance Tests" section.

Tests should also be conducted to evaluate the effect of staging on leg reactions for various setting pressures. Effective leg area should be determined by evaluating the slope of applied force versus leg pressure plots.

## UNSYMMETRIC CONTACT SHIELD RESPONSES

Unsymmetric contact configurations are derived by combining symmetric configurations, one established on the left side of the shield and the other on the right side of the shield. The mechanisms for component loading remain essentially the same as for symmetric loading: axial loading is prevalent for the links and legs and bending for the canopy, base, and caving shield. Because unsymmetric contact can create out-of-plane stress development, unsymmetric contact configurations can produce larger stresses than similar symmetric contact configurations. More specific shield responses for unsymmetric contact configurations follow.

- Unsymmetric (three-point) canopy contact produces higher strains than full canopy contact but does not produce significantly higher canopy strains than symmetric four-corner canopy contact.
- Three-point unsymmetric canopy contact with only one contact at the rear of the canopy will produce larger strains in the caving shield and lemniscate links than either symmetric partial canopy contact or unsymmetric canopy contact, where the missing contact is at one of the canopy tip corners. Load generated by the unsymmetric three-point canopy contact (one contact at the rear of the canopy) is likely to be carried more by one side of the caving

shield than the other and more through one set of links (left or right side) than the other. If the caving shield is twisting from the unsymmetric canopy response, a transfer of load across the caving shield may occur such that the set of links on the side opposite the missing canopy contact are more heavily loaded.

- Individual base units in split-base designs act as independent members and do not promote out-of-plane stress development in the base units. Link response will be dominated by the associated base contact consistent with symmetric base unit response. For example, two different symmetric base configurations that produce opposite link responses will produce these same opposite link responses on the left side compared to the right side when these base configurations are combined in an unsymmetric base configuration.
- Load distribution in the left and right side of the shield is dominated by the respective base contact. The side with the more dominant base contact will develop the most load.
- Symmetric base-on-toe and base-on-rear configurations produce larger strain development than when these configurations are employed only on one base member in an unsymmetric configuration.

## CRITICAL LOAD TEST CONFIGURATIONS

Critical load contact configurations for two-leg shield performance testing are identified in figure 19. Illustrated in the figure are four symmetric canopy and base contact configurations and four unsymmetric canopy and base contact configurations that are considered mandatory for performance testing. The symmetric configurations are described as (1) full canopy and base contact, (2) base-on-toe contact, (3) base-on-rear contact, and (4) two-point canopy and base contact. As previously indicated, concentrated load application at the leg location can be substituted for the full canopy contact if the shield will remain stable for these configurations. The unsymmetric contact

configurations are described as (1) unsymmetric base-on-rear contact with unsymmetric canopy contact at the leg location, (2) unsymmetric base-on-toe contact with unsymmetric canopy contact at the leg location, (3) unsymmetric base-on-rear contact with symmetric canopy contact at the leg location, and (4) unsymmetric base-on-toe contact with symmetric canopy contact at the leg location.

Also included in figure 19 are eight optional tests. These tests are not likely to produce higher stress development than the mandatory tests, but do provide slightly different loading mechanisms and therefore can be considered for critical load testing.

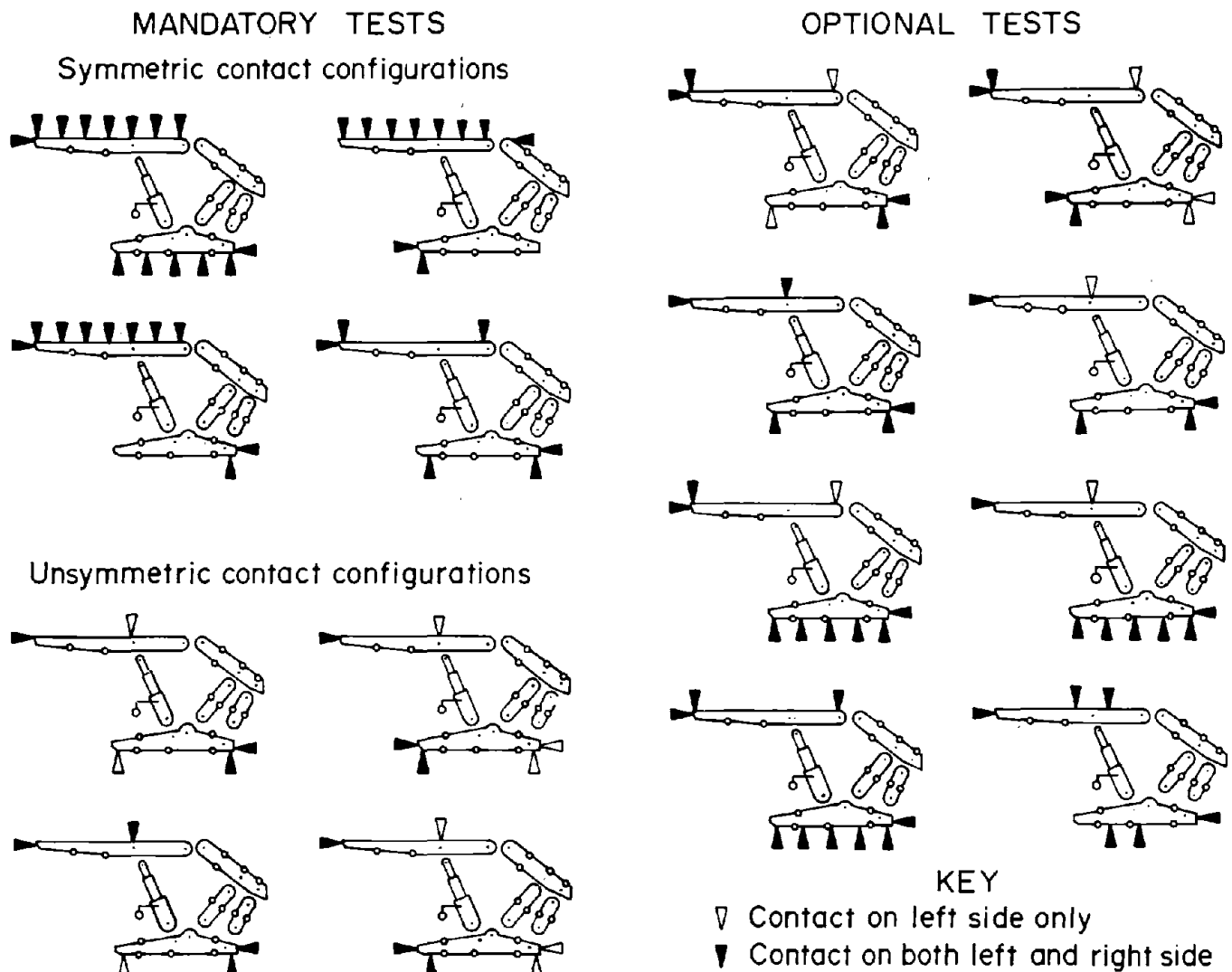


Figure 19.—Critical load test configurations.

## DETERMINATION OF SUPPORT RESISTANCE

Because active load frames provide controlled forces or displacements, information concerning shield loading is usually available from the load frame. Both displacements and forces should be known. In addition, it is necessary to know not only applied forces, but reactive forces as well. For example, figure 20 depicts a horizontal shield reaction in response to an applied vertical displacement of the canopy (relative to the base). While load frame information may provide resultant shield loading (forces), partial contact configurations should employ load cells to measure loading at each point of contact.

Simple rigid-body statics are often used to assess shield resistance in the absence of accurate load frame information and are frequently utilized to evaluate support resistances underground. However, many analyses violate fundamental equilibrium requirements by ignoring horizontal forces acting on the shield. For example, the analysis

shown in figure 21 that is commonly used by manufacturers is valid only for a very limited load condition where there is no horizontal force acting on the support. There is almost always a horizontal force couple acting on two-leg shield supports because of the inclination of the leg cylinders. Only if there is a frictionless interface between the roof and canopy or base and floor is there likely to be no horizontal force acting on the shield. Full shield equilibrium, both force and moment equilibrium, must be satisfied for all analytical analyses of shield resistance.

It is recommended that each analytical analysis of support resistance begin by drawing the free-body diagram for the full shield and ensuring that force and moment equilibrium is attainable. Appendix C contains the proper rigid-body static analysis for determination of shield resistance.

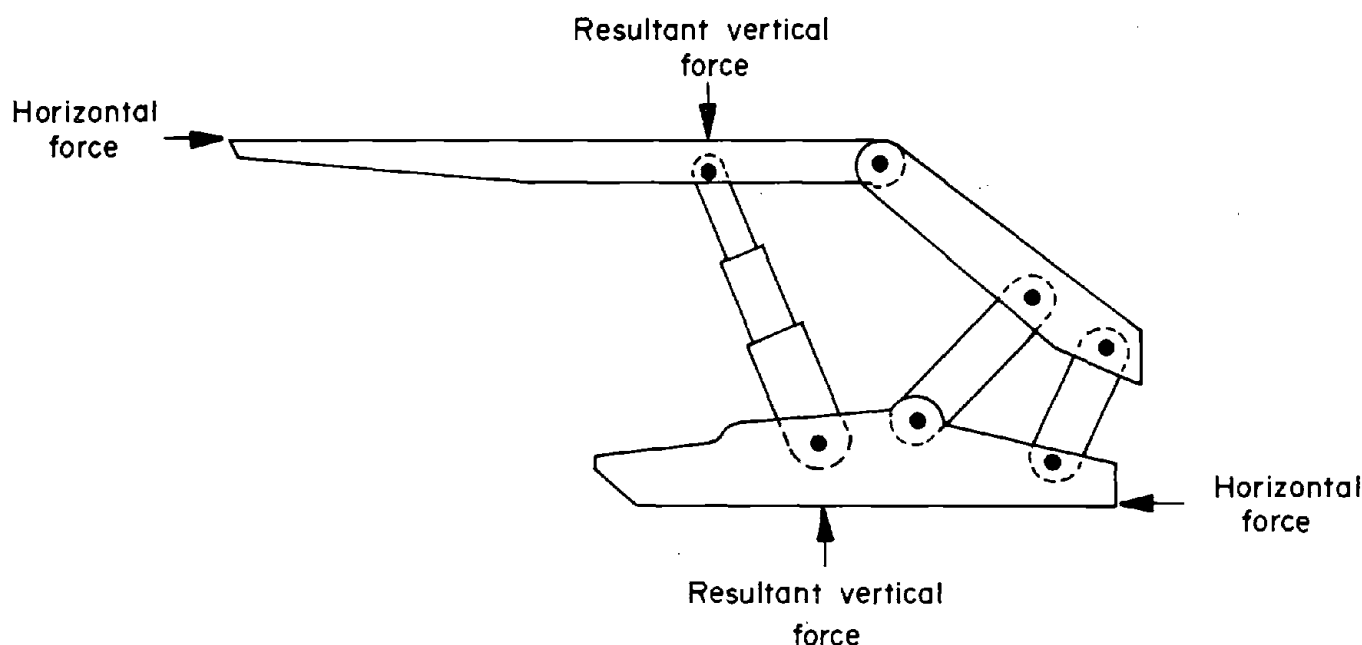


Figure 20.—Horizontal shield reaction to vertical displacement.

## STANDARDIZED PERFORMANCE TESTS

The various issues described in this report provide insight into the performance testing of longwall supports. As seen in these discussions, several options are available, which makes determination of standardized performance tests difficult. The scope of the performance tests are likely to be controlled by the facilities and funding available.

### TEST DOCUMENTATION

As indicated in the introduction, there is a need to establish a standard reporting format for shield performance testing. This can be accomplished by using the form presented in figure 22. This four-page form provides documentation for a test name, test series, objective, brief description of test procedures, identification of boundary and loading conditions, data reductions available for analysis, instrumentation identification, and well-defined test results for both static and cyclic testing. This form will provide for a common data base to facilitate support comparisons as well as provide a concise history of support performance test results.

### PERFORMANCE TESTS

Given the considerations discussed through out this report, the following performance test guidelines are developed. Six test series are noted on the test documentation form presented in figure 22. Each of these test

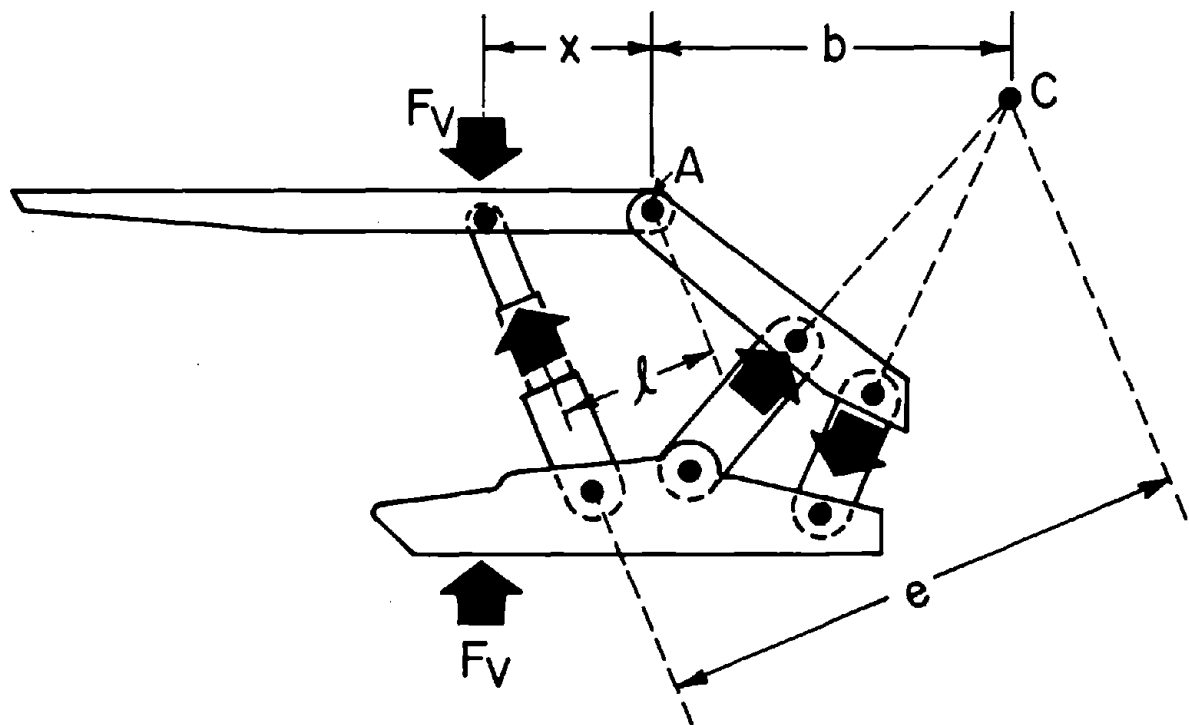
series has a basic objective and it defines the basis for the proposed standardized tests. Within each test series, several tests are required to parametrically evaluate all influential variables. A performance test report, using the four-page form documented in figure 22, should be prepared for each test.

A discussion of each of the six test series follows. Appendix D contains performance test report forms (based on figure 22) with pretest information and data documentation requirements completed on the form for each test required in each of the six test series. Therefore, an operator can simply take these forms and provide them to the manufacturer as statement of required tests and reporting deliverables.

### Resistance Characteristics

The purpose of this test series is to evaluate the resistance characteristics of the shield and to determine its maximum load carrying capability and supporting efficiency. The following tests are documented for this series (appendix D).

*Support Capacity—Height Effects (Tests CAPHTO1 through CAPHTO4).*—The objective of these tests is to determine the support capacity as a function of shield height. Vertical and horizontal support resistance is determined at leg yield for full canopy and base contact at various shield heights.



**ASSUMPTIONS:** No horizontal force acting on shield.

**KNOWNs:** Leg force ( $L$ )  
Distances  $b$ ,  $e$ ,  $\ell$

**UNKNOWNs:** Resultant vertical force ( $F_v$ )  
Resultant vertical force location ( $x$ )  
Front link force (FL)  
Rear link force (RL)

**ANALYSIS:** Moment equilibrium

$$M(A) = F_v(x) - L(\ell) = 0$$

$$M(C) = F_v(x + b) - L(e) = 0$$

**SOLUTION:**  $F_v = \frac{L(e - \ell)}{b}$

$$x = \frac{(1)(b)}{e - \ell}$$

Figure 21.-Typically used rigid-body analysis of shield resistance.

## SUPPORT PERFORMANCE TEST REPORT

**TEST NAME:**

**TEST SERIES:**

|                            |       |                      |       |
|----------------------------|-------|----------------------|-------|
| Resistance characteristics | _____ | Stability            | _____ |
| Shield stiffness           | _____ | Load transfer        | _____ |
| Leg mechanics              | _____ | Structural integrity | _____ |

**OBJECTIVE:**

**TEST PROCEDURE:**

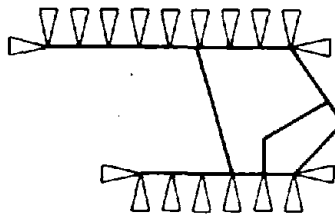
**TEST FRAME:** Static \_\_\_\_\_ Active \_\_\_\_\_

**SHIELD CONFIGURATION:**

|                  |       |                         |
|------------------|-------|-------------------------|
| Shield height    | _____ | inches                  |
| Leg inclination  | _____ | degrees from vertical   |
| Canopy rotation  | _____ | degrees from horizontal |
| Setting pressure | _____ | psi                     |

**BOUNDARY CONDITIONS:** Constrained \_\_\_\_\_ Unconstrained \_\_\_\_\_

Fill in appropriate  $\nabla$   
to establish symmetric  
contact configuration



Fill in appropriate  $\circ$   
to establish unsymmetric  
contact configuration

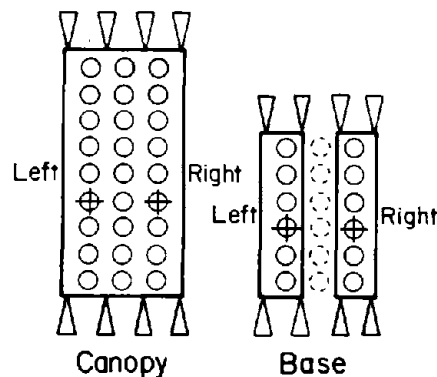


Figure 22.—Standardized test report form.

**LOAD APPLICATION:****CONTROL PARAMETERS AND LOADING RATES:**

Vertical force \_\_\_\_\_ kips/in  
 Horizontal force: \_\_\_\_\_  
     Face-to-waste \_\_\_\_\_ kips/in  
     Waste-to-face \_\_\_\_\_ kips/in  
 Vertical displacement \_\_\_\_\_ kips/in

Horizontal displacement:  
     Face-to-waste \_\_\_\_\_ in/min  
     Waste-to-face \_\_\_\_\_ in/min  
 Leg pressure \_\_\_\_\_ psi/min  
 Cycles per minute \_\_\_\_\_ cyc/min

**LOAD SEQUENCE:**

Vertical only \_\_\_\_\_  
 Horizontal only \_\_\_\_\_  
 Simultaneous vertical and horizontal \_\_\_\_\_

Vertical-horizontal \_\_\_\_\_  
 Horizontal-vertical \_\_\_\_\_

**DATA REDUCTION AVAILABLE FOR ANALYSIS:**

Vertical force vs vertical displacement \_\_\_\_\_  
 Horizontal force vs vertical displacement \_\_\_\_\_  
 Strain channels vs vertical displacement \_\_\_\_\_  
 Strain channels vs vertical force \_\_\_\_\_  
 Strain channels vs sum of leg pressures \_\_\_\_\_  
 Vertical force vs sum of leg pressures \_\_\_\_\_  
 Horizontal force vs sum of leg pressure \_\_\_\_\_  
 Strain channels vs number of cycles \_\_\_\_\_

vs horizontal displacement \_\_\_\_\_  
 vs horizontal displacement \_\_\_\_\_  
 vs horizontal displacement \_\_\_\_\_  
 vs horizontal force \_\_\_\_\_  
 vs individual leg pressure \_\_\_\_\_  
 vs individual leg pressure \_\_\_\_\_  
 vs individual leg pressure \_\_\_\_\_

**COMMENTS:****INSTRUMENTATION IDENTIFICATION:**

Fill in appropriate ○  
 to establish instrumentation  
 location

Nomenclature: L-Left  
                   R-Right  
                   C-Center

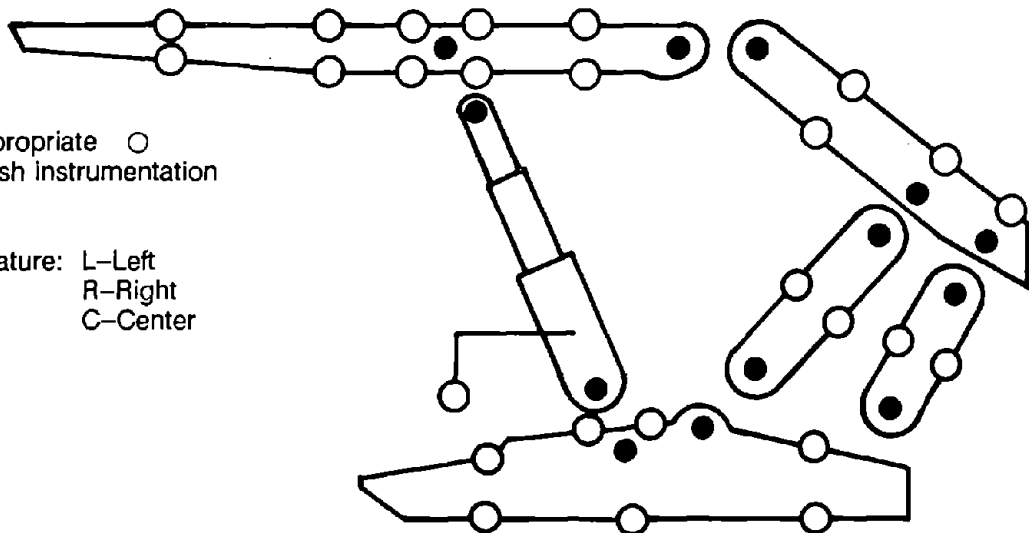


Figure 22.-Standardized test report form-Continued.

**MATERIAL PROPERTIES:**

| Component        | Steel type | Yield stress,<br>psi | Critical stress intensity<br>factor, kip/in <sup>2</sup> |
|------------------|------------|----------------------|----------------------------------------------------------|
| Canopy .....     | _____      | _____                | _____                                                    |
| Base .....       | _____      | _____                | _____                                                    |
| Caving shield .. | _____      | _____                | _____                                                    |
| Links .....      | _____      | _____                | _____                                                    |
| Link pins .....  | _____      | _____                | _____                                                    |

**TEST RESULTS FOR STATIC LOAD TESTS:**

| SUPPORT RESISTANCE:                    | Initial conditions | Maximum load |
|----------------------------------------|--------------------|--------------|
| Maximum vertical force ..... kips ..   | _____              | _____        |
| Maximum horizontal force ..... kips .. | _____              | _____        |

| DISPLACEMENTS:                      |       |       |
|-------------------------------------|-------|-------|
| Vertical displacement ..... in ..   | _____ | _____ |
| Horizontal displacement ..... in .. | _____ | _____ |

| SUPPORT STABILITY:               |       |       |
|----------------------------------|-------|-------|
| Rear of base lifted ..... in ..  | _____ | _____ |
| Toe of base lifted ..... in ..   | _____ | _____ |
| Canopy tip lowered ..... in ..   | _____ | _____ |
| Canopy tip raised ..... in ..    | _____ | _____ |
| Canopy rear lowered ..... in ..  | _____ | _____ |
| Canopy rear raised ..... in ..   | _____ | _____ |
| Shield slid forward ..... in ..  | _____ | _____ |
| Shield slid backward ..... in .. | _____ | _____ |

| LOAD TRANSFER:                     |       |       |
|------------------------------------|-------|-------|
| Leg forces:                        |       |       |
| Vertical leg force ..... kips ..   | _____ | _____ |
| Horizontal leg force ..... kips .. | _____ | _____ |
| Caving shield assembly:            |       |       |
| Vertical pin force ..... kips ..   | _____ | _____ |
| Horizontal pin force ..... kips .. | _____ | _____ |

| LOAD DISTRIBUTION:                 | Gage ID |       |       |       |
|------------------------------------|---------|-------|-------|-------|
| Canopy ..... microstrain ..        | _____   | _____ | _____ | _____ |
| Base ..... microstrain ..          | _____   | _____ | _____ | _____ |
| Front link ..... microstrain ..    | _____   | _____ | _____ | _____ |
| Rear link ..... microstrain ..     | _____   | _____ | _____ | _____ |
| Caving shield ..... microstrain .. | _____   | _____ | _____ | _____ |
| Left leg cylinder ..... psi ..     | _____   | _____ | _____ | _____ |
| Right leg cylinder ..... psi ..    | _____   | _____ | _____ | _____ |

|                  |                   |                        |
|------------------|-------------------|------------------------|
| TEST LIMITATION: | Leg yield _____   | Component strain _____ |
|                  | Instability _____ | Other _____            |

Figure 22.—Standardized test report form—Continued.

**TEST RESULTS FOR CYCLIC LOADING:**

LOAD ASSESSMENT:      Number of cycles \_\_\_\_\_  
                                  Load variation per cycle \_\_\_\_\_ to \_\_\_\_\_

**ASSESSMENT OF GENERAL YIELDING:**

| Component    | Location | Residual strain, microstrain | Maximum deflection, in | Cycles |
|--------------|----------|------------------------------|------------------------|--------|
| Canopy ..... | _____    | _____                        | _____                  | _____  |
| Base .....   | _____    | _____                        | _____                  | _____  |
| Caving ..... | _____    | _____                        | _____                  | _____  |
| Links .....  | _____    | _____                        | _____                  | _____  |

**ASSESSMENT OF FRACTURE MECHANICS:**

| Crack formation:                 | Crack 1 | Crack 2 | Crack 3 | Crack 4 | Crack 5 |
|----------------------------------|---------|---------|---------|---------|---------|
| Component .....                  | _____   | _____   | _____   | _____   | _____   |
| Crack length ..... in ...        | _____   | _____   | _____   | _____   | _____   |
| Nominal stress ..... psi ...     | _____   | _____   | _____   | _____   | _____   |
| Cycle number .....               | _____   | _____   | _____   | _____   | _____   |
| Crack propagation:               |         |         |         |         |         |
| Change in length, ... in/cyc ... | _____   | _____   | _____   | _____   | _____   |
| Maximum crack length ... in ...  | _____   | _____   | _____   | _____   | _____   |

**SUMMARY PERFORMANCE ASSESSMENT:**

Capacity:

Stability:

Structural integrity:

**Tip Load Capability (Tests TIPO1 through TIPO6).**—These tests are designed to determine tip loading characteristics of the shield. Tests TIP01 and TIP02 evaluate maximum tip load capability for symmetric two-point canopy contact. Tests TIP03 and TIP04 evaluate tip loading that is generated for full canopy contact. This is important because this is the tip loading that will normally be generated by the shield underground for most setting conditions. Tests TIP05 and TIP06 evaluate tip loading generated by active capsule pressurization once the shield is set.

**Horizontal Support Capacity (Tests HCO1 through HCO4).**—Tests HC01 and HC02 determine the shield resistance to externally applied face-to-waste horizontal displacements. Tests HC03 and HC04 determine the horizontal reaction developed by the shield for vertical displacements. This provides an indication of the horizontal force the shield might generate into the roof strata.

### Shield Stiffness

The purpose of this test series is to determine the horizontal and vertical stiffness of the shield in accordance with the following linear elastic model (4):

$$F_v = K_1 * \delta_v + K_2 * \delta_h \text{ and}$$

$$F_h = K_3 * \delta_v + K_4 * \delta_h,$$

where  $F_v$  = resultant vertical force,  
 $F_h$  = resultant horizontal force,  
 $\delta_v$  = vertical displacement,  
 $\delta_h$  = horizontal displacement,

and  $K_1, K_2, K_3, K_4$  = stiffness coefficients.

The objective of these tests is to determine the stiffness coefficients ( $K_1, K_2, K_3, K_4$ ) by applying independent controlled vertical and horizontal displacements to a shield while measuring vertical and horizontal shield reactions (4). These stiffness determinations enable prediction of support reactions when in underground service and provide valuable design information pertaining to component loading and shield behavior.

Two parameters are considered influential in this test series: Shield height and horizontal constraint. It is recommended that these stiffness tests be conducted at a minimum of two shield heights (one low, one high) and for both constrained and unconstrained initial conditions. Shield stiffness is slightly dependent on contact configuration, therefore it is suggested that the stiffness tests be conducted with full canopy and base contact and two-point symmetric canopy and base contact, as these two configurations should provide the extreme values.

The following tests are documented in appendix D.

**Shield Stiffness—Constrained Configurations (Tests STFCO1 through STFCO4).**—Determines shield stiffness for constrained initial conditions for vertical and face-to-waste horizontal displacements.

**Shield Stiffness—Constrained Configurations (Tests STFCO5 through STFCO8).**—Repeats tests STFCO1 through STFCO4 for vertical and waste-to-face horizontal displacements.

**Shield Stiffness—Unconstrained Configurations (Tests STFUO1 through STFUO4).**—Determines shield stiffness for unconstrained initial conditions for vertical and face-to-waste horizontal displacements.

**Shield Stiffness—Unconstrained Configurations (Tests STFUO5 through STFUO8).**—Repeats tests STFUO1 through STFUO4 for vertical and waste-to-face horizontal displacements.

### Leg Mechanics

The purpose of this test series is to evaluate the capabilities of the legs cylinders to provide specified support resistance and yield capability to the support.

Evaluation of the yield behavior of the leg cylinders is accomplished by continuing to converge the shield after initial yield pressure is reached, while observing leg pressure and resultant support forces. Both legs should yield at close to the same pressures. Upon yielding, leg pressure should remain constant independent of shield displacement or leg closure. Vertical supporting force may decrease slightly during yielding, but any decrease should be very gradual. The most influential parameter for this study is the rate of displacement. It is recommended that displacement rates of 0.1 and 1.0 in/min be tested. Shields to be employed in burst-prone conditions should be tested at impact loading.

Another important consideration involving leg mechanics is to evaluate the effect of leg staging on resulting leg force and subsequent shield setting force. As previously discussed, leg force is considerably reduced when the first stage is fully extended. This test series is designed to evaluate these effects by setting the support with a constant setting pressure at different shield heights and observing resulting vertical and horizontal shield resistance. In addition, effective leg area for the various leg extensions is determined by evaluating applied force as a function of leg pressure.

The final requirement in this test series is to compare effective leg area for setting (leg extension) with effective leg area for shield (leg) convergence. Effective leg area for convergence should be nearly constant for all shield heights (leg extensions), whereas effective leg area for setting operations may vary depending on staging mechanics. Leg area determinations are necessary to properly determine shield resistances from leg pressure measurements.

The following tests are documented in appendix D.

*Leg Mechanics—Yield Pressure (Tests LEGCAPO1 and LEGCAPO2).*—The objectives of these tests are to determine (1) capability of the shield and individual leg cylinders to yield at specified pressure, (2) reduction in support resistance from yield and displacement between yields, and (3) comparison of leg stiffness by evaluation of increase in leg pressure per unit displacement.

*Leg Mechanics—Impact Load Yield (Test LEGYLD01).*—The purpose of this test is to determine the capability of the yield valves to effectively relieve pressure from impact loading without structural damage to the leg casing or extensive seal damage.

*Leg Mechanics—Leg Cylinder Area (Tests LEGAEXO1 and LEGACOO1).*—The purpose of these tests is to determine effective leg area for leg extension from active leg pressurization (test LEGAEXO1) and for convergence from externally applied force or displacement (test LEGACOO1).

*Leg Mechanics—Setting Force (Tests LEGSETO1 through LEGSETO3).*—The objectives of these tests are to evaluate the effect of leg mechanics on shield setting forces and to determine shield setting force as a function of shield height.

### Stability

The purpose of this test series is to evaluate the stability of the shield under various contact configurations and load conditions. Specific boundary conditions proposed for this test series are documented in appendix D. Vertical displacement, face-to-waste horizontal displacement, and waste-to-face horizontal displacement must be evaluated to properly assess shield stability. Horizontal force couples acting on the shield help maintain stability in certain configurations, and worst-case tests where horizontal forces are removed are included in these investigations of shield stability.

The following tests to evaluate shield stability are documented in appendix D:

*Shield Stability—Tip Resultant (Tests STATIPO1 and STATIPO2).*—The purpose of these tests is to evaluate shield stability for canopy contact forward of the leg location.

*Shield Stability—Zero Horizontal Load (Tests STAHORO1 and STAHORO2).*—These tests are designed to evaluate the stability of shield when there are no external horizontal forces acting on the shield. This load condition depends on the caving shield-lemniscate assembly to maintain stability.

*Shield Stability—Base-on-Toe (Tests STABOTO1 and STABOTO2).*—The purpose of these tests is to evaluate the stability of the shield for a base-on-toe contact configuration with waste-to-face horizontal displacement.

*Shield Stability—Base-on-Rear (Tests STABORO1 and STABORO2).*—The purpose of these tests is to evaluate the

stability of the shield for a base-on-rear contact configuration subjected to face-to-waste horizontal displacement.

*Shield Stability—Leg Imbalance (Tests STALEGO1 and STALEGO20).*—These tests are designed to evaluate the stability of the shield for imbalanced leg pressures.

### Load Transfer

The goal of this test series is to determine how much load is being transferred through the leg cylinders and the caving shield-lemniscate assembly for various contact configurations and load conditions. Load transferring mechanisms are dependent primarily on base responses and horizontal constraint for specific shield displacements. As previous discussions of shield mechanics indicated, vertical support resistance is likely to be dominated by the leg reactions, and the participation of the caving shield-lemniscate assembly in horizontal support resistance will depend on the translational freedom in the numerous pin joints of the structure. Hence, an objective of these tests is to determine the participation of the caving shield-lemniscate assembly in the shield's load transfer mechanics. Load transfer to the caving shield-lemniscate assembly is determined from instrumented load sensing pins at the canopy-caving shield joints. Both symmetric and unsymmetric contact configurations are evaluated in these tests.

The following load transfer tests are documented in appendix D:

*Load Transfer—Unconstrained Load Conditions (Tests LTSUFWO1, LTSUFWO2, LTSUWFO1, and LTSUWFO2).*—These tests evaluate the participation of the caving shield-lemniscate assembly and the leg cylinders in the shield load transfer mechanics for unconstrained initial load conditions. Test series LTSUFW evaluates vertical and face-to-waste horizontal displacements and test series LTSUWF evaluates vertical and waste-to-face horizontal displacements.

*Load Transfer—Constrained Load Conditions (Tests LTSCFWO1, LTSCFWO2, LTSCWFO1, and LTSCWFO2).*—These tests evaluate the participation of the caving shield-lemniscate assembly and leg cylinders in the shield load transfer mechanics for constrained initial load conditions. Test series LTSCFW evaluates vertical and face-to-waste horizontal displacements and test series LTSCWF evaluate waste-to-face horizontal displacements.

*Load Transfer—Unsymmetric Contact Configurations.*—The purpose of these tests is to evaluate load transfer mechanics for unsymmetric contact configurations. Test identifications and associated contact configurations are as follows: test LTSLEG, unsymmetric canopy contact at one leg location; test LTSBOT, unsymmetric base-on-toe contact; and test LTSBOR, unsymmetric base-on-rear contact.

## Structural Integrity

The most difficult and time-consuming portion of the program is to assess the structural integrity of the shield. As the previous discussions have indicated, several influential variables must be evaluated to properly assess a shield's structural integrity. These include (1) height, (2) contact configuration, (3) direction and magnitude of applied loading (displacement), and (4) constraint. Horizontal displacement and horizontal constraint are two very influential parameters that are frequently overlooked in support performance testing. Appendix D documents tests that include all of these parameter considerations.

Structural failure is attributed to either fatigue or component loading beyond its design strength. Static load tests should be employed to evaluate the overall integrity of the structure from strength of materials considerations by evaluating various loading mechanisms that produce different stress developments in each of the support components. Cycle tests should be conducted to evaluate fatigue loading using fracture mechanics principles to relate crack growth and stress intensity factors for specific component geometries.

Fatigue occurs from repeated loading at nominal loads below the design strength (i.e., no general inelastic component deformation although there will be plastic deformation on the microscopic scale at the crack tip). Mechanically, fatigue causes crack formation and promotes crack growth as the number of cycles increases. When a crack grows large enough (reaches critical crack length), crack growth becomes unstable and failure (fracture) occurs. Fatigue failures generally develop in or near weldments because of stress concentration formed by material discontinuities or inherent flaws in the welds. Fatigue failures generally develop gradually but fracture, which results in loss of load-carrying capability, can be sudden, being caused by one more application of load.

Structural failures also occur from loading beyond the design strength of the material. The primary failure mechanism is described as general yielding, in which cumulative deformations are sufficiently widespread to threaten

the structural integrity or functional capability of a component. Failure (fracture) by static loading is unlikely, because longwall roof supports are generally constructed from mild steel that exhibits good ductility. This means the steel will deform, usually bend, considerably before reaching ultimate strength and rupturing.

Maximum stresses are likely to occur in areas where the geometry of the structure changes drastically, such as around holes or where plates are welded together, or where there are changes in material properties. These localized high stress concentrations may or may not affect the overall structural integrity of the component. The probability of failure from localized high-stress concentrations depends on the ability of the structure (material) to redistribute the strain energy. If the energy can be redistributed through plastic deformation, then the probability of failure (fracture development) is reduced.

Several tests are documented in appendix D to evaluate the structural integrity of the shield. These tests are divided into two main categories: static load tests and fatigue loading tests. Each of the symmetric and unsymmetric contact configurations identified in the "Critical Load Test Configurations" section (fig. 19) should be evaluated. The static load tests should be conducted for vertical, face-to-waste horizontal, and waste-to-face horizontal displacements applied independently and in combination with one another as indicated in appendix D. It is mandatory that all tests be conducted for horizontally constrained configurations to ensure full participation of the caving shield-lemniscate assembly in the shield's load transfer mechanics.

A minimum of 10,000 cycles per load case should be applied for the fatigue loading tests. All mandatory load cases specified in the critical load test configurations identified in figure 19 should be evaluated. If this number of tests is prohibitive, then full canopy and base contact, symmetric base-on-toe contact, and two-point canopy and base contact tests should be given highest priority. The number of cycles should not be sacrificed to permit testing more configurations.

## CONCLUSIONS

Because actual underground loading conditions are rarely known, knowledge of support mechanics is essential to develop performance testing programs that explore the full capabilities of longwall supports. It is believed that the guidelines provided in this report will advance the state-of-the-art of shield performance testing. Several influential parameters that are often ignored in current testing programs, such as horizontal displacement and horizontal constraint, are included in the scope of these advanced guidelines.

Equally important is the need to standardize testing procedures and test documentation so that a meaningful comparison of support performance can be made. Obviously, there will be circumstances that dictate shield

specific tests, but it seems reasonable that some basic tests can be conducted on all supports to provide a common and historical data base of support performance. It is believed that the proposed four-page test documentation form is a good start in that direction.

If advancements in support design are to be made, performance testing must become more conscious of design considerations. Although the main objective of the test guidelines proposed in this report is not design consideration, the tests will provide considerably more design information than current performance tests, which investigate fewer parameters and are conducted under less controlled environments.

## REFERENCES

1. Barczak, T. M., and C. A. Goode. Considerations in the Design of Longwall Mining Systems. Paper in Proceedings, International Symposium on State-of-the-Art of Ground Control in Longwall Mining and Subsidence (Honolulu, HI, Sept. 4-5, 1982). Soc. Min. Eng. AIME, 1982, pp.
2. Barczak, T. M., and D. E. Schwemmer. Horizontal and Vertical Load Transferring Mechanisms in Longwall Roof Supports. BuMines RI 9188, 1988, 24 pp.
3. Barczak, T. M., and D. E. Schwemmer. Two-Leg Longwall Shield Mechanics. BuMines RI 9220, 1989, 34 pp.
4. \_\_\_\_\_. Stiffness Characteristics of Longwall Shields. BuMines RI 9154, 1988, 14 pp.
5. \_\_\_\_\_. Critical-Load Studies of a Shield Support. BuMines RI 9141, 1987, 15 pp.

## APPENDIX A.—SHIELD KINEMATICS COMPUTER PROGRAM

A computer program<sup>1</sup> is provided that calculates the spatial coordinates for a designated shield height for a two-leg longwall shield with lemniscate linkage. The program evaluates the kinematics of the shield using a parametric approach, which is outlined below and depicted in figures A-1 and A-2.

Note that in the test and figures of this appendix, lengths (distances between coordinate points) are prefixed with either an A (AL), indicating actual measured or known quantities, or an S (SL), indicating shield-height-dependent quantity that is unknown.

Using figure A-2 and beginning with a selected value of SL—

1. Compute  $B_3$  using law of cosines in triangle DGC.
2. Compute SM using the law of cosines in triangle DFC.
3. Compute  $\gamma_2$  and  $\gamma_3$  using the law of cosines in triangle DAC.
4. Compute  $\delta_1$ , then shield height, Y3 coordinate, using trigonometry.
5. Compare Y3 coordinate, plus thickness of canopy and base relative to appropriate pin connection locations, to shield height requested. Adjust SL accordingly until difference between computed and actual shield height is less than a prescribed small value,  $\epsilon$ . Steps 1 through 5 are repeated until it is attained.
6. Once the correct SL is found, basic trigonometry is used to compute the remaining coordinates and angles.

<sup>1</sup>Developed by David E. Schwemmer, structural engineer, Boeing Services International, Pittsburgh, PA.

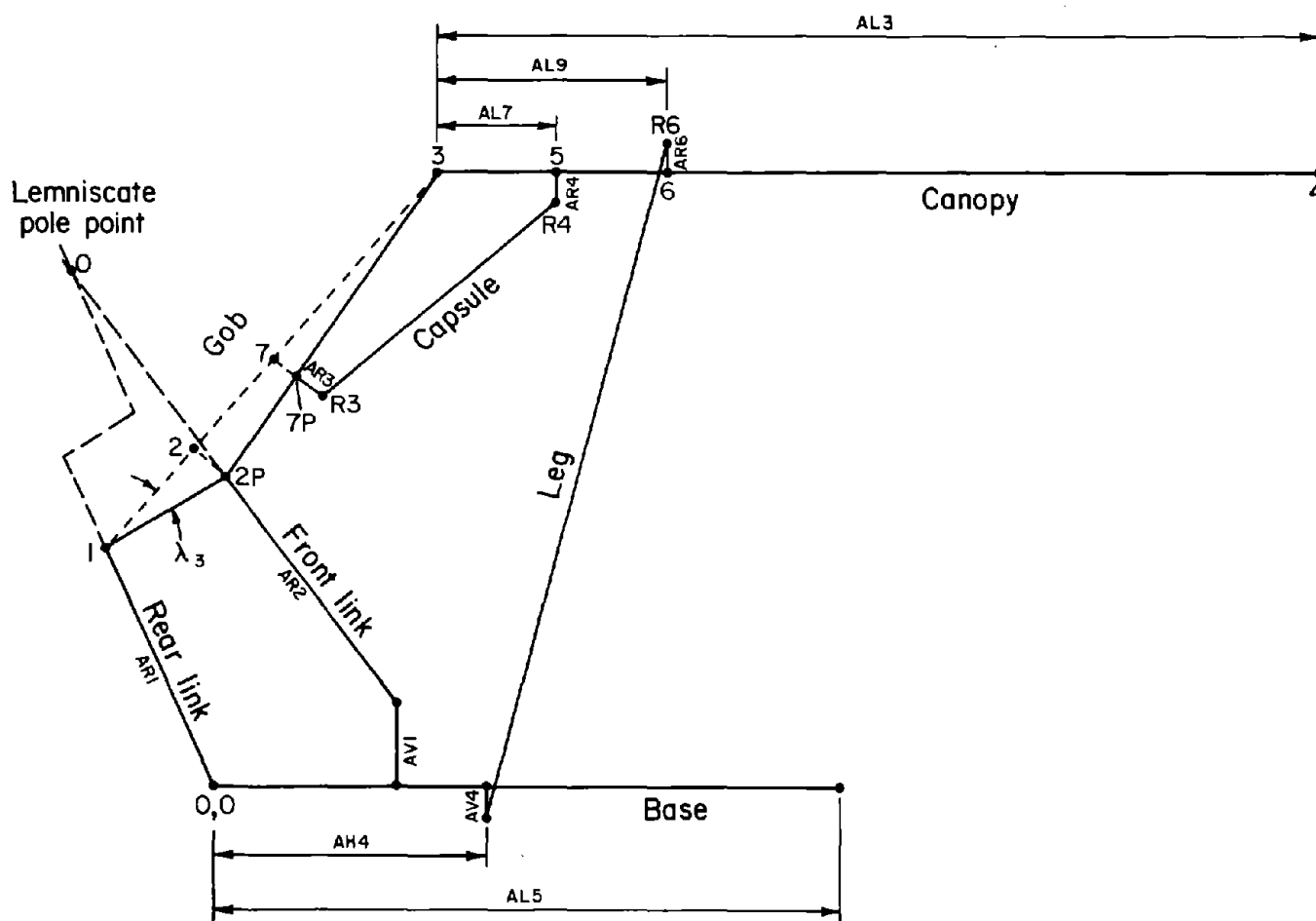


Figure A-1.—Shield components, joint identification, and component dimension nomenclature.

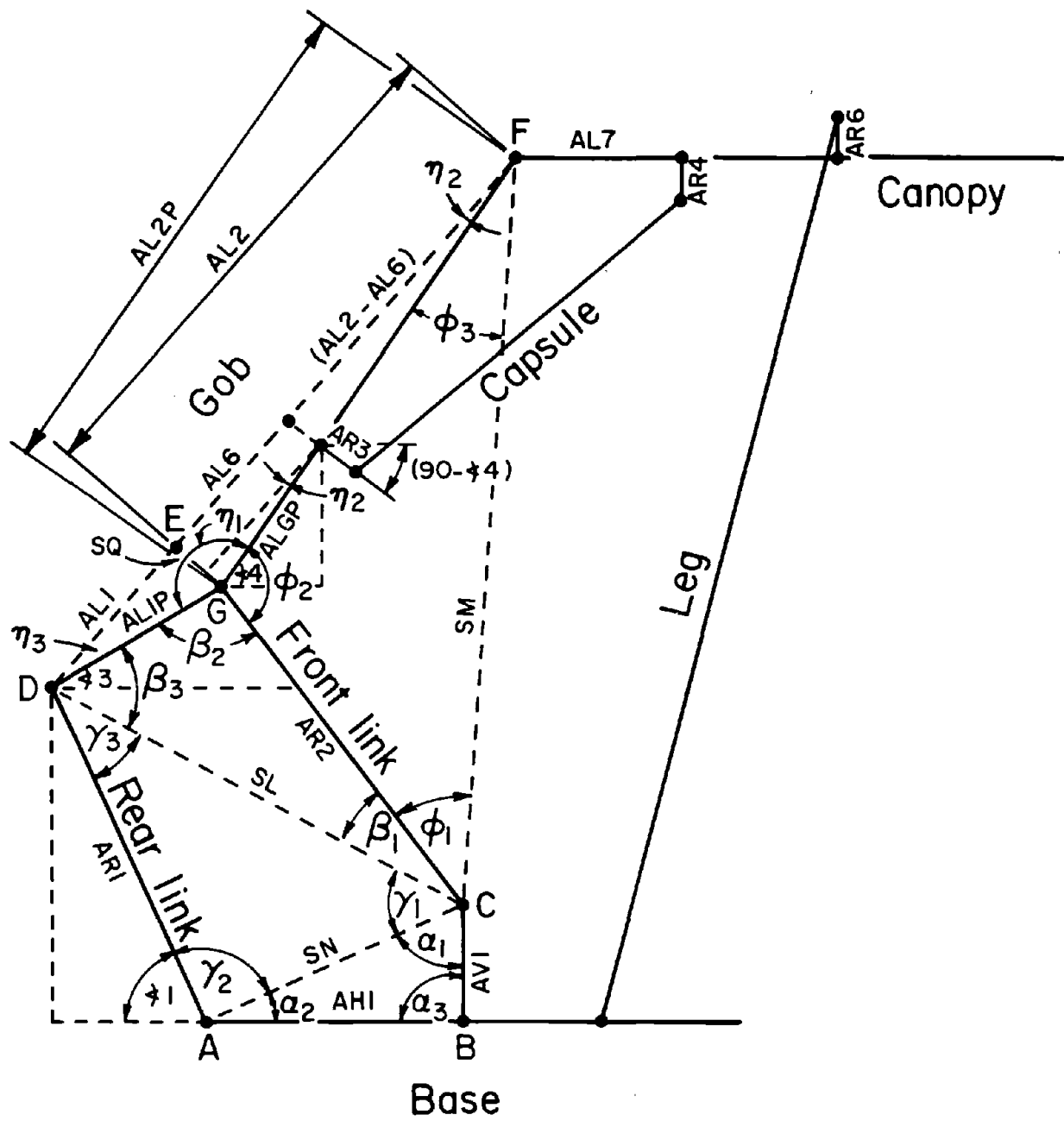


Figure A-2.—Geometric analysis of shield support.

```

C SHIELD GEOMETRY
C
C MODIFIED VERSION OF SHGEOM.FOR TO ACCOMMODATE TERMINAL INPUT
C OF CANOPY AND BASE THICKNESS
C
C FILE: NEWGEOM.FOR
C
C PROGRAM FOR THE KINEMATIC DETERMINATION OF A SHIELD
C
C DUE TO NONLINEARITY OF GOVERNING EQUATIONS, A PARAMETRIC TECHNIQUE TO
C ZERO IN ON THE UNIQUE GEOMETRY FOR A SPECIFIED SHIELD HEIGHT IS
C UTILIZED.
C
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION VF(50),VL(50),XHT(50),HF(50),HL(50)
C
      OPEN(UNIT=2,TYPE='OLD',FILE='[METF.FORTRAN]SHIELD.DAT')
      OPEN(UNIT=3,TYPE='NEW',FILE='[METF.FORTRAN]NEWGEOM.OUT')
C
      READ(2,1100)AR1
      READ(2,1100)AR2
      READ(2,1100)AR3
      READ(2,1100)AR4
      READ(2,1100)AR6
      READ(2,1100)AH4
      READ(2,1100)AV1
      READ(2,1100)AV4
      READ(2,1100)AL1
      READ(2,1100)AL2
      READ(2,1100)AL3
      READ(2,1100)AL4
      READ(2,1100)AL5
      READ(2,1100)AL6
      READ(2,1100)AL7
      READ(2,1100)AL9
      READ(2,1100)ETA3
      CLOSE(2)
      WRITE(*,1010)
      READ(*,1020)ASHT
      WRITE(*,1420)
      READ(*,1020)BAS
      WRITE(*,1430)
      READ(*,1020)CAN
C
C BEGINNING WITH A SELECTED VALUE OF THE PARAMETER SL
C
      PI=3.141592654
      CONV=2.*PI/360.

```

```

C
      SL=30.
      ETA3=ETA3*CONV
      EPSILON=0.01
      DN=PI-.1
      UP=PI+.1
C
C DETERMINE THE ANGLES AND LENGTH SM TO COMPUTE THE OVERALL HEIGHT
C OF SHIELD (SHTO) FOR COMPARISON WITH THE REQUIRED HEIGHT.
C
      150          DO 100 I=1,150
                  IF(I.EQ.1)SUM=SUM+1.
C
                  IF(I.EQ.150)WRITE(*,1160)
                  IF(I.EQ.150)STOP
C
                  AL1P=AL1/COS(ETA3)
                  TANG=((AR2*AR2-SL*SL-AL1P*AL1P)/(-2.*SL*AL1P))
C
                  IF(TANG.GE.1.0.OR.TANG.LE.-1.0)WRITE(*,1410)
                  IF(TANG.GE.1.0.OR.TANG.LE.-1.0)STOP
C
                  BETA3=DACOS((AR2*AR2-SL*SL-AL1P*AL1P)/(-2.*SL*AL1P))
                  SM=SQRT((AL1+AL2)*(AL1+AL2)+SL*SL-2.*(AL1+AL2)*SL*
                  1COS(ETA3+BETA3))
C
                  AN=SQRT(AL4*AL4+AV1*AV1)
                  GAMMA2=DACOS((AR1*AR1+AN*AN-SL*SL)/(2.*AR1*AN))
                  GAMMA3=DACOS((AR1*AR1-AN*AN+SL*SL)/(2.*SL*AR1))
                  ALPHA2=DATAN((AV1/AL4))
                  ANGLE1=PI-ALPHA2-GAMMA2
                  IF(ANGLE1.GT.(PI/2.))GO TO 510
                  ANGLE3=GAMMA3+BETA3-ANGLE1
C
                  Y3=AR1*SIN(ANGLE1)+(AL1+AL2)*SIN(ANGLE3+ETA3)
C
C CANOPY AND BASE THICKNESS ASSUMES PIN LOCATIONS AT BASE
C AND CANOPY CROSS-SECTIONAL MIDPOINTS
C
                  SHTO=Y3+BAS/2.+CAN/2.
C
                  TEST=SHTO-ASHT
                  IF(ABS(TEST).LE.EPSILON)GO TO 500
                  IF(TEST.LE.0.)SL=SL+TEST/10.
                  IF(TEST.GT.0.)SL=SL-TEST/10.
      100          CONTINUE
      510          SL=SL+SUM
                  GO TO 150
C
C THE PARAMETRIC EVALUATION IS COMPLETE AND THE SHIELD COORDINATES
C CAN NOW BE COMPUTED

```

```

C
500      ETA2=DATAN(AL1*TAN(ETA3)/AL2)
          ETA1=PI-ETA3+ETA2
C
          AL2P=SQRT(AL2*AL2+(AL1*TAN(ETA3))*(AL1*TAN(ETA3)))
          BETA1=DACOS((AL1P*AL1P-SL*SL-AR2*AR2)/(-2.*SL*AR2))
          BETA2=DACOS((SL*SL-AL1P*AL1P-AR2*AR2)/(-2.*AL1P*AR2))
          TRI=BETA1+BETA2+BETA3
          IF(TRI.GE.DN.AND.TRI.LE.UP)GO TO 110
          WRITE(*,1400)1
          STOP
C
110      PHI1=DACOS((AL2P*AL2P-SM*SM-AR2*AR2)/(-2.*SM*AR2))
          PHI2=DACOS((SM*SM-AR2*AR2-AL2P*AL2P)/(-2.*AR2*AL2P))
          PHI3=DACOS((AR2*AR2-SM*SM-AL2P*AL2P)/(-2.*SM*AL2P))
          TRI=PHI1+PHI2+PHI3
          IF(TRI.GE.DN.AND.TRI.LE.UP)GO TO 120
          WRITE(*,1400)2
          STOP
C
120      X1=-AR1*COS(ANGLE1)
          Y1=AR1*SIN(ANGLE1)
C
          X2P=X1+AL1*COS(ANGLE3+ETA3)
          Y2P=Y1+AL1*SIN(ANGLE3+ETA3)
C
          X2=X1+AL1P*COS(ANGLE3)
          Y2=Y1+AL1P*SIN(ANGLE3)
C
          X7P=X1+(AL1+AL6)*COS(ANGLE3+ETA3)
          Y7P=Y1+(AL1+AL6)*SIN(ANGLE3+ETA3)
C
          X3=X1+(AL1+AL2)*COS(ANGLE3+ETA3)
          Y3=Y1+(AL1+AL2)*SIN(ANGLE3+ETA3)
C
          ANGLE4=DATAN((Y3-Y2)/(X3-X2))
          X7=X2+(AL6/COS(ETA2))*COS(ANGLE4)
          Y7=Y2+(AL6/COS(ETA2))*SIN(ANGLE4)
C
          XR3=X7+AR3*COS((PI/2.)-ANGLE4)
          YR3=Y7-AR3*SIN((PI/2.)-ANGLE4)
C
          X5=X3+AL7
          Y5=Y3
C
          XR4=X5
          YR4=Y5-AR4
C

```

```

X6=X3+AL9
Y6=Y3
C
XR6=X6
YR6=Y6-AR6
C
X4=X3+AL3
Y4=Y3
C
AM1=Y1/X1
AM2=(Y2-AV1)/(X2-AL4)
AB2=Y2-(AM2*X2)
X0=AB2/(AM1-AM2)
Y0=AM1*X0
C
ALANG=DATAN((YR6-AV4)/(XR6-AH4))
AFANG=PHI2-ANGLE4
C
C PRINT OUTPUT TO THE SCREEN AND DATA FILE
C
WRITE(*,1210)SHTO
WRITE(*,1220)X0,Y0
WRITE(*,1230)X1,Y1
WRITE(*,1240)X2,Y2
WRITE(*,1250)X3,Y3
WRITE(*,1260)X4,Y4
WRITE(*,1270)X5,Y5
WRITE(*,1280)X6,Y6
WRITE(*,1290)X7,Y7
WRITE(*,1300)XR3,YR3
WRITE(*,1310)XR4,YR4
WRITE(*,1320)XR6,YR6
WRITE(*,1330)X2P,Y2P
WRITE(*,1340)X7P,Y7P
WRITE(*,1350)ALANG/CONV,AFANG/CONV
C
IOUT=3
WRITE(IOUT,1210)SHTO
WRITE(IOUT,1440)BAS
WRITE(IOUT,1450)CAN
WRITE(IOUT,1220)X0,Y0
WRITE(IOUT,1230)X1,Y1
WRITE(IOUT,1240)X2,Y2
WRITE(IOUT,1250)X3,Y3
WRITE(IOUT,1260)X4,Y4
WRITE(IOUT,1270)X5,Y5
WRITE(IOUT,1280)X6,Y6
WRITE(IOUT,1290)X7,Y7
WRITE(IOUT,1300)XR3,YR3

```

```

WRITE(IOUT,1310)XR4,YR4
WRITE(IOUT,1320)XR6,YR6
WRITE(IOUT,1330)X2P,Y2P
WRITE(IOUT,1340)X7P,Y7P
WRITE(IOUT,1350)ALANG/CONV,AFANG/CONV

```

C

C FORMAT STATEMENTS

C

```

1010      FORMAT(5X,'SPECIFY OVERALL SHIELD HEIGHT IN inches : ', $)
1020      FORMAT(F6.2)
1100      FORMAT(1X,F12.5)
1160      FORMAT(10X,'SHIELD HT OF: ',E10.4,' NOT COMPUTED')
1210      FORMAT(10X,'OVERALL SHIELD HEIGHT IS ',E10.4/)
1220      FORMAT(5X,'X0 AND Y0 COORDINATES : ',E10.4,5X,E10.4)
1230      FORMAT(5X,'X1 AND Y1 COORDINATES : ',E10.4,5X,E10.4)
1240      FORMAT(5X,'X2 AND Y2 COORDINATES : ',E10.4,5X,E10.4)
1250      FORMAT(5X,'X3 AND Y3 COORDINATES : ',E10.4,5X,E10.4)
1260      FORMAT(5X,'X4 AND Y4 COORDINATES : ',E10.4,5X,E10.4)
1270      FORMAT(5X,'X5 AND Y5 COORDINATES : ',E10.4,5X,E10.4)
1280      FORMAT(5X,'X6 AND Y6 COORDINATES : ',E10.4,5X,E10.4)
1290      FORMAT(5X,'X7 AND Y7 COORDINATES : ',E10.4,5X,E10.4)
1300      FORMAT(5X,'XR3 AND YR3 COORDINATES : ',E10.4,5X,E10.4)
1310      FORMAT(5X,'XR4 AND YR4 COORDINATES : ',E10.4,5X,E10.4)
1320      FORMAT(5X,'XR6 AND YR6 COORDINATES : ',E10.4,5X,E10.4)
1330      FORMAT(5X,'X2P AND Y2P COORDINATES : ',E10.4,5X,E10.4)
1340      FORMAT(5X,'X7P AND Y7P COORDINATES : ',E10.4,5X,E10.4)
1350      FORMAT(5X,'LEG AND F. LINK ANGLES : ',E10.4,5X,E10.4)
1400      FORMAT(5X,'ERROR ???',I2/)
1410      FORMAT(5X,'HEIGHT IS OUT OF NORMAL OPERATING RANGE'//)
1420      FORMAT(5X,'SPECIFY SHIELD BASE THICKNESS IN inches : ', $)
1430      FORMAT(5X,'SPECIFY SHIELD CANOPY THICKNESS IN inches : ', $)
1440      FORMAT(10X,'BASE THICKNESS IS ',E10.4/)
1450      FORMAT(10X,'CANOPY THICKNESS IS ',E10.4/)
      END

```

## APPENDIX B.-SHIELD COMPONENT RESPONSES AND LOADING MECHANISMS

Utilizing mechanics of materials concepts and known kinematic relationships for two-leg shield supports, shield component responses for various canopy and base contact configurations and displacement loading conditions are depicted in figures B-1 through B-15.

Each figure shows three diagrams that depict component responses for vertical displacement, face-to-waste

horizontal displacement, and waste-to-face horizontal displacement for a unique contact configuration. These displacement behaviors can be superimposed to describe shield behavior to any load (displacement) combination.

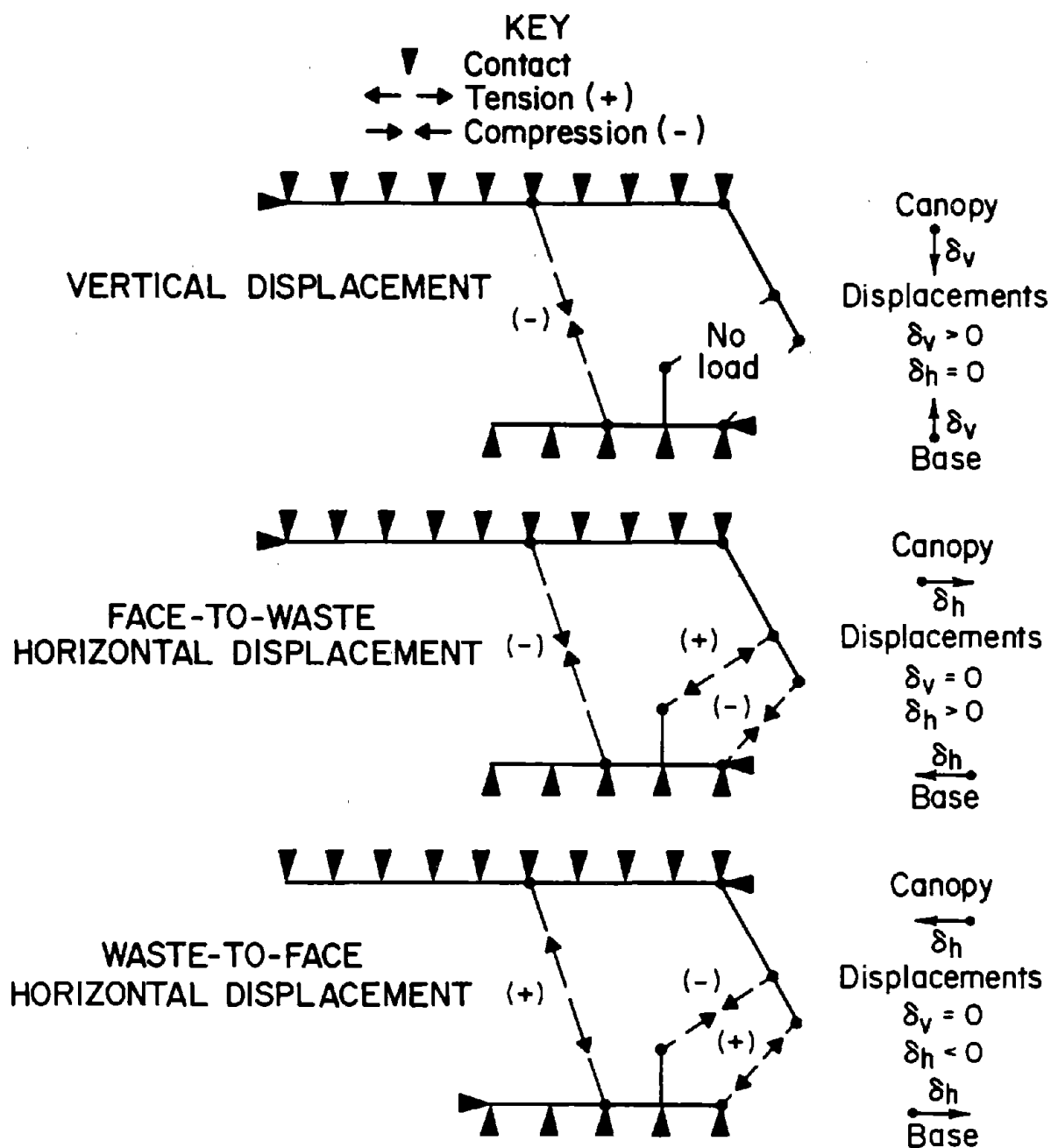


Figure B-1.-Full canopy and base contact.

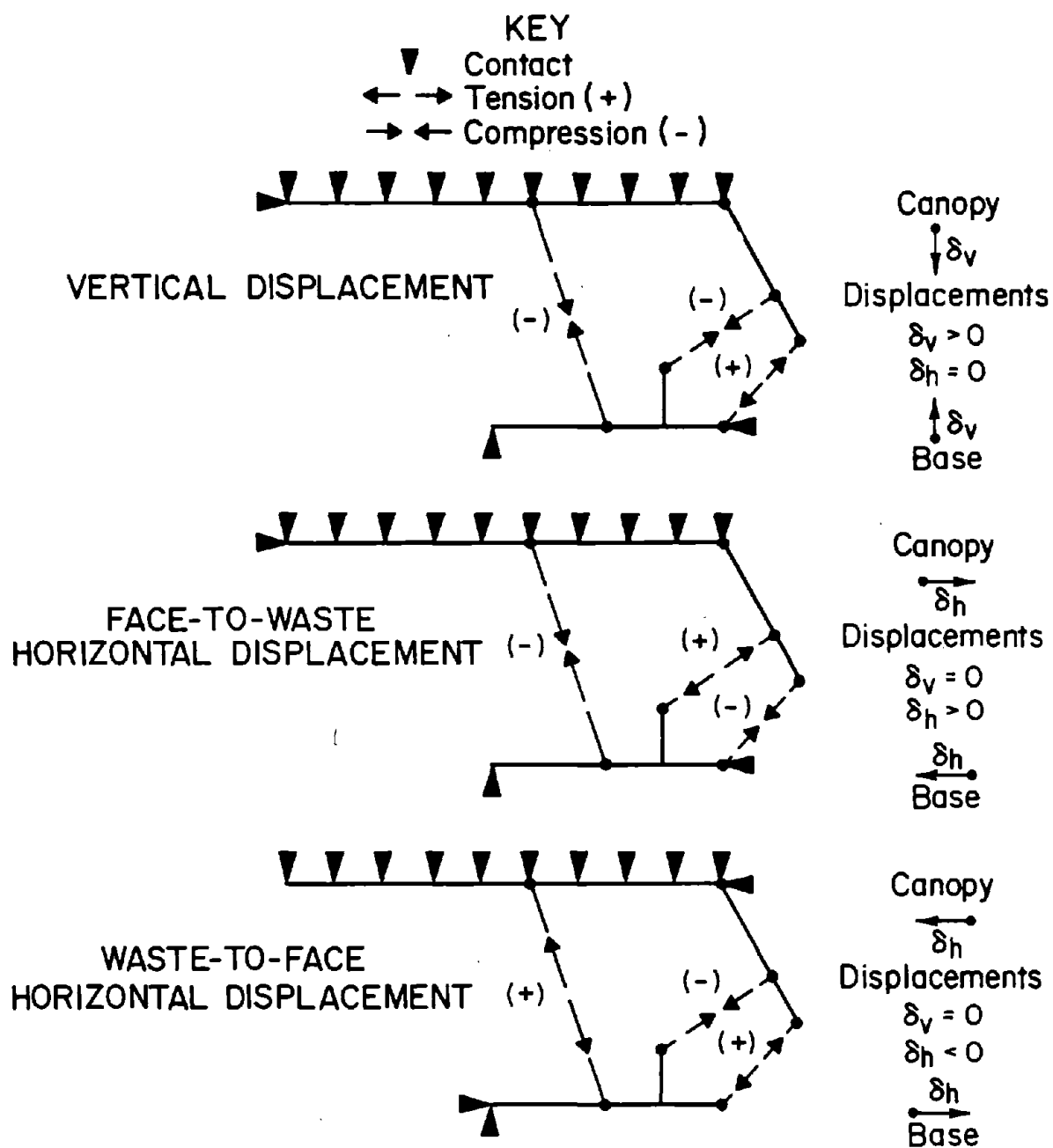


Figure B-2.-Base-on-toe contact.

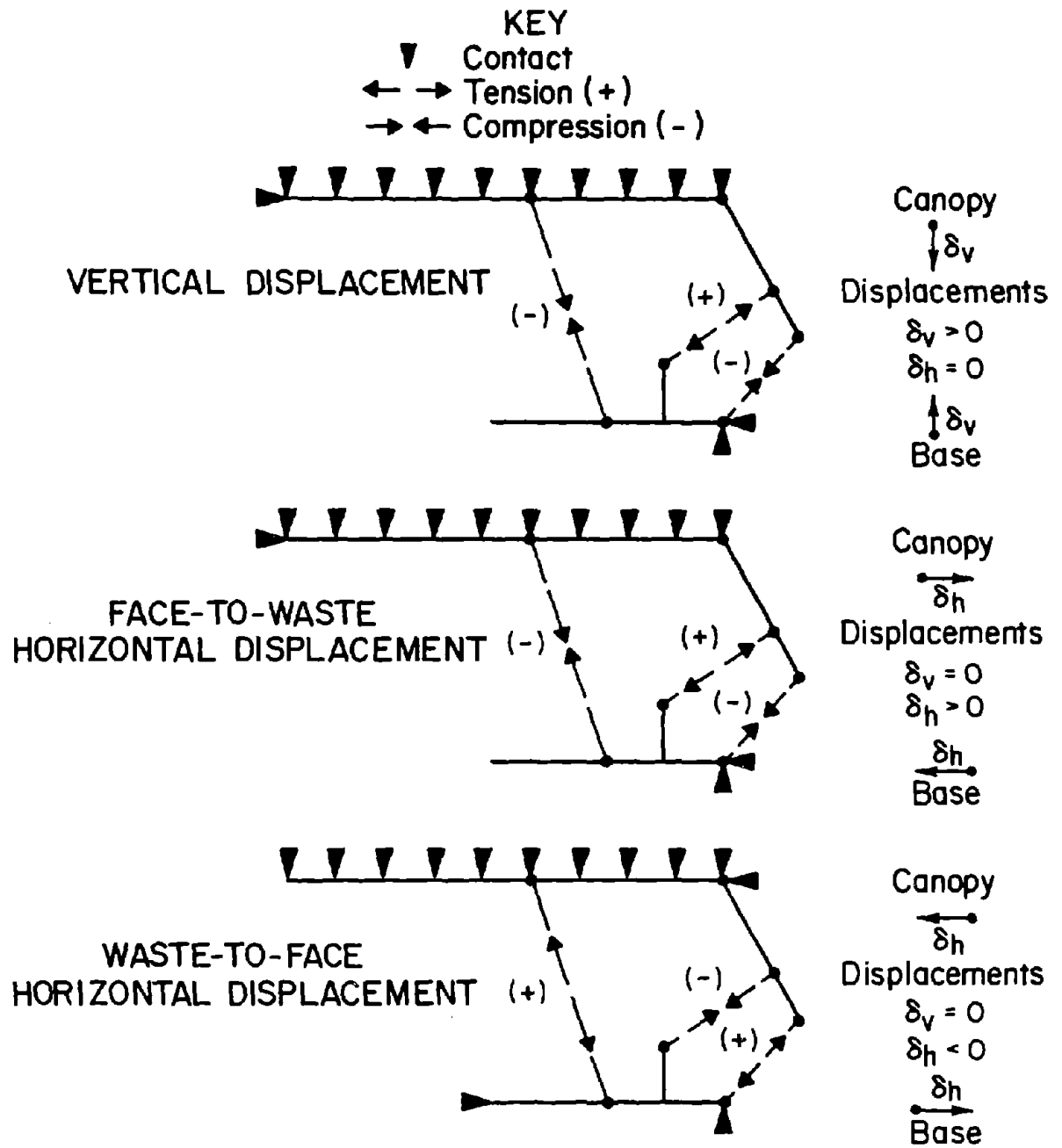


Figure B-3.-Base-on-rear contact.

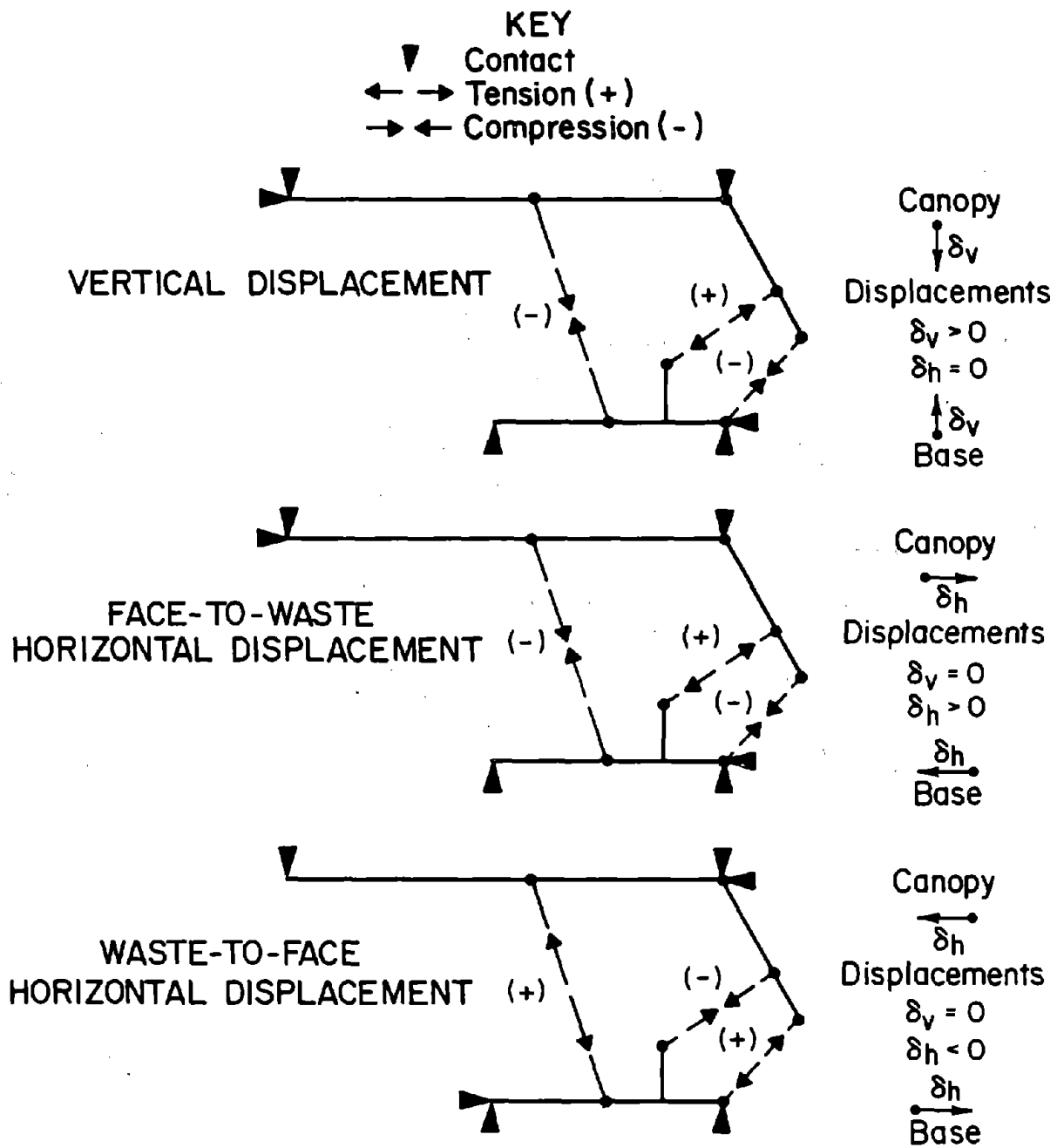


Figure B-4.-Two-point canopy and base contact.

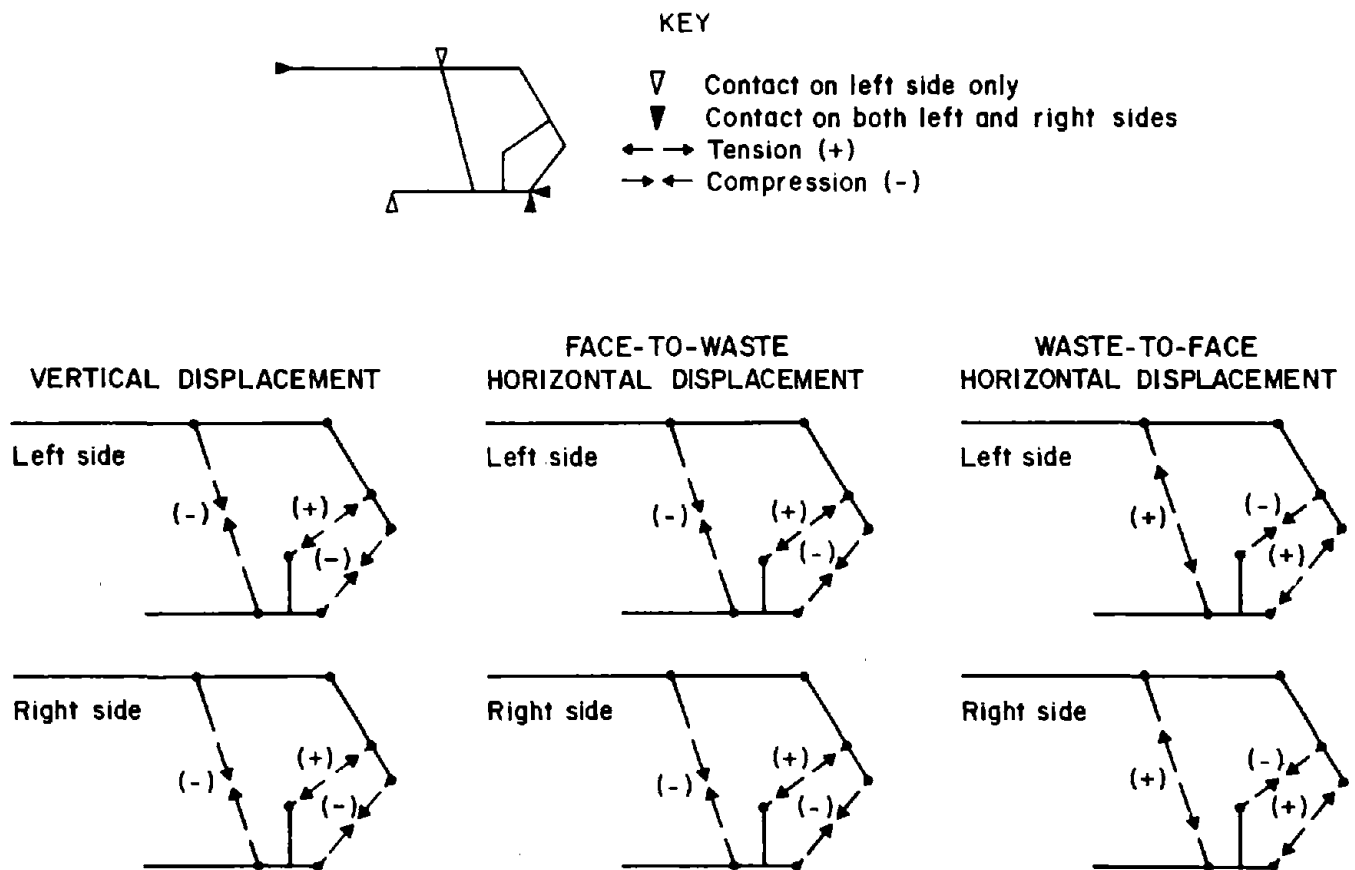
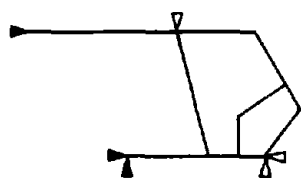


Figure B-5.—Unsymmetric base-on-rear contact and unsymmetric canopy contact at leg location.

## KEY



- ▽ Contact on left side only
- ▼ Contact on both left and right sides
- ←→ Tension (+)
- ← Compression (-)

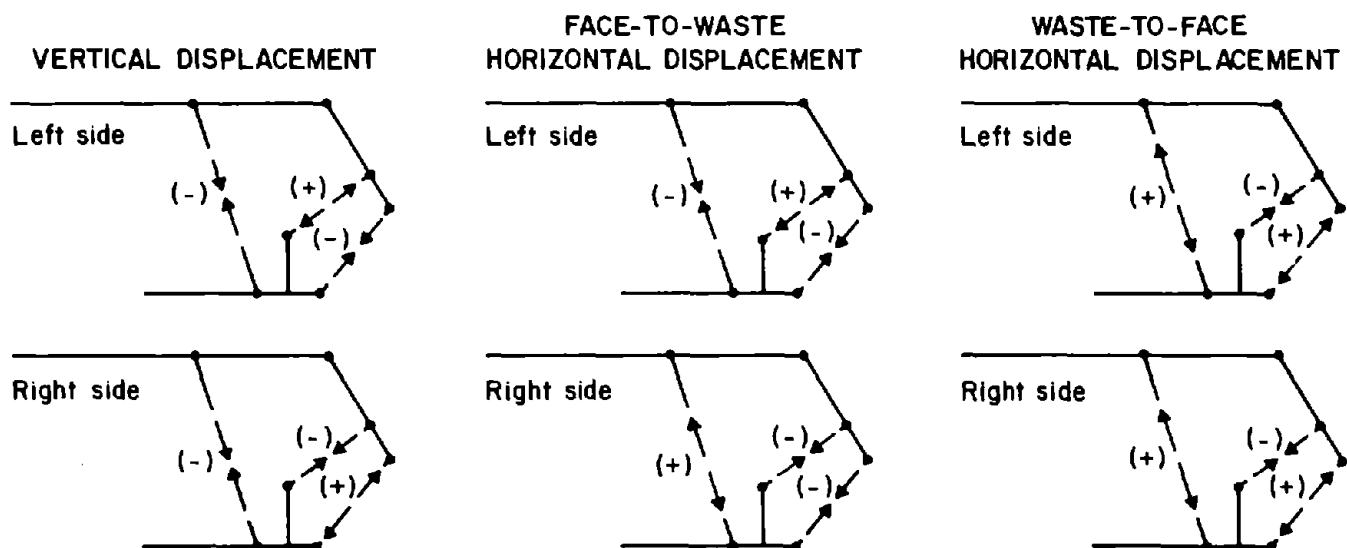


Figure B-6.—Unsymmetric base-on-toe contact and unsymmetric canopy contact at leg location.

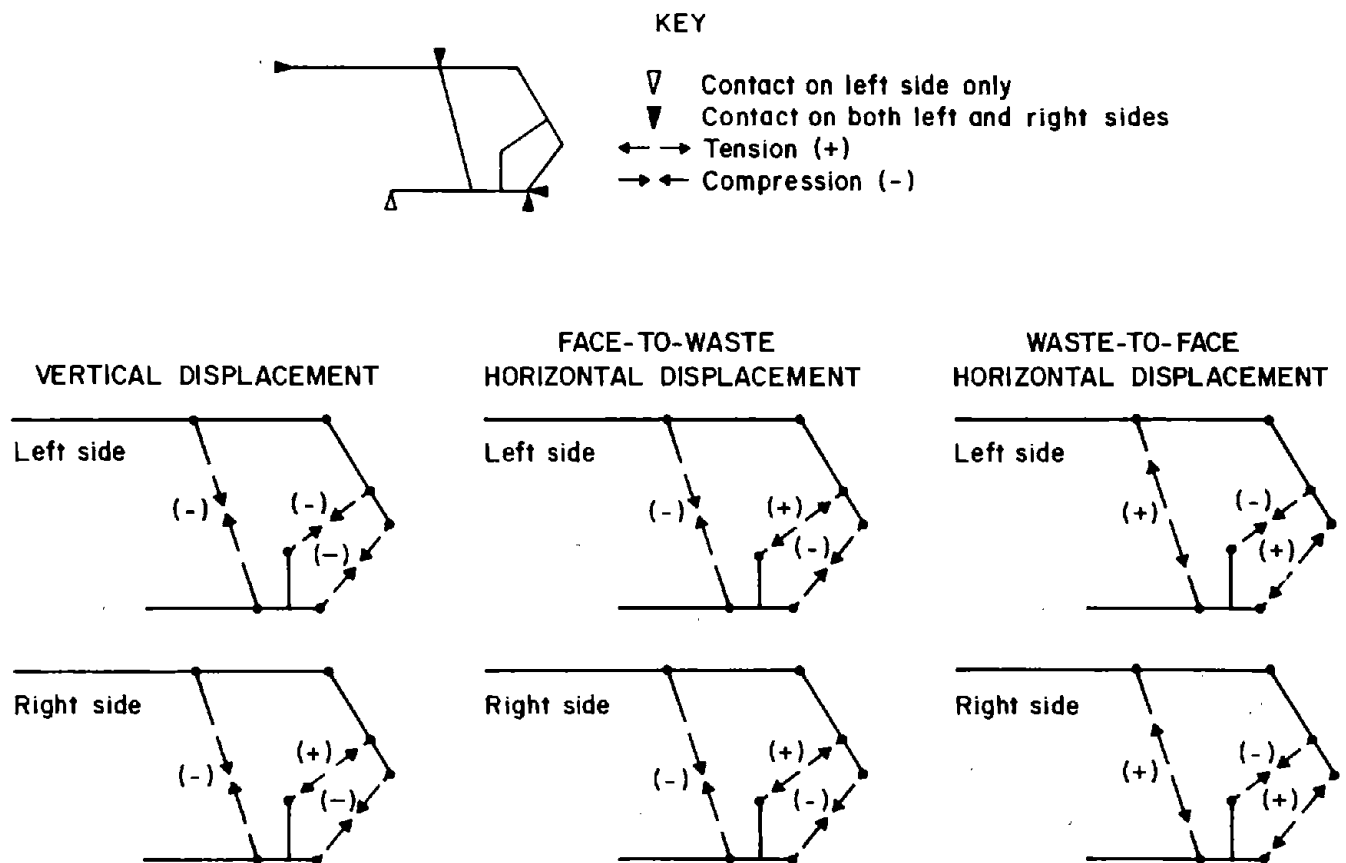
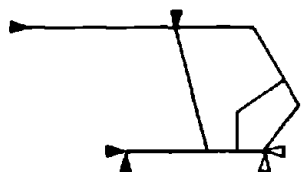


Figure B-7.—Unsymmetric base-on-rear contact and symmetric canopy contact at leg location.

## KEY



- ▽ Contact on left side only
- ▼ Contact on both left and right sides
- ←→ Tension (+)
- ← Compression (-)

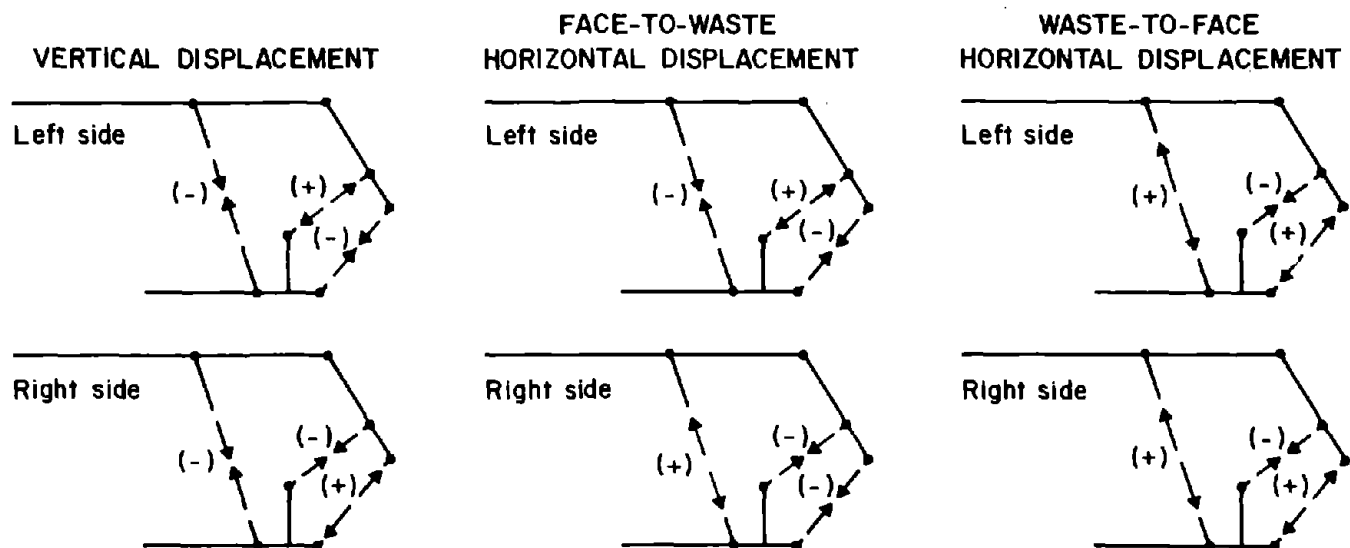


Figure B-8.—Unsymmetric base-on-toe contact and symmetric canopy contact at leg location.

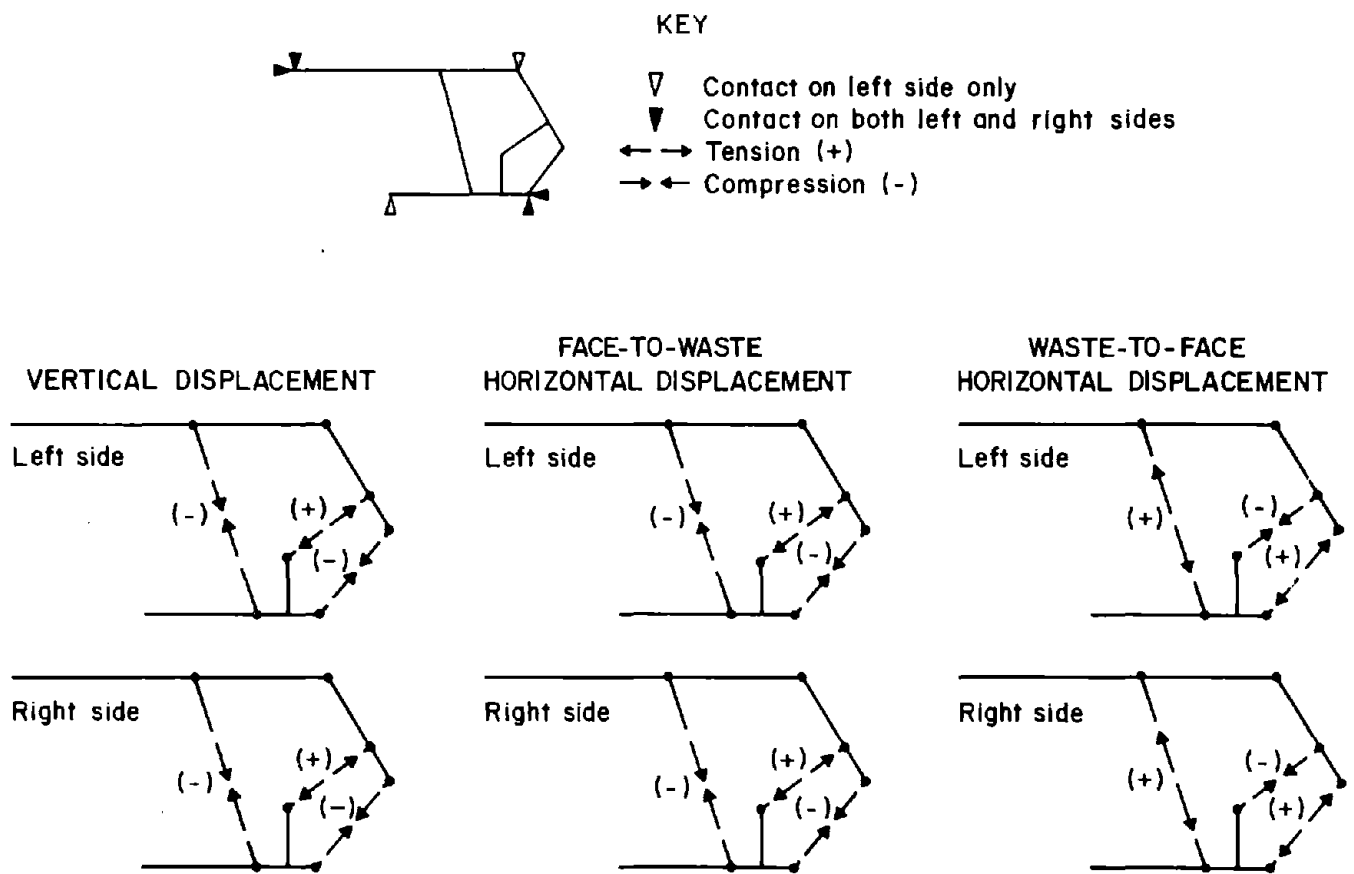


Figure B-9.—Unsymmetric base-on-rear contact and unsymmetric three-point canopy contact.

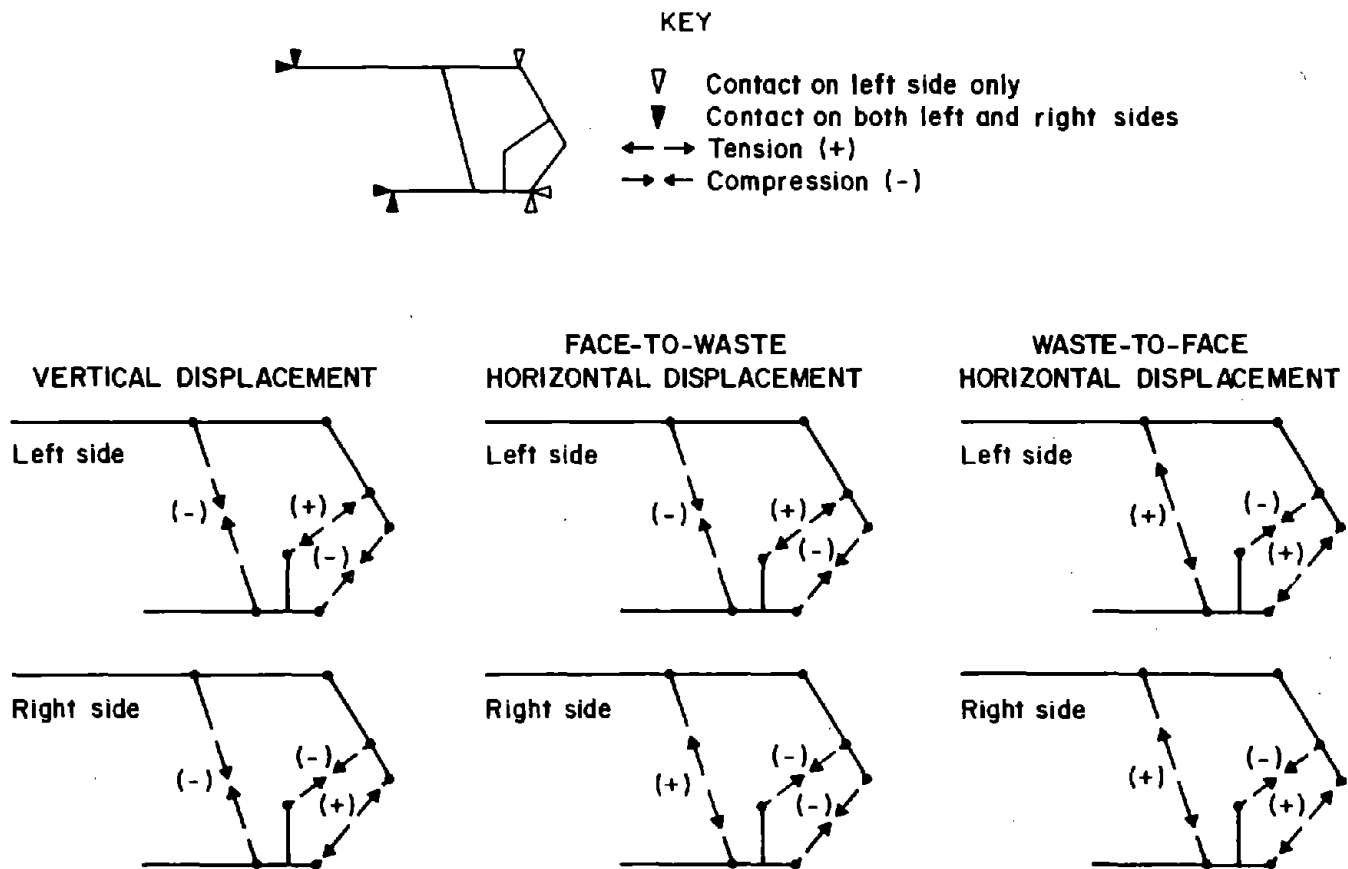


Figure B-10.—Unsymmetric base-on-toe contact and unsymmetric three-point canopy contact.

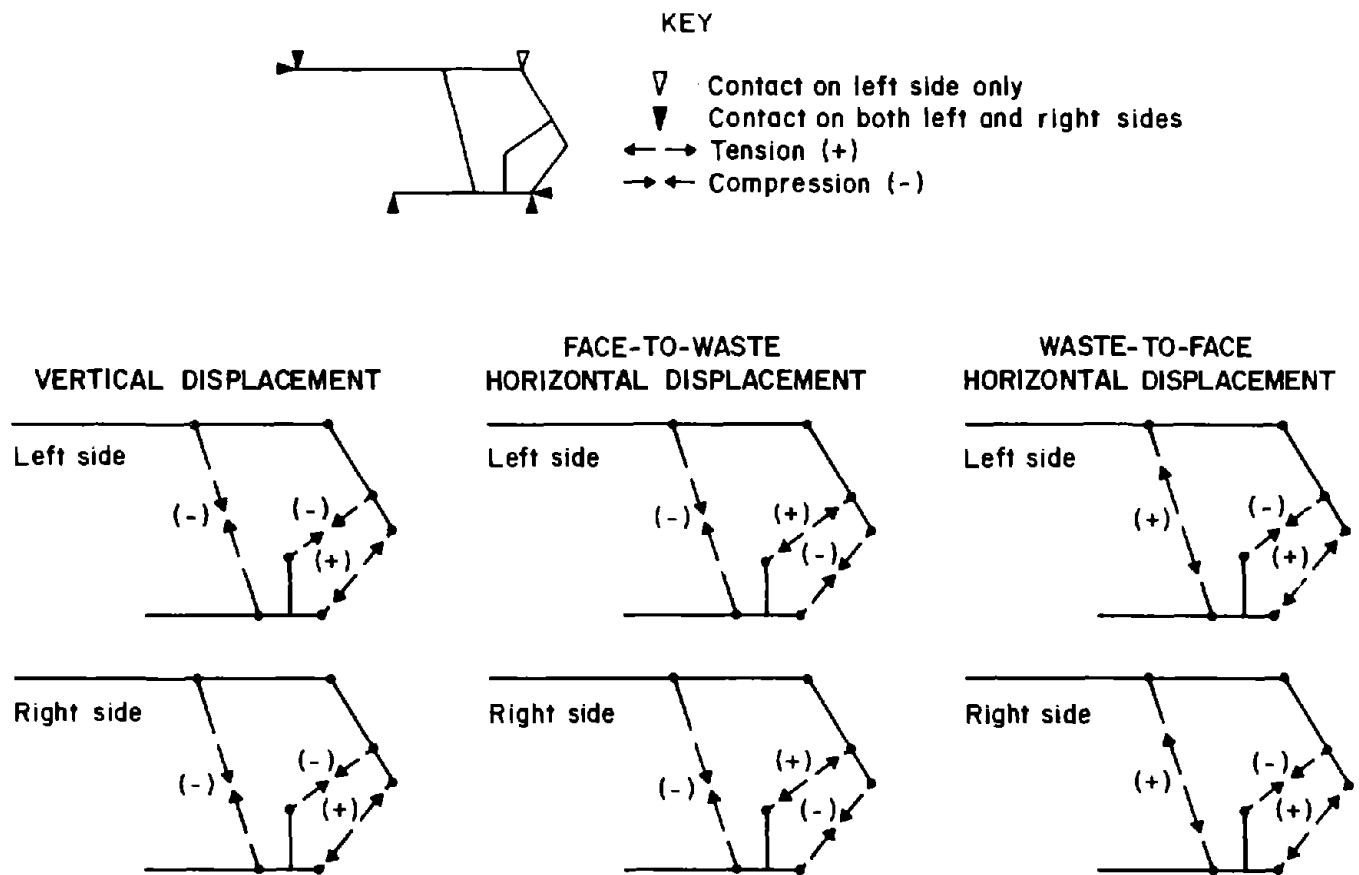


Figure B-11.—Symmetric two-point base contact and unsymmetric three-point canopy contact.

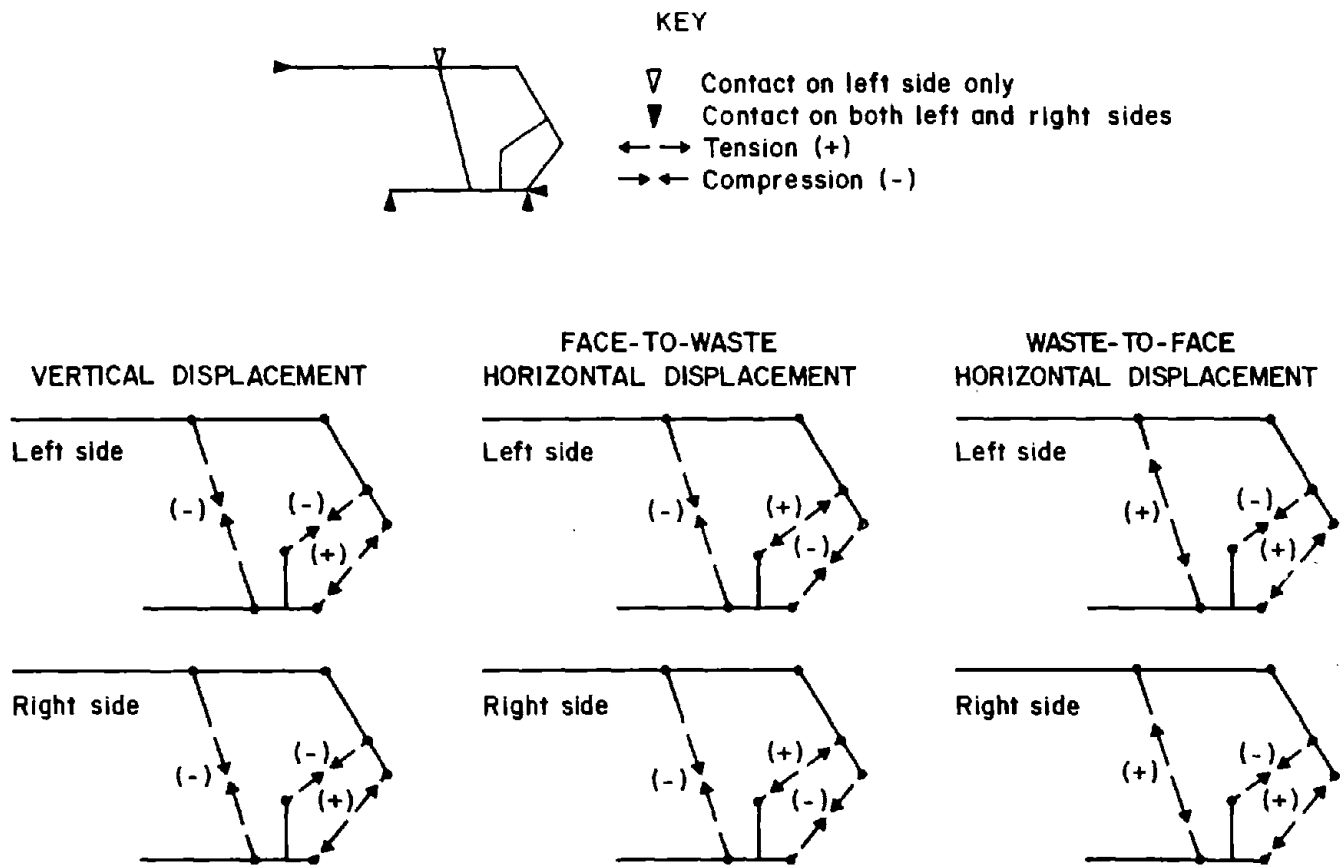


Figure B-12.-Symmetric two-point base contact and unsymmetric canopy contact at leg location.

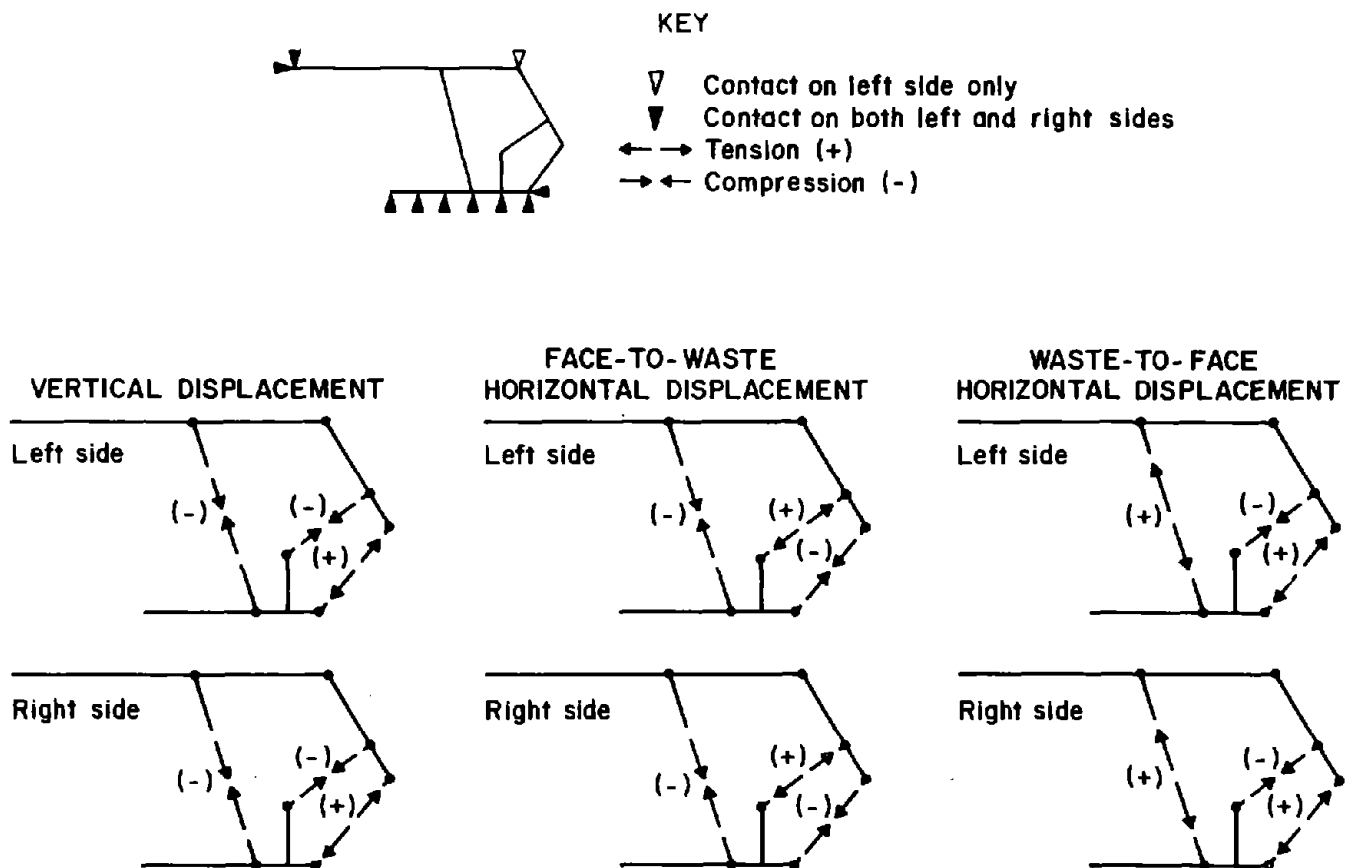
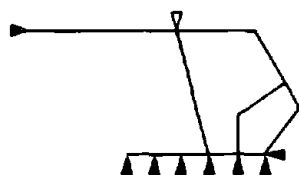


Figure B-13.—Full base contact and unsymmetric three-point canopy contact.

## KEY



- ▽ Contact on left side only
- ▼ Contact on both left and right sides
- ←→ Tension (+)
- ← Compression (-)

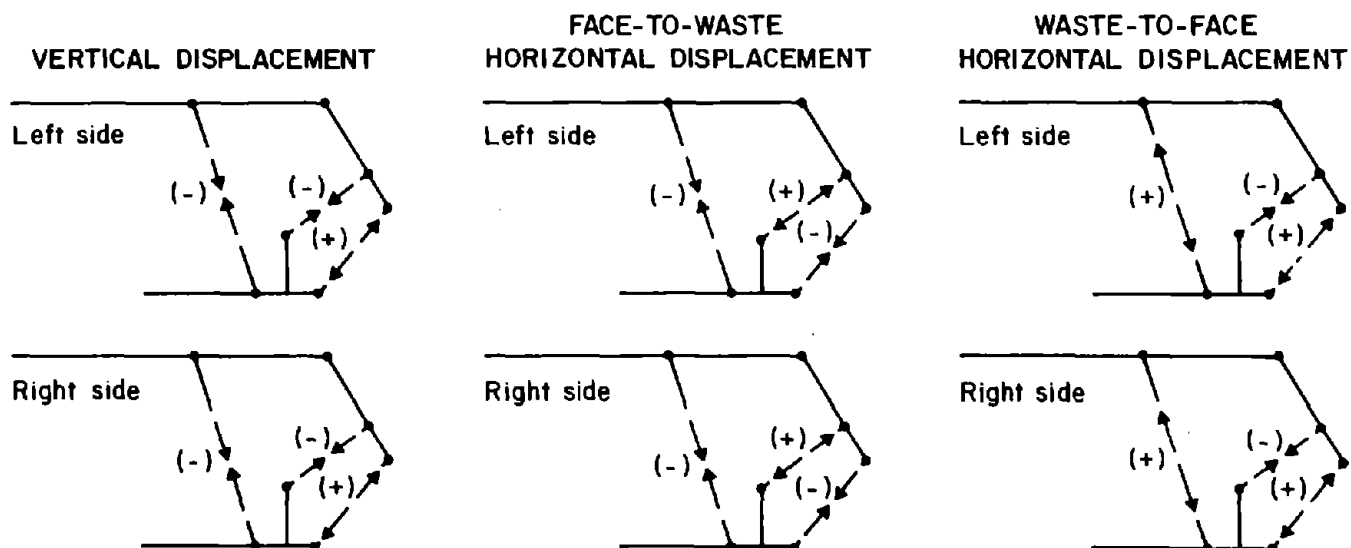


Figure B-14.—Full base contact and unsymmetric canopy contact at leg location.

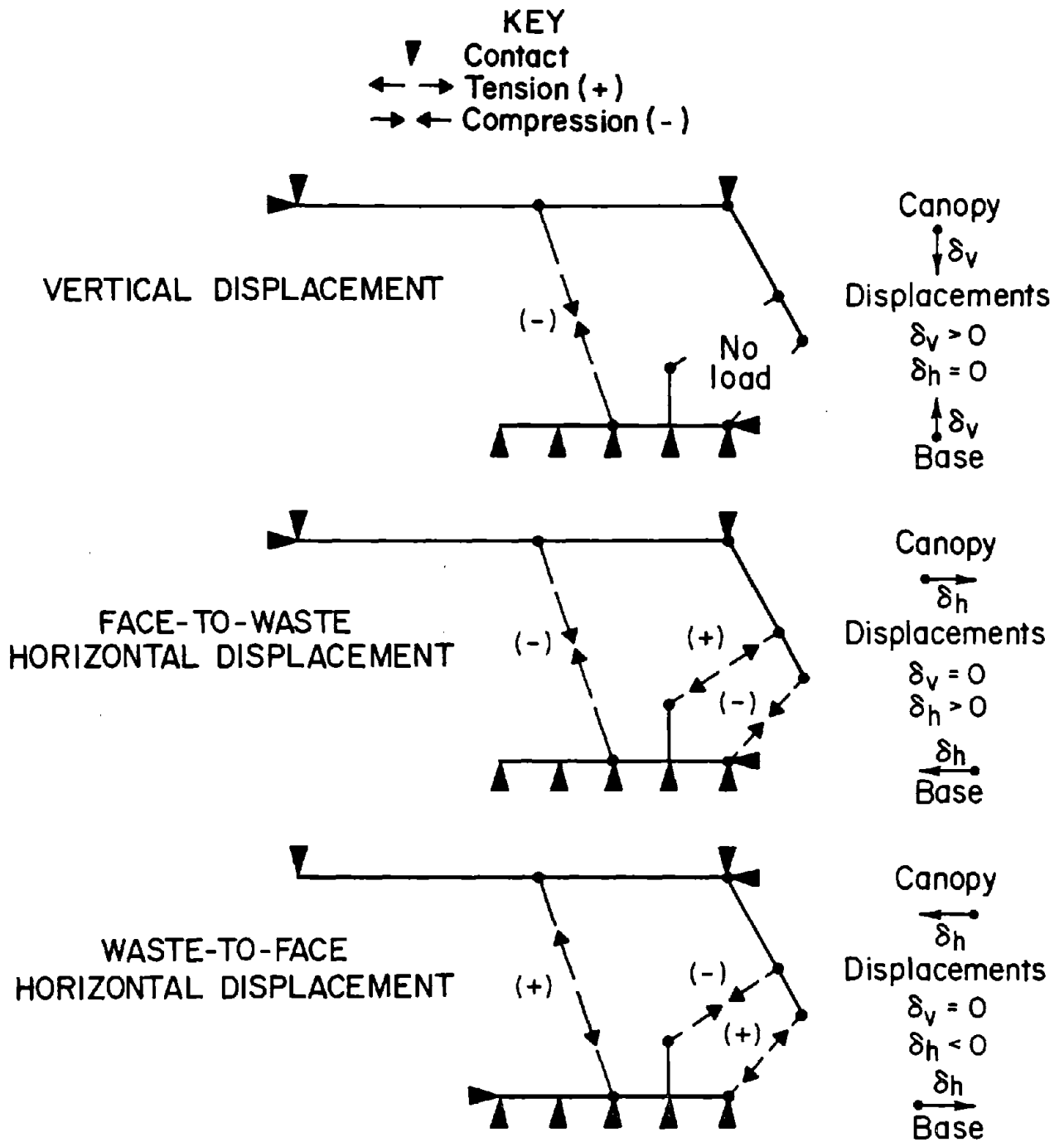


Figure B-15.—Symmetric full base contact and symmetric two-point canopy contact.

## APPENDIX C.-SUPPORT RESISTANCE CALCULATIONS

Static rigid-body equations of equilibrium are developed for a two-leg shield acted upon by both vertical and horizontal forces. Figures C-1 through C-3 illustrate free-body diagrams used in these analyses. Resultant vertical force and its location on the canopy and resultant horizontal force are determined from measurement of leg and front link forces.

The following are the moment of equilibrium equations given on figures C-1 through C-3:

$$F_v(x) - L(\ell) = 0, \quad (C-1)$$

$$F_v(x + b) - L(e) - F_H(h) = 0, \text{ and} \quad (C-2)$$

$$F_v(x + a) - L(f) - F_H(z) - FL(c) = 0. \quad (C-3)$$

Solutions:

1. Solve equation (C-1) for  $F_v(x)$ :

$$F_v(x) = L(\ell). \quad (C-4)$$

2. Solve equation (C-2) for  $F_H$ :

$$F_H = \frac{F_v(x = b) - L(e)}{h}. \quad (C-5)$$

3. Substitute equations C-4 and C-5 into C-3 and solve for  $F_v$ :

$$F_v = L(V_L) - FL(V_{FL}), \quad (C-6)$$

$$\text{where } V_L = \frac{(\ell)(h) - (f)(h) - (\ell)(z) - c(z)}{(b)(z) - (a)(h)}$$

$$\text{and } V_{FL} = \frac{(c)(h)}{(b)(z) - (a)(h)}.$$

4. Substitute equation C-6 into C-2 and solve for  $F_H$ :

$$F_H = L(H_L) - FL(H_{FL}), \quad (C-7)$$

$$\text{where } H_L = \frac{\ell - e + b}{h} \cdot \frac{(\ell)(h) - (f)(h) - (\ell)(z) - (e)(z)}{(b)(z) - (a)(h)}$$

$$\text{and } H_{FL} = \frac{(b)(c)}{(b)(z) - (a)(h)}.$$

5. Solve equation C-5 for  $x$  substituting equation C-6 for  $F_v$ :

$$x = \frac{L(\ell)}{F_v}.$$

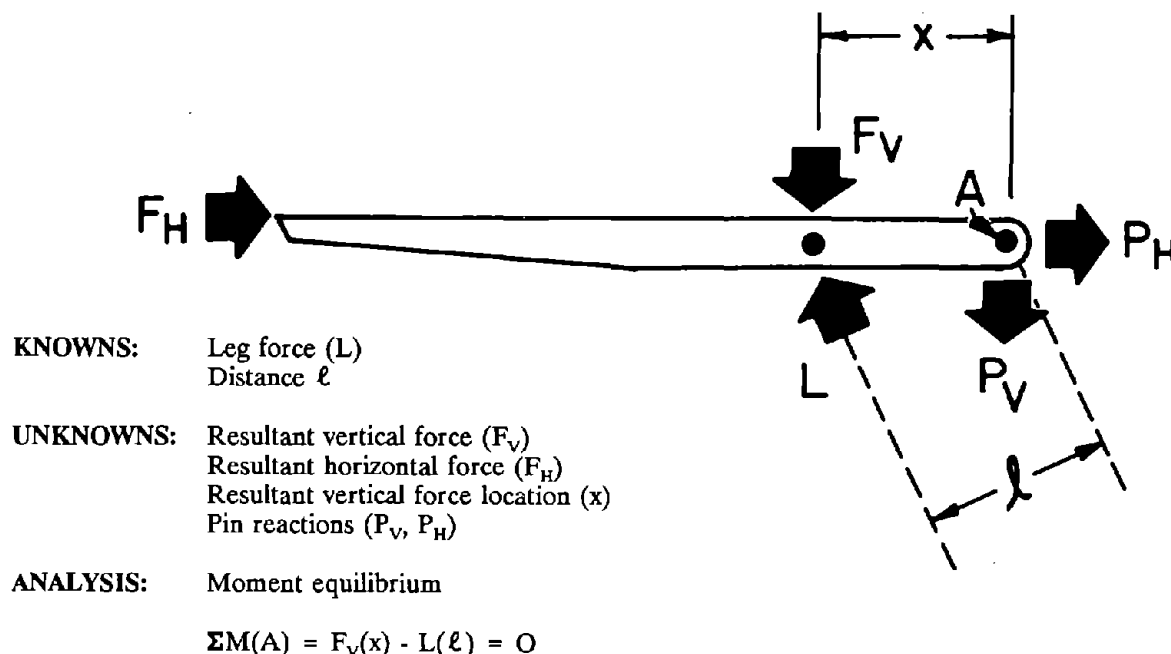


Figure C-1.-Moment equilibrium of canopy.

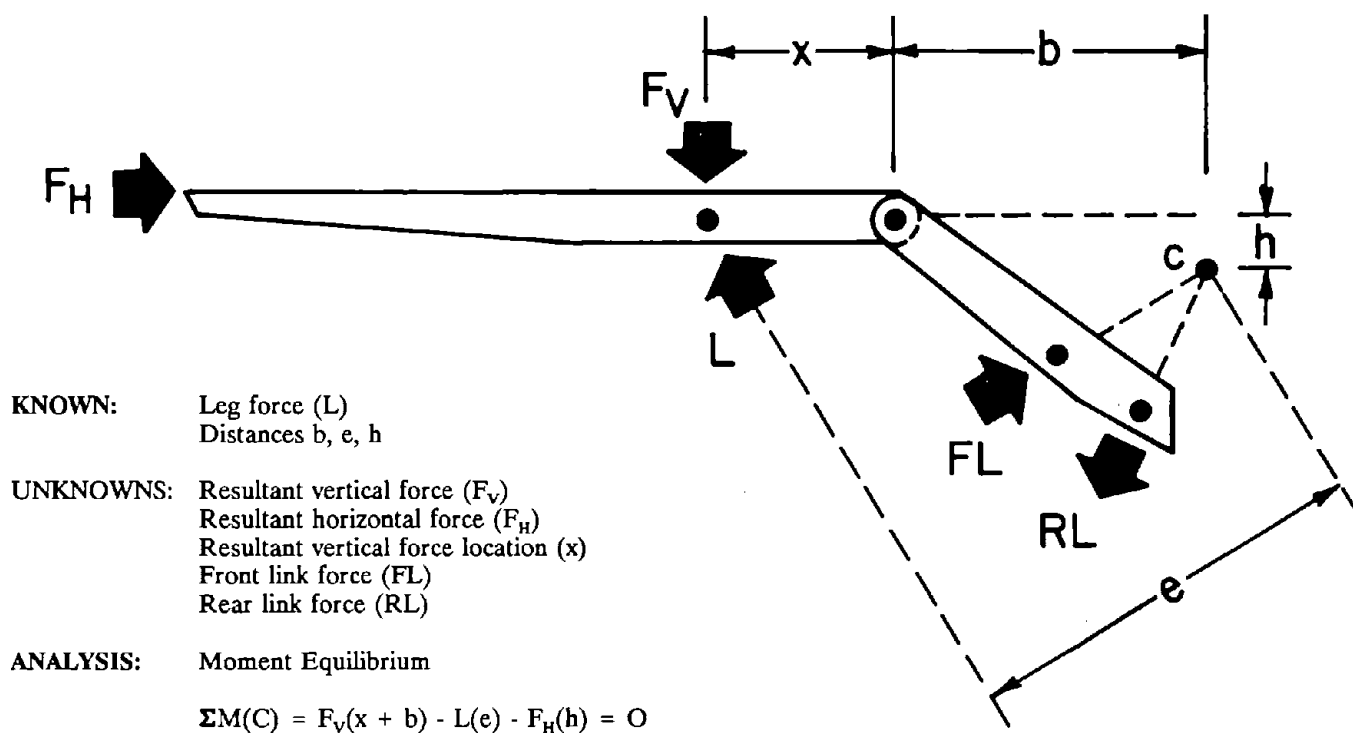


Figure C-2.-Moment equilibrium of canopy caving-shield combination (summation of moments at link center).

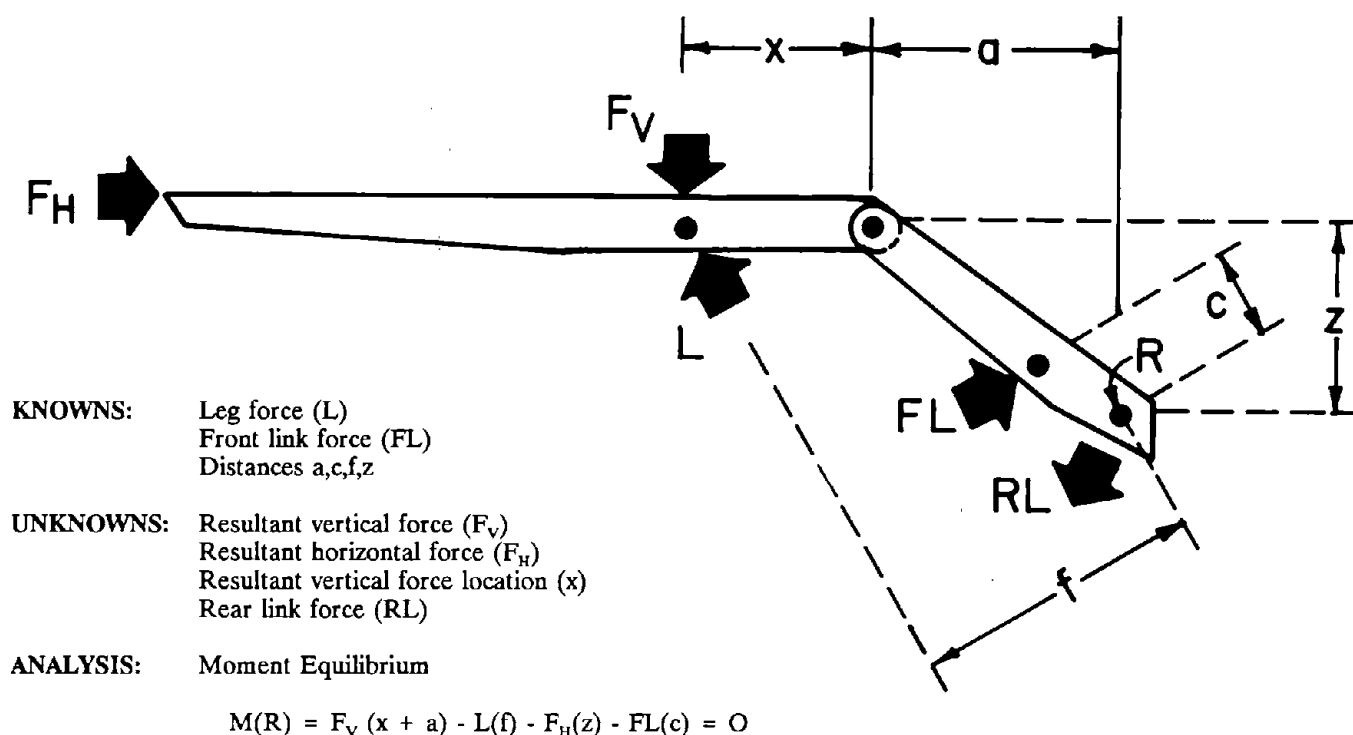


Figure C-3.-Moment equilibrium of canopy-caving shield combination (summation of moments at tension link pin).

## **APPENDIX D.—DESCRIPTION OF STANDARDIZED PERFORMANCE TESTS**

A sample description of suggested standardized tests is provided using a preliminary version of the performance test report illustrated in figure 22 of the main text. The first two pages of the test report are used to describe a specific test. These tests are consistent with the testing

recommendations set forth in the main text of this report. These tests are categorized in terms of (1) support resistance characteristics, (2) shield stiffness, (3) leg mechanics, (4) stability, (5) load transfer mechanics, and (6) structural integrity.

## SUPPORT RESISTANCE CHARACTERISTICS

SUPPORT PERFORMANCE TEST REPORT

**TEST NAME:** Support Capacity - Height Effects CAPHT01 thru CAPHT04

**TEST SERIES:** Resistance Characteristics xx Stability \_\_\_\_\_  
 Shield Stiffness \_\_\_\_\_ Load Transfer \_\_\_\_\_  
 Leg Mechanics \_\_\_\_\_ Structural Integrity \_\_\_\_\_

**OBJECTIVE:** Determine support capacity as a function of shield height.

\_\_\_\_\_

\_\_\_\_\_

**TEST PROCEDURE:** Select four heights to include upper and lower end of operating range plus two heights in between. Load shield by vertical convergence of canopy to leg yield and document vertical and horizontal support reactions.

\_\_\_\_\_

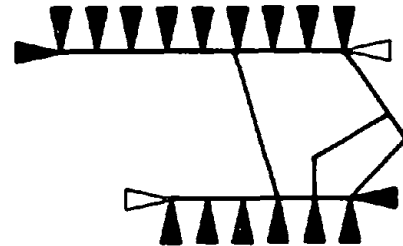
\_\_\_\_\_

**TEST FRAME:** Static \_\_\_\_\_ Active xxx

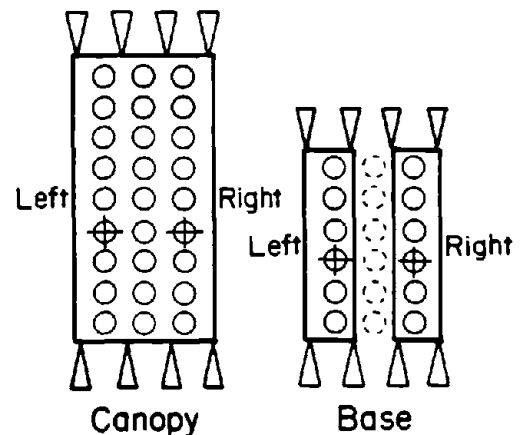
**SHIELD CONFIGURATION:** Shield Height H1,H2,H3,H4 in  
 Leg inclination  $\alpha_1,\alpha_2,\alpha_3,\alpha_4$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

**BOUNDARY CONDITIONS:**  Constrained \_\_\_\_\_ Unconstrained xxx

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



# SUPPORT RESISTANCE CHARACTERISTICS

55

## LOAD APPLICATION:

### CONTROL PARAMETERS AND LOADING RATES:

|                                       |            |          |
|---------------------------------------|------------|----------|
| Vertical Force                        | _____      | kips/min |
| Face-to-waste Horizontal Force        | _____      | kips/min |
| Waste-to-face Horizontal Force        | _____      | kips/min |
| Vertical Displacement                 | <u>0.1</u> | in/min   |
| Face-to-waste Horizontal Displacement | _____      | in/min   |
| Waste-to-face Horizontal Displacement | _____      | in/min   |
| Leg Pressure                          | _____      | psi/min  |
| Cycles per minute                     | _____      | cyc/min  |

### LOAD SEQUENCE:

|                                      |            |                      |       |
|--------------------------------------|------------|----------------------|-------|
| Vertical only                        | <u>xxx</u> | Vertical--Horizontal | _____ |
| Horizontal only                      | _____      | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal |            |                      | _____ |

### DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |       |
|------------------|--------------------------|-----------|----------------------------|-------|
| Vertical Force   | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | _____ |
| Horizontal Force | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | _____ |
| Strain Channels  | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____ |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | _____ |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____ |
| Vertical Force   | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____ |
| Horizontal Force | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____ |
| Strain Channels  | vs Number of cycles      | _____     |                            |       |

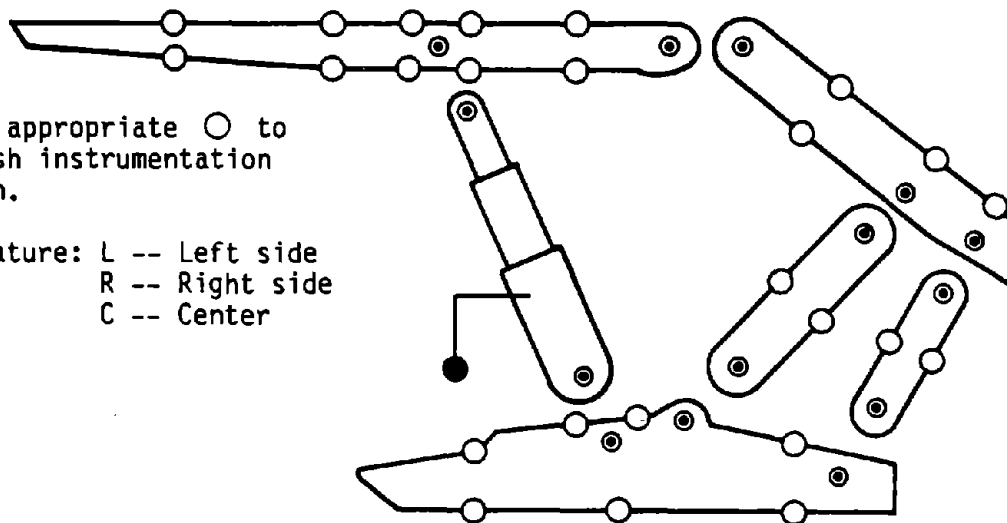
### Comments:

Provide plots of vertical force and horizontal force  
at leg yield as a function of shield height.

### INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ○ to  
establish instrumentation  
location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



# SUPPORT RESISTANCE CHARACTERISTICS

## SUPPORT PERFORMANCE TEST REPORT

**TEST NAME:** Tip Load Capability TIP01 and TIP02

**TEST SERIES:** Resistance Characteristics xx Stability       
 Shield Stiffness      Load Transfer       
 Leg Mechanics      Structural Integrity     

**OBJECTIVE:** Determine maximum tip load capacity of shield.

\_\_\_\_\_

\_\_\_\_\_

**TEST PROCEDURE:** Set shield with level canopy to generate minimum capsule pressure. Apply vertical displacement to two-point canopy contact. Place load cells at points of contact to measure contact loading. Determine tip load at leg/capsule yield. Conduct tests at low and high shield height.

\_\_\_\_\_

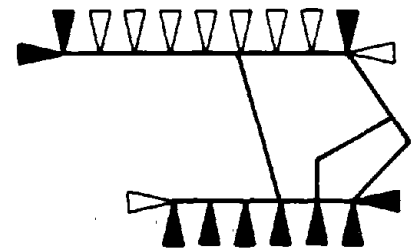
\_\_\_\_\_

**TEST FRAME:** Static      Active xxx

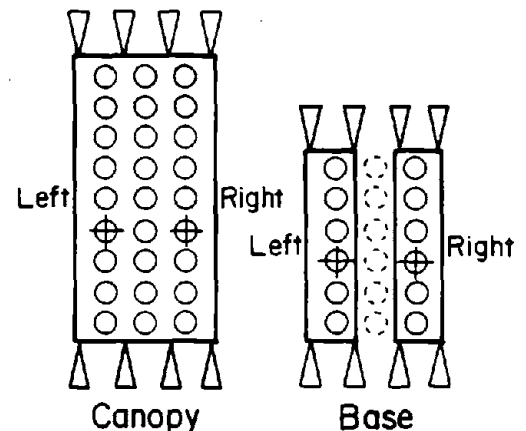
**SHIELD CONFIGURATION:** Shield Height H1,H2 in  
 Leg inclination  $\alpha 1, \alpha 2$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

**BOUNDARY CONDITIONS:** → Constrained      Unconstrained xxx

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



# SUPPORT RESISTANCE CHARACTERISTICS

57

## LOAD APPLICATION:

### CONTROL PARAMETERS AND LOADING RATES:

|                                       |       |          |
|---------------------------------------|-------|----------|
| Vertical Force                        | _____ | kips/min |
| Face-to-waste Horizontal Force        | _____ | kips/min |
| Waste-to-face Horizontal Force        | _____ | kips/min |
| Vertical Displacement                 | 0.1   | in/min   |
| Face-to-waste Horizontal Displacement | _____ | in/min   |
| Waste-to-face Horizontal Displacement | _____ | in/min   |
| Leg Pressure                          | _____ | psi/min  |
| Cycles per minute                     | _____ | cyc/min  |

### LOAD SEQUENCE:

|                                      |       |                      |       |
|--------------------------------------|-------|----------------------|-------|
| Vertical only                        | xxx   | Vertical--Horizontal | _____ |
| Horizontal only                      | _____ | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal | _____ |                      | _____ |

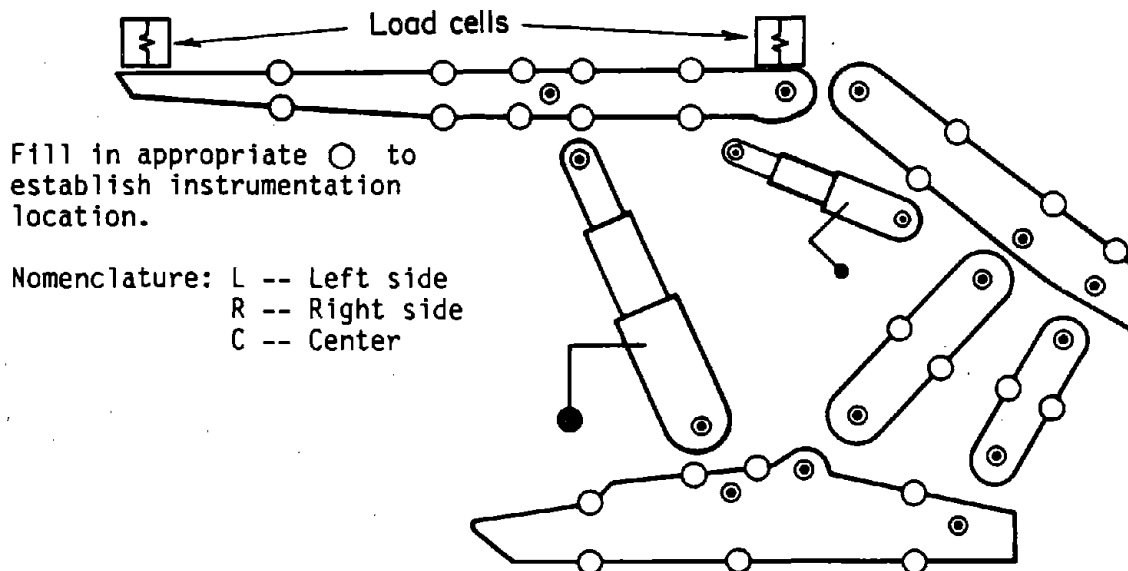
### DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |       |                            |       |
|------------------|--------------------------|-------|----------------------------|-------|
| Vertical Force   | vs Vertical Displacement | _____ | vs Horizontal Displacement | _____ |
| Horizontal Force | vs Vertical Displacement | _____ | vs Horizontal Displacement | _____ |
| Strain Channels  | vs Vertical Displacement | _____ | vs Horizontal Displacement | _____ |
| Strain Channels  | vs Vertical Force        | _____ | vs Horizontal Force        | _____ |
| Strain Channels  | vs Sum of Leg Pressures  | _____ | vs Individual Leg Pressure | _____ |
| Vertical Force   | vs Sum of Leg Pressures  | xx    | vs Individual Leg Pressure | _____ |
| Horizontal Force | vs Sum of Leg Pressures  | _____ | vs Individual Leg Pressure | _____ |
| Strain Channels  | vs Number of cycles      | _____ |                            | _____ |

### Comments:

Provide plots of load cells at points of canopy  
contact vs vertical displacement and leg pressure.

### INSTRUMENTATION IDENTIFICATION:



## SUPPORT RESISTANCE CHARACTERISTICS

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Tip Load Capability TIP03 and TIP04

TEST SERIES: Resistance Characteristics xx Stability       
 Shield Stiffness      Load Transfer       
 Leg Mechanics      Structural Integrity     

OBJECTIVE: Determine tip loading generated for full canopy contact.

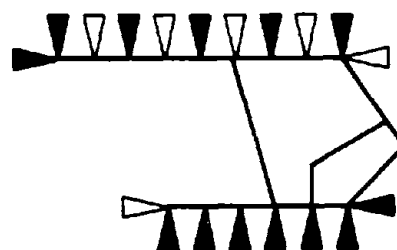
TEST PROCEDURE: Set shield with full canopy contact in level position to generate minimum capsule pressure. Place load cells at canopy contacts to measure contact loading. Apply vertical displacement to leg/capsule yield. Conduct tests at low and high shield height.

TEST FRAME: Static      Active xxx

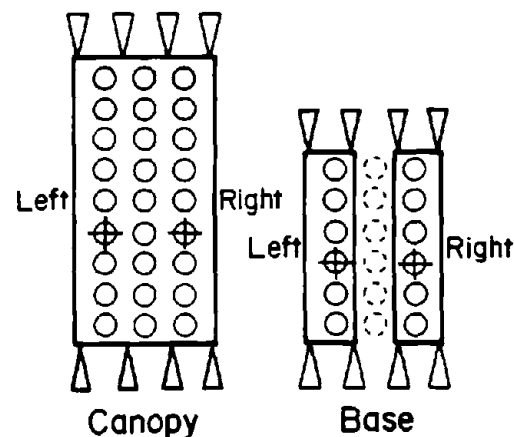
SHIELD CONFIGURATION: Shield Height H1,H2 in  
 Leg inclination  $\alpha 1, \alpha 2$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

BOUNDARY CONDITIONS: → Constrained      Unconstrained xxx

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



## SUPPORT RESISTANCE CHARACTERISTICS

59

### LOAD APPLICATION:

### CONTROL PARAMETERS AND LOADING RATES:

|                                       |       |          |
|---------------------------------------|-------|----------|
| Vertical Force                        | _____ | kips/min |
| Face-to-waste Horizontal Force        | _____ | kips/min |
| Waste-to-face Horizontal Force        | _____ | kips/min |
| Vertical Displacement                 | 0.1   | in/min   |
| Face-to-waste Horizontal Displacement | _____ | in/min   |
| Waste-to-face Horizontal Displacement | _____ | in/min   |
| Leg Pressure                          | _____ | psi/min  |
| Cycles per minute                     | _____ | cyc/min  |

### LOAD SEQUENCE:

|                                      |       |                      |       |
|--------------------------------------|-------|----------------------|-------|
| Vertical only                        | xxx   | Vertical--Horizontal | _____ |
| Horizontal only                      | _____ | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal |       |                      | _____ |

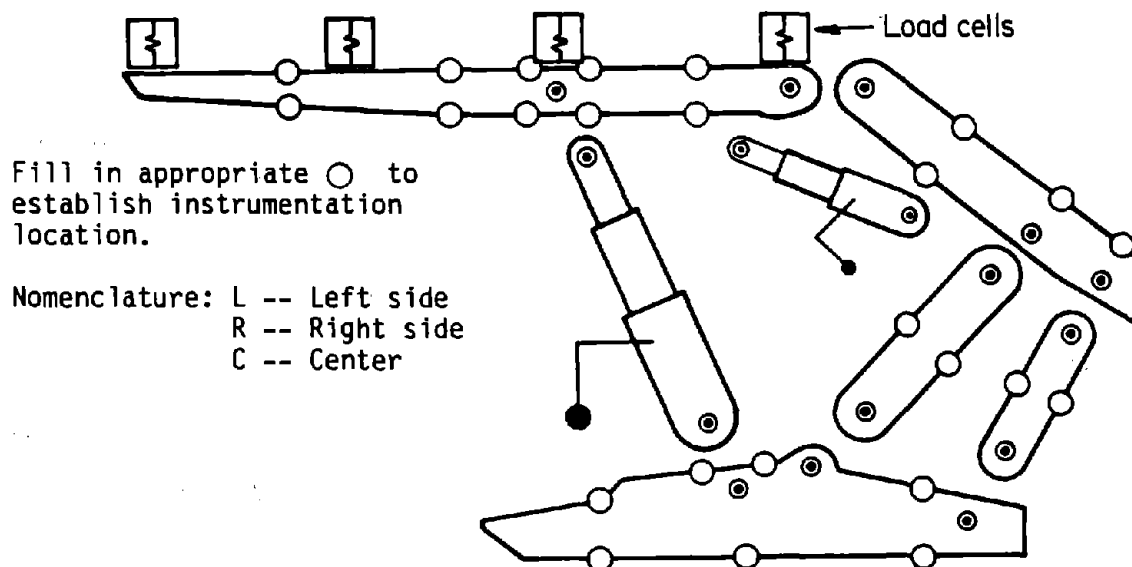
### DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |       |                            |       |
|------------------|--------------------------|-------|----------------------------|-------|
| Vertical Force   | vs Vertical Displacement | _____ | vs Horizontal Displacement | _____ |
| Horizontal Force | vs Vertical Displacement | _____ | vs Horizontal Displacement | _____ |
| Strain Channels  | vs Vertical Displacement | _____ | vs Horizontal Displacement | _____ |
| Strain Channels  | vs Vertical Force        | _____ | vs Horizontal Force        | _____ |
| Strain Channels  | vs Sum of Leg Pressures  | _____ | vs Individual Leg Pressure | _____ |
| Vertical Force   | vs Sum of Leg Pressures  | xx    | vs Individual Leg Pressure | _____ |
| Horizontal Force | vs Sum of Leg Pressures  | _____ | vs Individual Leg Pressure | _____ |
| Strain Channels  | vs Number of cycles      | _____ |                            |       |

### Comments:

Provide plots of load cell forces as a function of displacement and leg pressure.

### INSTRUMENTATION IDENTIFICATION:



## SUPPORT RESISTANCE CHARACTERISTICS

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Tip Load Capability TIP05 and TIP06

TEST SERIES: Resistance Characteristics xx Stability       
 Shield Stiffness      Load Transfer       
 Leg Mechanics      Structural Integrity     

OBJECTIVE: Determine tip load generation from active capsule pressurization at shield setting.

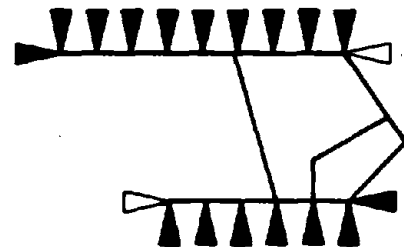
TEST PROCEDURE: Set shield with level canopy position to designated setting pressure. Activate capsule to generate additional tip loading. Monitor tip loading through capsule yield. Monitor base stability during capsule pressurization and subsequent shield loading.

TEST FRAME: Static      Active xxx

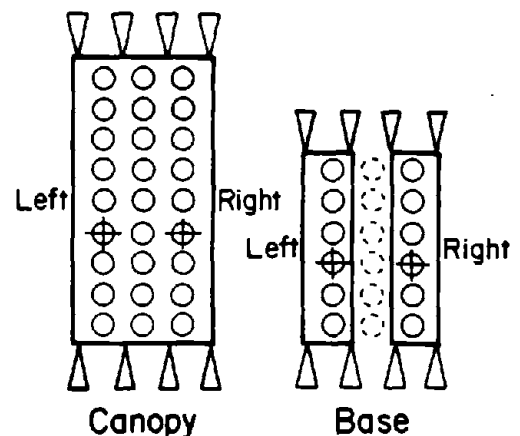
SHIELD CONFIGURATION: Shield Height H1,H2 in  
 Leg inclination  $\alpha_1, \alpha_2$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

BOUNDARY CONDITIONS:  Constrained      Unconstrained xxx

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



# SUPPORT RESISTANCE CHARACTERISTICS

61

## LOAD APPLICATION:

### CONTROL PARAMETERS

AND LOADING RATES:

|                                       |       |          |
|---------------------------------------|-------|----------|
| Vertical Force                        | _____ | kips/min |
| Face-to-waste Horizontal Force        | _____ | kips/min |
| Waste-to-face Horizontal Force        | _____ | kips/min |
| Vertical Displacement                 | 0.1   | in/min   |
| Face-to-waste Horizontal Displacement | _____ | in/min   |
| Waste-to-face Horizontal Displacement | _____ | in/min   |
| Leg Pressure                          | _____ | psi/min  |
| Cycles per minute                     | _____ | cyc/min  |

### LOAD SEQUENCE:

|                                      |       |                      |       |
|--------------------------------------|-------|----------------------|-------|
| Vertical only                        | xxx   | Vertical--Horizontal | _____ |
| Horizontal only                      | _____ | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal | _____ |                      | _____ |

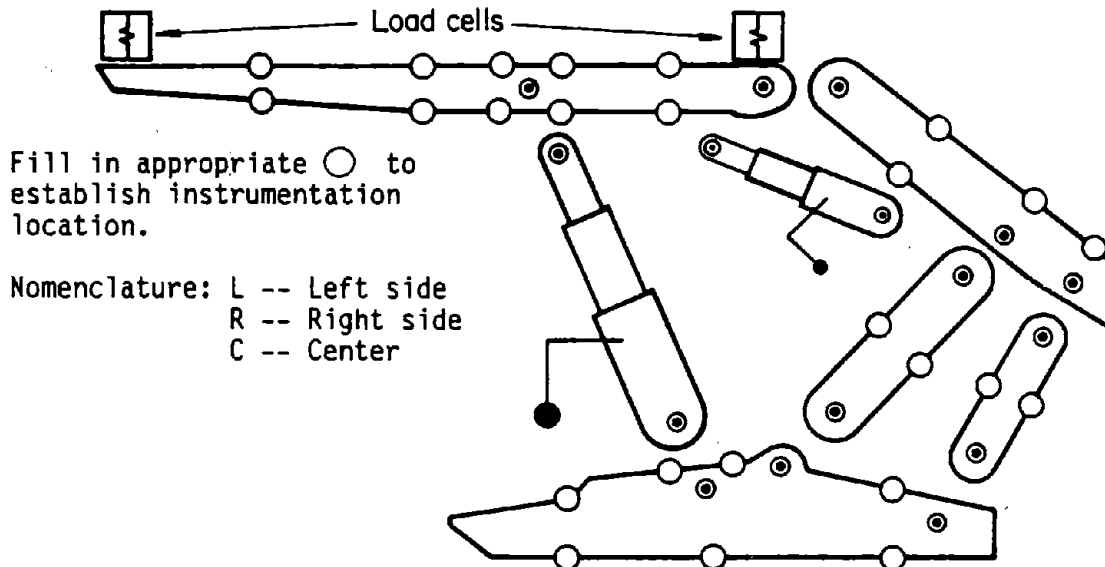
### DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |       |                            |       |
|------------------|--------------------------|-------|----------------------------|-------|
| Vertical Force   | vs Vertical Displacement | _____ | vs Horizontal Displacement | _____ |
| Horizontal Force | vs Vertical Displacement | _____ | vs Horizontal Displacement | _____ |
| Strain Channels  | vs Vertical Displacement | _____ | vs Horizontal Displacement | _____ |
| Strain Channels  | vs Vertical Force        | _____ | vs Horizontal Force        | _____ |
| Strain Channels  | vs Sum of Leg Pressures  | _____ | vs Individual Leg Pressure | _____ |
| Vertical Force   | vs Sum of Leg Pressures  | xx    | vs Individual Leg Pressure | _____ |
| Horizontal Force | vs Sum of Leg Pressures  | _____ | vs Individual Leg Pressure | _____ |
| Strain Channels  | vs Number of cycles      | _____ |                            | _____ |

### Comments:

Provide plots of load cells at points of canopy  
contact vs capsule pressure and leg pressure.

### INSTRUMENTATION IDENTIFICATION:



## SUPPORT RESISTANCE CHARACTERISTICS

SUPPORT PERFORMANCE TEST REPORT

**TEST NAME:** Horizontal Support Capacity HC01 and HC02

**TEST SERIES:** Resistance Characteristics xx Stability       
 Shield Stiffness      Load Transfer       
 Leg Mechanics      Structural Integrity     

**OBJECTIVE:** Determine shield resistance to face-to-waste  
horizontal displacement.

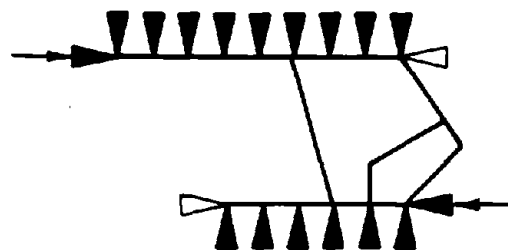
**TEST PROCEDURE:** Set shield at 3000 psi setting pressure. Displace shield in  
a face-to-waste direction. Monitor link loading and leg  
pressure. Maintain load until leg pressure yield or  
excessive component strain. Determine maximum horizontal  
force. Conduct test at low and high shield height.

**TEST FRAME:** Static      Active xxx

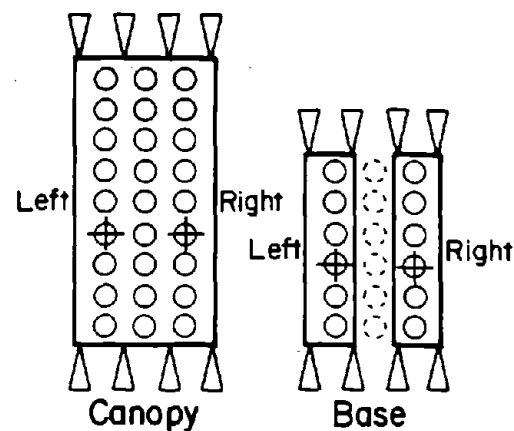
**SHIELD CONFIGURATION:** Shield Height H1,H2 in  
 Leg inclination a1,a2 degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

**BOUNDARY CONDITIONS:** → Constrained xxx Unconstrained     

Fill in appropriate  $\nabla$  to  
 establish symmetric  
 contact configuration



Fill in appropriate  $\bigcirc$  to  
 establish unsymmetric contact  
 configuration



# SUPPORT RESISTANCE CHARACTERISTICS

63

## LOAD APPLICATION:

### CONTROL PARAMETERS AND LOADING RATES:

|                                       |             |          |
|---------------------------------------|-------------|----------|
| Vertical Force                        | _____       | kips/min |
| Face-to-waste Horizontal Force        | _____       | kips/min |
| Waste-to-face Horizontal Force        | _____       | kips/min |
| Vertical Displacement                 | <u>Hold</u> | in/min   |
| Face-to-waste Horizontal Displacement | <u>0.1</u>  | in/min   |
| Waste-to-face Horizontal Displacement | _____       | in/min   |
| Leg Pressure                          | _____       | psi/min  |
| Cycles per minute                     | _____       | cyc/min  |

### LOAD SEQUENCE:

|                                      |            |                      |       |
|--------------------------------------|------------|----------------------|-------|
| Vertical only                        | _____      | Vertical--Horizontal | _____ |
| Horizontal only                      | <u>xxx</u> | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal | _____      |                      | _____ |

### DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | _____     | vs Horizontal Displacement | <u>xx</u> |
| Horizontal Force | vs Vertical Displacement | _____     | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | <u>xx</u> |
| Strain Channels  | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | _____     |
| Horizontal Force | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | _____     |
| Strain Channels  | vs Number of cycles      | _____     |                            | _____     |

### Comments:

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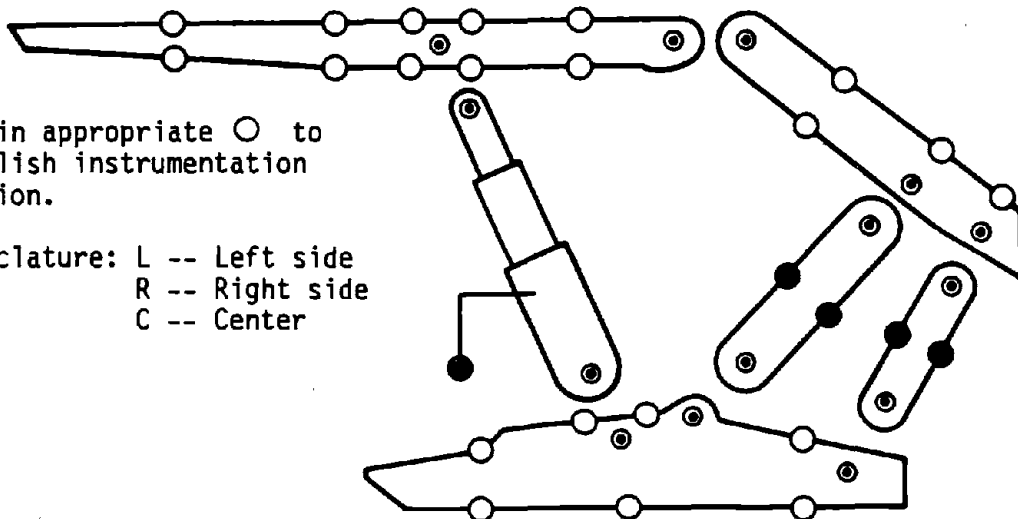


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### INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ○ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## SUPPORT RESISTANCE CHARACTERISTICS

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Horizontal Support Capacity HC03 and HC04

TEST SERIES: Resistance Characteristics xx Stability       
 Shield Stiffness      Load Transfer       
 Leg Mechanics      Structural Integrity     

OBJECTIVE: Determine horizontal load reaction to applied vertical displacement.

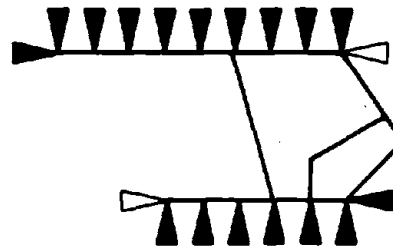
TEST PROCEDURE: Set shield at 3000 psi setting pressure. Apply vertical displacement to leg yield. Monitor horizontal force reaction developed from vertical displacement. Conduct at low and high shield height.

TEST FRAME: Static      Active xxx

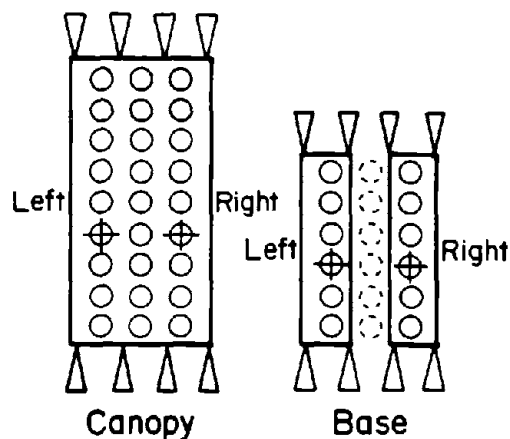
SHIELD CONFIGURATION: Shield Height H1,H2 in  
 Leg inclination a1,a2 degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

BOUNDARY CONDITIONS: → Constrained      Unconstrained xxx

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration





## SHIELD STIFFNESS

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Shield Stiffness - STFC01 and STFC02

TEST SERIES: Resistance Characteristics        Stability         
 Shield Stiffness xx Load Transfer         
 Leg Mechanics        Structural Integrity       

OBJECTIVE: Determine shield stiffness for constrained initial condition for full canopy and base contact configuration using linear elastic shield stiffness model. (Face-to-waste horz. displ.)

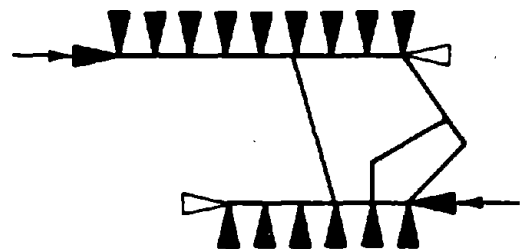
TEST PROCEDURE: Apply controlled vertical displacement and measure vertical and horizontal shield reactions. Compute K1 as ratio of vertical force to vertical displacement and K3 as ratio of horizontal force to vertical displacement. Apply horizontal displacement. Compute K2 as ratio of vertical force to horz displacement and K4 as ratio of horz. force to horz. displ.

TEST FRAME: Static        Active xxx

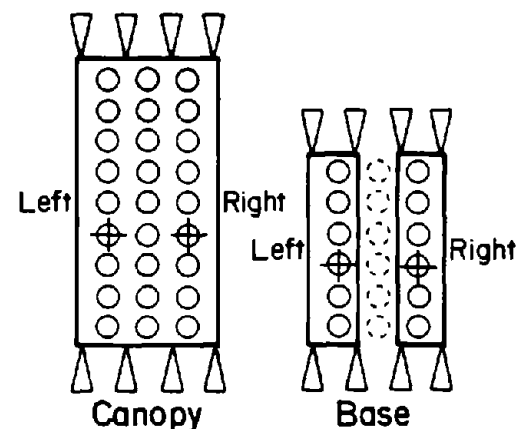
SHIELD CONFIGURATION: Shield Height H1,H2 in  
 Leg inclination  $\alpha 1, \alpha 2$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

BOUNDARY CONDITIONS: → Constrained xxx Unconstrained       

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



# SHIELD STIFFNESS

67

## LOAD APPLICATION:

### CONTROL PARAMETERS

### AND LOADING RATES:

|                                       |       |          |
|---------------------------------------|-------|----------|
| Vertical Force                        | _____ | kips/min |
| Face-to-waste Horizontal Force        | _____ | kips/min |
| Waste-to-face Horizontal Force        | _____ | kips/min |
| Vertical Displacement                 | 0.1   | in/min   |
| Face-to-waste Horizontal Displacement | 0.1   | in/min   |
| Waste-to-face Horizontal Displacement | _____ | in/min   |
| Leg Pressure                          | _____ | psi/min  |
| Cycles per minute                     | _____ | cyc/min  |

## LOAD SEQUENCE:

|                                      |       |                      |       |
|--------------------------------------|-------|----------------------|-------|
| Vertical only                        | _____ | Vertical--Horizontal | xxx   |
| Horizontal only                      | _____ | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal | _____ |                      | _____ |

## DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |       |                            |       |
|------------------|--------------------------|-------|----------------------------|-------|
| Vertical Force   | vs Vertical Displacement | xx    | vs Horizontal Displacement | xx    |
| Horizontal Force | vs Vertical Displacement | xx    | vs Horizontal Displacement | xx    |
| Strain Channels  | vs Vertical Displacement | _____ | vs Horizontal Displacement | _____ |
| Strain Channels  | vs Vertical Force        | _____ | vs Horizontal Force        | _____ |
| Strain Channels  | vs Sum of Leg Pressures  | _____ | vs Individual Leg Pressure | _____ |
| Vertical Force   | vs Sum of Leg Pressures  | _____ | vs Individual Leg Pressure | _____ |
| Horizontal Force | vs Sum of Leg Pressures  | _____ | vs Individual Leg Pressure | _____ |
| Strain Channels  | vs Number of cycles      | _____ |                            | _____ |

## Comments:

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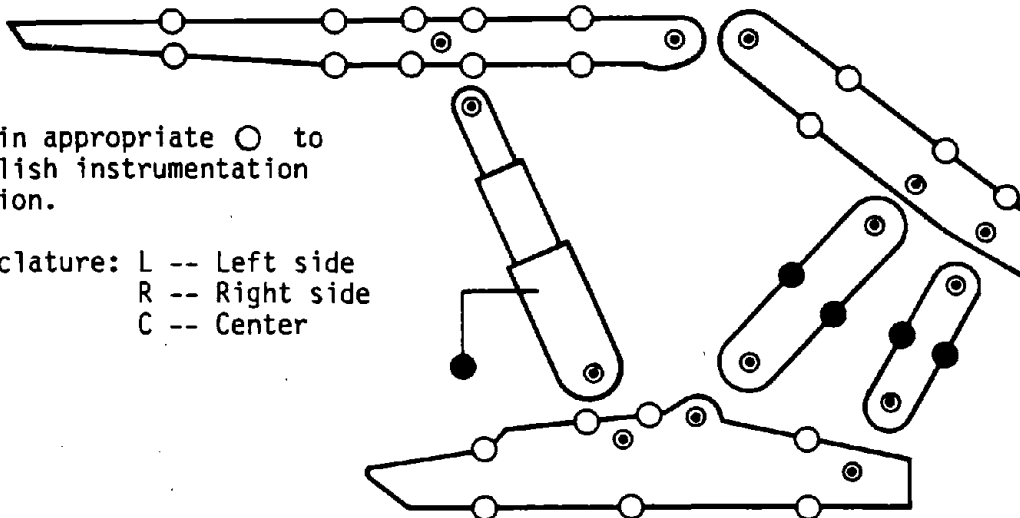


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## INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ○ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## SHIELD STIFFNESS

SUPPORT PERFORMANCE TEST REPORTTEST NAME: Shield Stiffness - STFC03 and STFC04

TEST SERIES: Resistance Characteristics        Stability         
 Shield Stiffness xx Load Transfer         
 Leg Mechanics        Structural Integrity       

OBJECTIVE: Determine shield stiffness for constrained initial condition  
for two-point canopy and base contact configuration using  
elastic shield stiffness model. (Face-to-waste horz. displ.)

TEST PROCEDURE: Repeat test procedures for Tests STFC01 and STFC02.

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\_\_\_\_\_

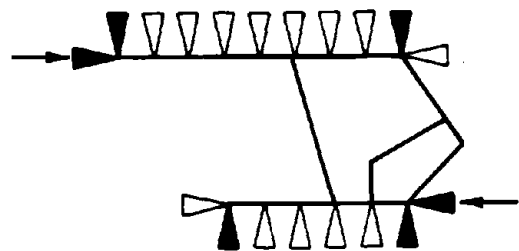
\_\_\_\_\_

TEST FRAME: Static        Active xxx

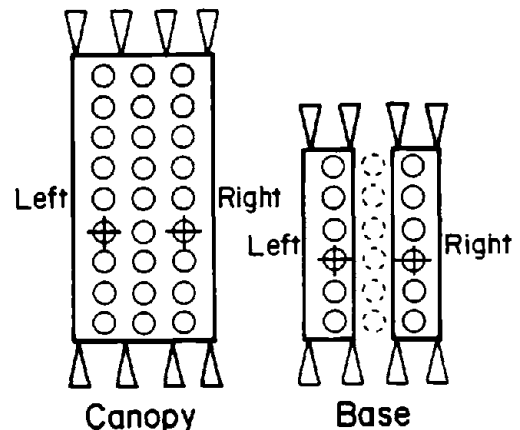
SHIELD CONFIGURATION: Shield Height H1,H2 in         
 Leg inclination  $\alpha 1, \alpha 2$  degrees from vertical         
 Canopy rotation 0 degrees from horizontal         
 Setting Pressure 3000 psi       

BOUNDARY CONDITIONS: → Constrained xxx Unconstrained       

Fill in appropriate  $\nabla$  to  
 establish symmetric  
 contact configuration.



Fill in appropriate  $\bigcirc$  to  
 establish unsymmetric contact  
 configuration



# SHIELD STIFFNESS

69

## LOAD APPLICATION:

### CONTROL PARAMETERS AND LOADING RATES:

|                                       |       |          |
|---------------------------------------|-------|----------|
| Vertical Force                        | _____ | kips/min |
| Face-to-waste Horizontal Force        | _____ | kips/min |
| Waste-to-face Horizontal Force        | _____ | kips/min |
| Vertical Displacement                 | 0.1   | in/min   |
| Face-to-waste Horizontal Displacement | 0.1   | in/min   |
| Waste-to-face Horizontal Displacement | _____ | in/min   |
| Leg Pressure                          | _____ | psi/min  |
| Cycles per minute                     | _____ | cyc/min  |

### LOAD SEQUENCE:

|                                      |       |                      |       |
|--------------------------------------|-------|----------------------|-------|
| Vertical only                        | _____ | Vertical--Horizontal | xxx   |
| Horizontal only                      | _____ | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal | _____ |                      | _____ |

### DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |       |                            |       |
|------------------|--------------------------|-------|----------------------------|-------|
| Vertical Force   | vs Vertical Displacement | xx    | vs Horizontal Displacement | xx    |
| Horizontal Force | vs Vertical Displacement | xx    | vs Horizontal Displacement | xx    |
| Strain Channels  | vs Vertical Displacement | _____ | vs Horizontal Displacement | _____ |
| Strain Channels  | vs Vertical Force        | _____ | vs Horizontal Force        | _____ |
| Strain Channels  | vs Sum of Leg Pressures  | _____ | vs Individual Leg Pressure | _____ |
| Vertical Force   | vs Sum of Leg Pressures  | _____ | vs Individual Leg Pressure | _____ |
| Horizontal Force | vs Sum of Leg Pressures  | _____ | vs Individual Leg Pressure | _____ |
| Strain Channels  | vs Number of cycles      | _____ |                            | _____ |

### Comments:

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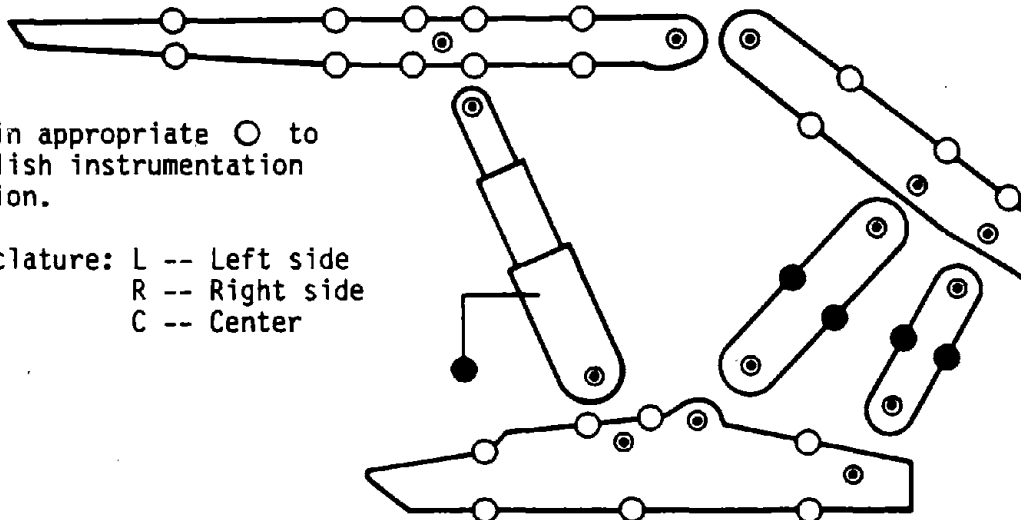


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### INSTRUMENTATION IDENTIFICATION:

Fill in appropriate O to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## SHIELD STIFFNESS

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Shield Stiffness - STFC05 and STFC06

TEST SERIES: Resistance Characteristics        Stability         
 Shield Stiffness xx Load Transfer         
 Leg Mechanics        Structural Integrity       

OBJECTIVE: Determine shield stiffness for constrained initial condition for full canopy and base contact configuration using linear elastic shield stiffness model. (Waste-to-face horz. displ.)

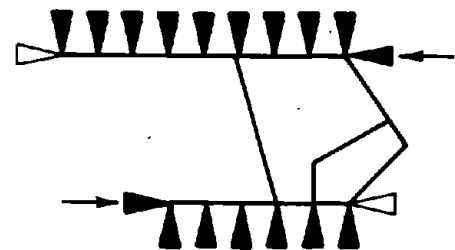
TEST PROCEDURE: Apply controlled vertical displacement and measure vertical and horizontal shield reactions. Compute K1 as ratio of vertical force to vertical displacement and K3 as ratio of horizontal force to vertical displacement. Apply horizontal displacement. Compute K2 as ratio of vertical force to horz displacement and K4 as ratio of horz. force to horz. displ.

TEST FRAME: Static        Active xxx

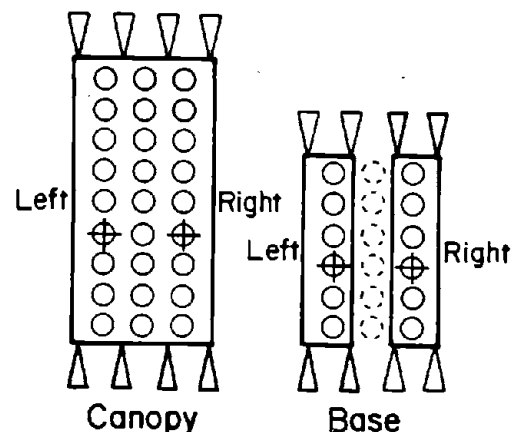
SHIELD CONFIGURATION: Shield Height H1,H2 in         
 Leg inclination  $\alpha 1, \alpha 2$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

BOUNDARY CONDITIONS: → Constrained xxx Unconstrained       

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



# SHIELD STIFFNESS

71

## LOAD APPLICATION:

### CONTROL PARAMETERS AND LOADING RATES:

|                                       |            |          |
|---------------------------------------|------------|----------|
| Vertical Force                        | _____      | kips/min |
| Face-to-waste Horizontal Force        | _____      | kips/min |
| Waste-to-face Horizontal Force        | _____      | kips/min |
| Vertical Displacement                 | <u>0.1</u> | in/min   |
| Face-to-waste Horizontal Displacement | _____      | in/min   |
| Waste-to-face Horizontal Displacement | <u>0.1</u> | in/min   |
| Leg Pressure                          | _____      | psi/min  |
| Cycles per minute                     | _____      | cyc/min  |

### LOAD SEQUENCE:

|                                      |       |                      |            |
|--------------------------------------|-------|----------------------|------------|
| Vertical only                        | _____ | Vertical--Horizontal | <u>xxx</u> |
| Horizontal only                      | _____ | Horizontal--Vertical | _____      |
| Simultaneous vertical and horizontal | _____ |                      | _____      |

### DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Horizontal Force | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | _____     |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Horizontal Force | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Strain Channels  | vs Number of cycles      | _____     |                            |           |

### Comments:

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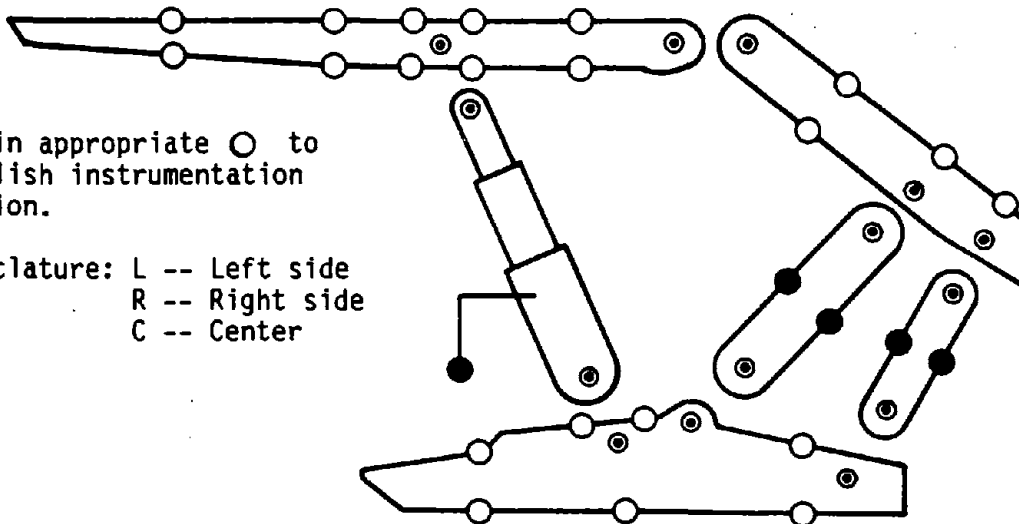


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### INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ☐ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## SHIELD STIFFNESS

SUPPORT PERFORMANCE TEST REPORTTEST NAME: Shield Stiffness - STFC07 and STFC08

TEST SERIES: Resistance Characteristics        Stability         
 Shield Stiffness   xx   Load Transfer         
 Leg Mechanics        Structural Integrity       

OBJECTIVE: Determine shield stiffness for constrained initial condition  
 for two-point canopy and base contact configuration using  
 elastic shield stiffness model. (Waste-to-face horz. displ.)

TEST PROCEDURE: Repeat test procedures for Tests STFC05 and STFC06.

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\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

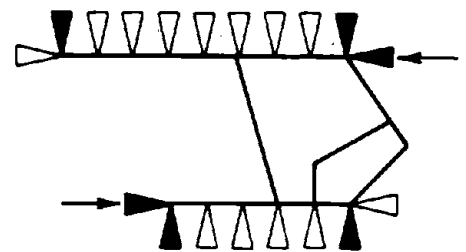
\_\_\_\_\_

TEST FRAME: Static        Active   xxx  

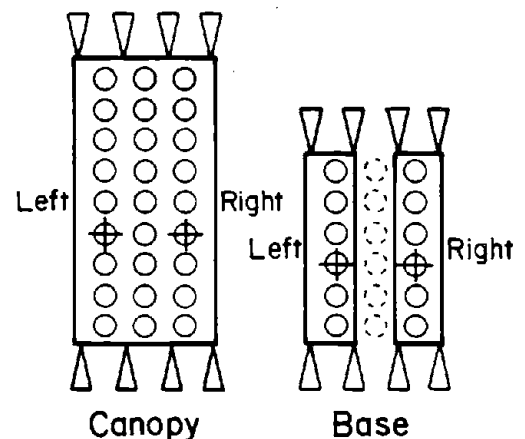
SHIELD CONFIGURATION: Shield Height   H1,H2   in  
 Leg inclination   a1,a2   degrees from vertical  
 Canopy rotation       0       degrees from horizontal  
 Setting Pressure   3000   psi

BOUNDARY CONDITIONS: → Constrained   xxx   Unconstrained       

Fill in appropriate  $\nabla$  to  
 establish symmetric  
 contact configuration



Fill in appropriate  $\bigcirc$  to  
 establish unsymmetric contact  
 configuration



# SHIELD STIFFNESS

73

## LOAD APPLICATION:

### CONTROL PARAMETERS AND LOADING RATES:

|                                       |            |          |
|---------------------------------------|------------|----------|
| Vertical Force                        | _____      | kips/min |
| Face-to-waste Horizontal Force        | _____      | kips/min |
| Waste-to-face Horizontal Force        | _____      | kips/min |
| Vertical Displacement                 | <u>0.1</u> | in/min   |
| Face-to-waste Horizontal Displacement | _____      | in/min   |
| Waste-to-face Horizontal Displacement | <u>0.1</u> | in/min   |
| Leg Pressure                          | _____      | psi/min  |
| Cycles per minute                     | _____      | cyc/min  |

### LOAD SEQUENCE:

|                                      |       |                      |            |
|--------------------------------------|-------|----------------------|------------|
| Vertical only                        | _____ | Vertical--Horizontal | <u>xxx</u> |
| Horizontal only                      | _____ | Horizontal--Vertical | _____      |
| Simultaneous vertical and horizontal | _____ |                      | _____      |

### DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Horizontal Force | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | _____     |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Horizontal Force | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Strain Channels  | vs Number of cycles      | _____     |                            |           |

### Comments:

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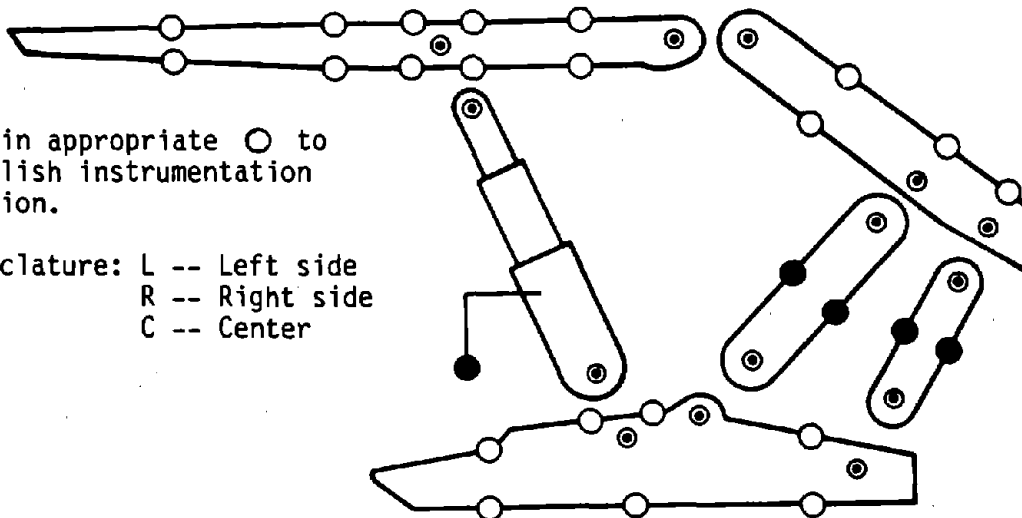


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### INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ☐ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## SHIELD STIFFNESS

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Shield Stiffness - STFU01 and STFU02

TEST SERIES: Resistance Characteristics        Stability         
 Shield Stiffness xx Load Transfer         
 Leg Mechanics        Structural Integrity       

OBJECTIVE: Determine shield stiffness - unconstrained initial condition for full canopy and base contact configuration using linear elastic shield stiffness model. (Face-to-waste horz. displ.)

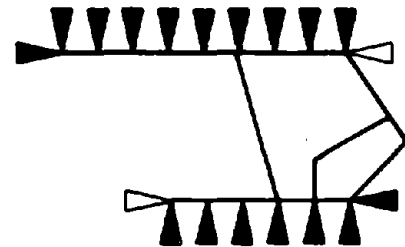
TEST PROCEDURE: Apply controlled vertical displacement and measure vertical and horizontal shield reactions. Compute K1 as ratio of vertical force to vertical displacement and K3 as ratio of horizontal force to vertical displacement. Apply horizontal displacement. Compute K2 as ratio of vertical force to horz displacement and K4 as ratio of horz. force to horz. displ.

TEST FRAME: Static        Active xxx

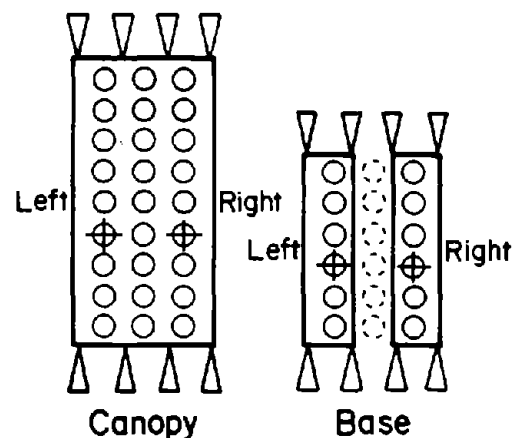
SHIELD CONFIGURATION: Shield Height H1,H2 in  
 Leg inclination  $\alpha 1, \alpha 2$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

BOUNDARY CONDITIONS: → Constrained        Unconstrained xxx

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



# SHIELD STIFFNESS

75

## LOAD APPLICATION:

### CONTROL PARAMETERS AND LOADING RATES:

|                                       |            |          |
|---------------------------------------|------------|----------|
| Vertical Force                        | _____      | kips/min |
| Face-to-waste Horizontal Force        | _____      | kips/min |
| Waste-to-face Horizontal Force        | _____      | kips/min |
| Vertical Displacement                 | <u>0.1</u> | in/min   |
| Face-to-waste Horizontal Displacement | <u>0.1</u> | in/min   |
| Waste-to-face Horizontal Displacement | _____      | in/min   |
| Leg Pressure                          | _____      | psi/min  |
| Cycles per minute                     | _____      | cyc/min  |

### LOAD SEQUENCE:

|                                      |       |                      |            |
|--------------------------------------|-------|----------------------|------------|
| Vertical only                        | _____ | Vertical--Horizontal | <u>xxx</u> |
| Horizontal only                      | _____ | Horizontal--Vertical | _____      |
| Simultaneous vertical and horizontal | _____ |                      | _____      |

### DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Horizontal Force | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | _____     |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Horizontal Force | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Strain Channels  | vs Number of cycles      | _____     |                            | _____     |

### Comments:

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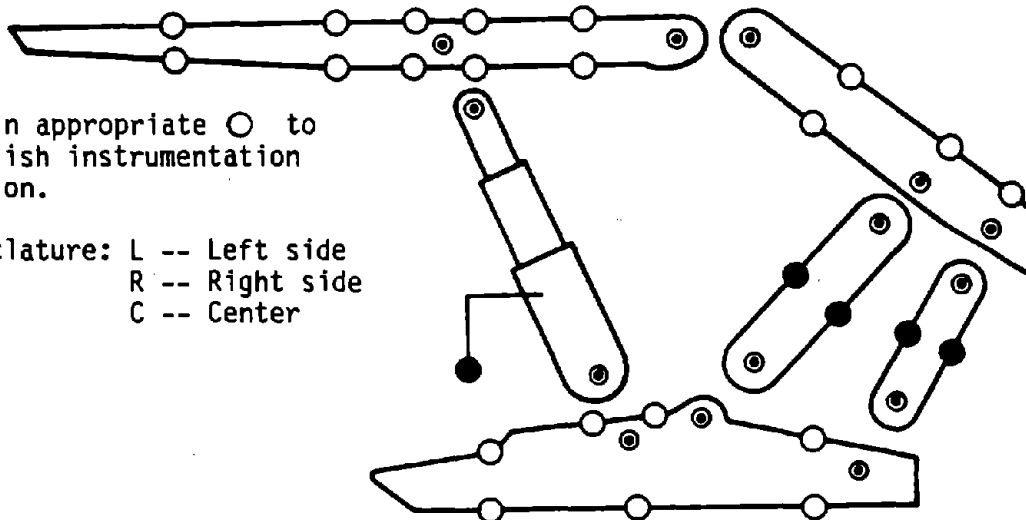


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### INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ○ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## SHIELD STIFFNESS

SUPPORT PERFORMANCE TEST REPORTTEST NAME: Shield Stiffness - STFU03 and STFU04

TEST SERIES: Resistance Characteristics        Stability         
 Shield Stiffness xx Load Transfer         
 Leg Mechanics        Structural Integrity       

OBJECTIVE: Determine shield stiffness - unconstrained initial condition  
 for two-point canopy and base contact configuration using  
 elastic shield stiffness model. (Face-to-waste horz. displ.)

TEST PROCEDURE: Repeat test procedures for Tests STFU01 and STFU02.

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\_\_\_\_\_

\_\_\_\_\_

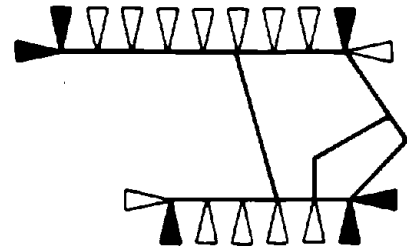
\_\_\_\_\_

TEST FRAME: Static        Active xxx

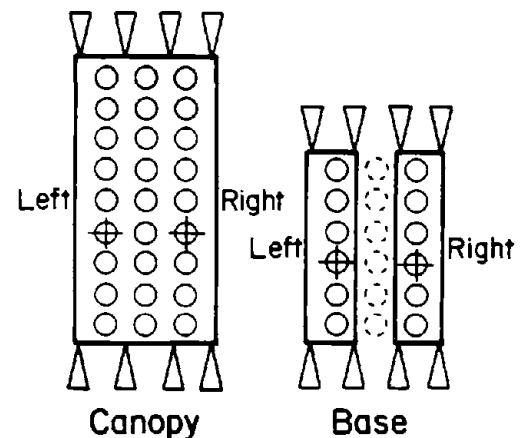
SHIELD CONFIGURATION: Shield Height H1,H2 in  
 Leg inclination  $\alpha_1, \alpha_2$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

BOUNDARY CONDITIONS: → Constrained        Unconstrained xxx

Fill in appropriate  $\nabla$  to  
 establish symmetric  
 contact configuration



Fill in appropriate  $\bigcirc$  to  
 establish unsymmetric contact  
 configuration



# SHIELD STIFFNESS

77

## LOAD APPLICATION:

### CONTROL PARAMETERS AND LOADING RATES:

|                                       |            |          |
|---------------------------------------|------------|----------|
| Vertical Force                        | _____      | kips/min |
| Face-to-waste Horizontal Force        | _____      | kips/min |
| Waste-to-face Horizontal Force        | _____      | kips/min |
| Vertical Displacement                 | <u>0.1</u> | in/min   |
| Face-to-waste Horizontal Displacement | <u>0.1</u> | in/min   |
| Waste-to-face Horizontal Displacement | _____      | in/min   |
| Leg Pressure                          | _____      | psi/min  |
| Cycles per minute                     | _____      | cyc/min  |

### LOAD SEQUENCE:

|                                      |       |                      |            |
|--------------------------------------|-------|----------------------|------------|
| Vertical only                        | _____ | Vertical--Horizontal | <u>xxx</u> |
| Horizontal only                      | _____ | Horizontal--Vertical | _____      |
| Simultaneous vertical and horizontal | _____ |                      | _____      |

### DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Horizontal Force | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | _____     |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Horizontal Force | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Strain Channels  | vs Number of cycles      | _____     |                            |           |

### Comments:

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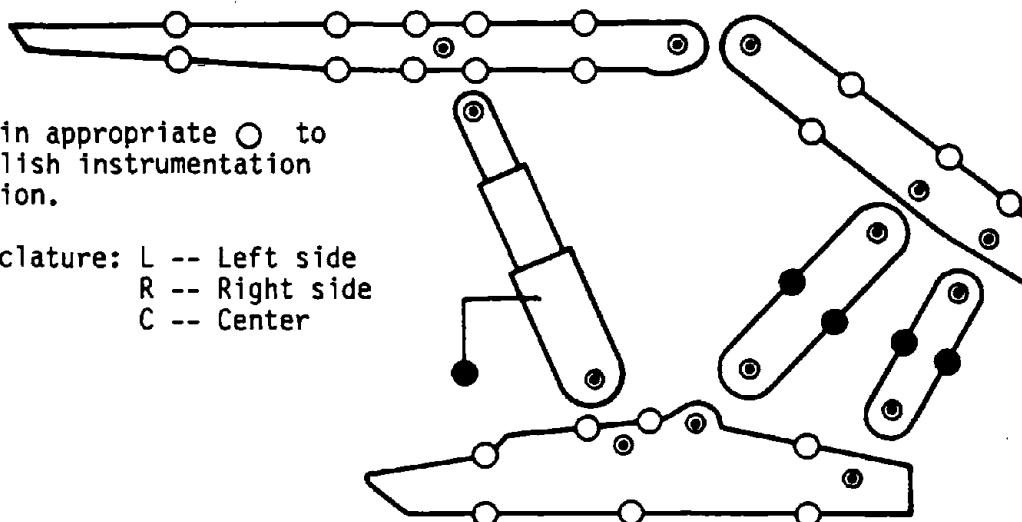


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### INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ○ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## SHIELD STIFFNESS

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Shield Stiffness - STFU05 and STFU06

TEST SERIES: Resistance Characteristics        Stability         
 Shield Stiffness xx Load Transfer         
 Leg Mechanics        Structural Integrity       

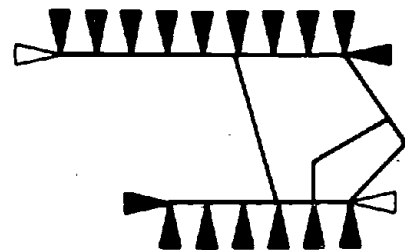
OBJECTIVE: Determine shield stiffness - unconstrained initial condition for full canopy and base contact configuration using linear elastic shield stiffness model. (Waste-to-face horz. displ.)

TEST PROCEDURE: Apply controlled vertical displacement and measure vertical and horizontal shield reactions. Compute K1 as ratio of vertical force to vertical displacement and K3 as ratio of horizontal force to vertical displacement. Apply horizontal displacement. Compute K2 as ratio of vertical force to horz displacement and K4 as ratio of horz. force to horz. displ.

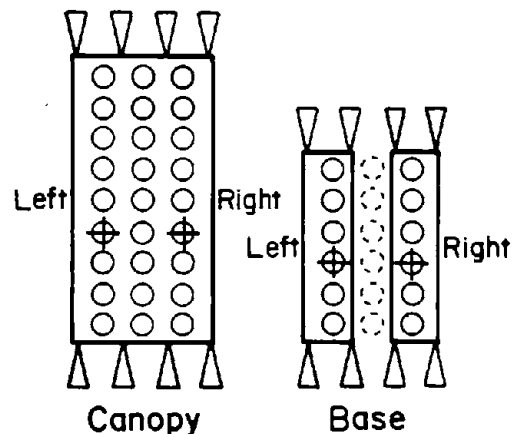
TEST FRAME: Static        Active xxx  
SHIELD CONFIGURATION: Shield Height H1,H2 in  
 Leg inclination  $\alpha 1, \alpha 2$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

BOUNDARY CONDITIONS: Constrained        Unconstrained xxx

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



# SHIELD STIFFNESS

79

## LOAD APPLICATION:

### CONTROL PARAMETERS AND LOADING RATES:

|                                       |            |          |
|---------------------------------------|------------|----------|
| Vertical Force                        | _____      | kips/min |
| Face-to-waste Horizontal Force        | _____      | kips/min |
| Waste-to-face Horizontal Force        | _____      | kips/min |
| Vertical Displacement                 | <u>0.1</u> | in/min   |
| Face-to-waste Horizontal Displacement | _____      | in/min   |
| Waste-to-face Horizontal Displacement | <u>0.1</u> | in/min   |
| Leg Pressure                          | _____      | psi/min  |
| Cycles per minute                     | _____      | cyc/min  |

### LOAD SEQUENCE:

|                                      |       |                      |            |
|--------------------------------------|-------|----------------------|------------|
| Vertical only                        | _____ | Vertical--Horizontal | <u>xxx</u> |
| Horizontal only                      | _____ | Horizontal--Vertical | _____      |
| Simultaneous vertical and horizontal | _____ |                      | _____      |

### DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Horizontal Force | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | _____     |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Horizontal Force | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Strain Channels  | vs Number of cycles      | _____     |                            |           |

### Comments:

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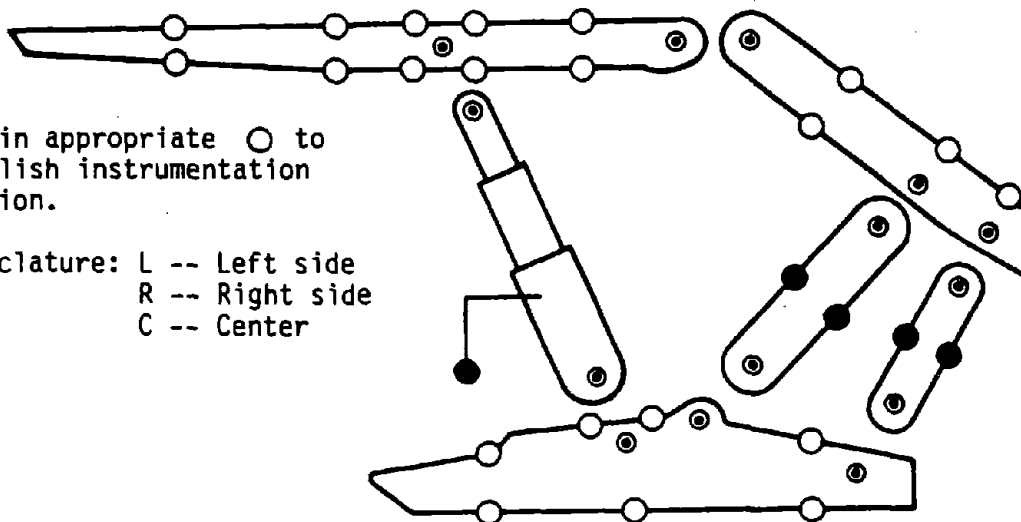


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### INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ☐ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## SHIELD STIFFNESS

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Shield Stiffness - STFU07 and STFU08

TEST SERIES: Resistance Characteristics        Stability         
 Shield Stiffness xx Load Transfer         
 Leg Mechanics        Structural Integrity       

OBJECTIVE: Determine shield stiffness - unconstrained initial condition for two-point canopy and base contact configuration using elastic shield stiffness model. (Waste-to-face horz. displ.)

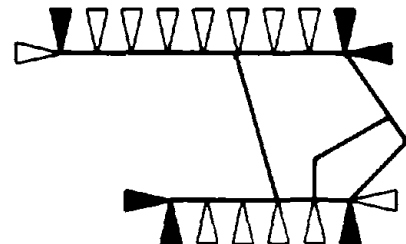
TEST PROCEDURE: Repeat test procedures for Tests STFU05 and STFU06.

TEST FRAME: Static        Active xxx

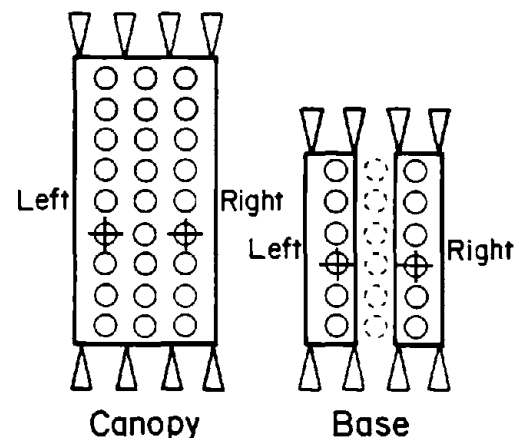
SHIELD CONFIGURATION: Shield Height H1,H2 in  
 Leg inclination  $\alpha_1, \alpha_2$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

BOUNDARY CONDITIONS: → Constrained        Unconstrained xxx

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



# SHIELD STIFFNESS

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## LOAD APPLICATION:

### CONTROL PARAMETERS AND LOADING RATES:

|                                       |       |          |
|---------------------------------------|-------|----------|
| Vertical Force                        | _____ | kips/min |
| Face-to-waste Horizontal Force        | _____ | kips/min |
| Waste-to-face Horizontal Force        | _____ | kips/min |
| Vertical Displacement                 | 0.1   | in/min   |
| Face-to-waste Horizontal Displacement | _____ | in/min   |
| Waste-to-face Horizontal Displacement | 0.1   | in/min   |
| Leg Pressure                          | _____ | psi/min  |
| Cycles per minute                     | _____ | cyc/min  |

### LOAD SEQUENCE:

|                                      |       |                      |       |
|--------------------------------------|-------|----------------------|-------|
| Vertical only                        | _____ | Vertical--Horizontal | xxx   |
| Horizontal only                      | _____ | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal | _____ |                      | _____ |

### DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |       |                            |       |
|------------------|--------------------------|-------|----------------------------|-------|
| Vertical Force   | vs Vertical Displacement | xx    | vs Horizontal Displacement | xx    |
| Horizontal Force | vs Vertical Displacement | xx    | vs Horizontal Displacement | xx    |
| Strain Channels  | vs Vertical Displacement | _____ | vs Horizontal Displacement | _____ |
| Strain Channels  | vs Vertical Force        | _____ | vs Horizontal Force        | _____ |
| Strain Channels  | vs Sum of Leg Pressures  | _____ | vs Individual Leg Pressure | _____ |
| Vertical Force   | vs Sum of Leg Pressures  | _____ | vs Individual Leg Pressure | _____ |
| Horizontal Force | vs Sum of Leg Pressures  | _____ | vs Individual Leg Pressure | _____ |
| Strain Channels  | vs Number of cycles      | _____ |                            |       |

### Comments:

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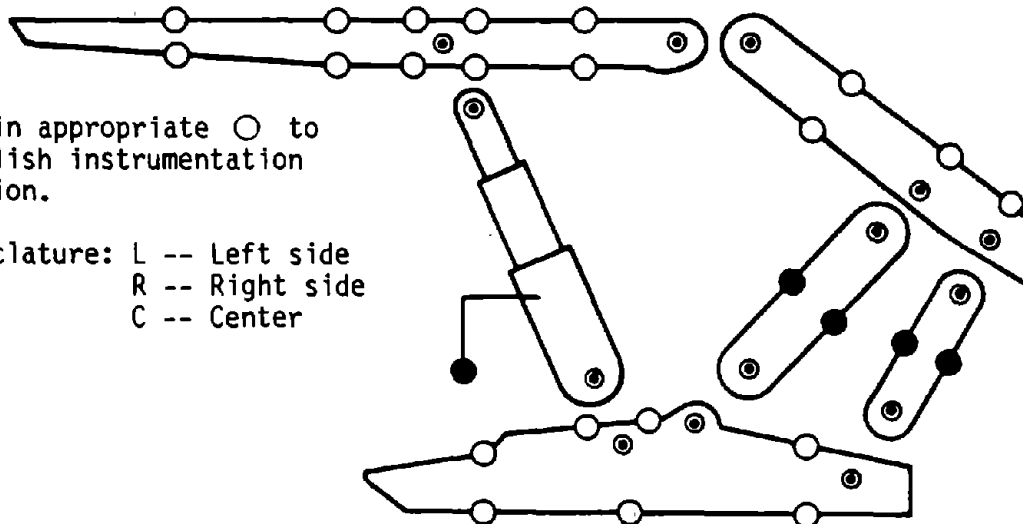


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### INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ○ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## LEG MECHANICS

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Leg Mechanics - Yield Pressure. Tests LEGCAP01 and LEGCA002

TEST SERIES: Resistance Characteristics \_\_\_\_\_ Stability \_\_\_\_\_  
 Shield Stiffness \_\_\_\_\_ Load Transfer \_\_\_\_\_  
 Leg Mechanics xx Structural Integrity \_\_\_\_\_

OBJECTIVE: Determine: (1) capability of shield and legs to yield at \_\_\_\_\_  
 specified pressures; (2) reduction in support resistance and \_\_\_\_\_  
 displacement between yields; (3) comparison of leg stiffness. \_\_\_\_\_

TEST PROCEDURE: Apply vertical displacement to shield until leg pressure is \_\_\_\_\_  
 reached. Continue to provide vertical displacement through \_\_\_\_\_  
 succession of leg yields. \_\_\_\_\_

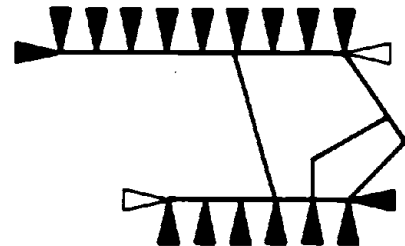
Conduct tests at low and high shield height. \_\_\_\_\_

TEST FRAME: Static \_\_\_\_\_ Active xxx

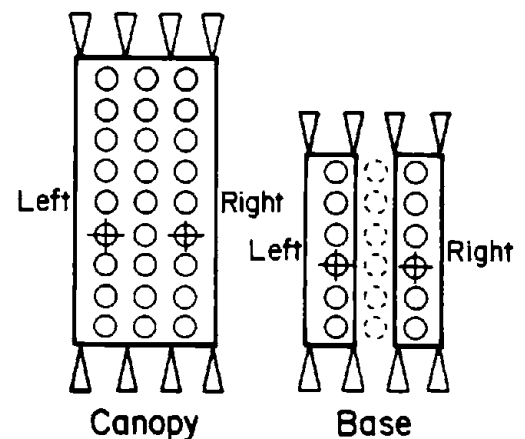
SHIELD CONFIGURATION: Shield Height H1, H2 in \_\_\_\_\_  
 Leg inclination  $\alpha_1, \alpha_2$  degrees from vertical \_\_\_\_\_  
 Canopy rotation 0 degrees from horizontal \_\_\_\_\_  
 Setting Pressure 3000 psi \_\_\_\_\_

BOUNDARY CONDITIONS:  Constrained \_\_\_\_\_ Unconstrained xxx

Fill in appropriate  $\nabla$  to  
 establish symmetric  
 contact configuration



Fill in appropriate  $\bigcirc$  to  
 establish unsymmetric contact  
 configuration



## LEG MECHANICS

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### LOAD APPLICATION:

### CONTROL PARAMETERS AND LOADING RATES:

|                                       |            |          |
|---------------------------------------|------------|----------|
| Vertical Force                        | _____      | kips/min |
| Face-to-waste Horizontal Force        | _____      | kips/min |
| Waste-to-face Horizontal Force        | _____      | kips/min |
| Vertical Displacement                 | <u>0.1</u> | in/min   |
| Face-to-waste Horizontal Displacement | _____      | in/min   |
| Waste-to-face Horizontal Displacement | _____      | in/min   |
| Leg Pressure                          | _____      | psi/min  |
| Cycles per minute                     | _____      | cyc/min  |

### LOAD SEQUENCE:

|                                      |            |                      |       |
|--------------------------------------|------------|----------------------|-------|
| Vertical only                        | <u>xxx</u> | Vertical--Horizontal | _____ |
| Horizontal only                      | _____      | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal |            |                      | _____ |

### DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | _____     |
| Horizontal Force | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | _____     |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Strain Channels  | vs Number of cycles      | _____     |                            |           |

### Comments:

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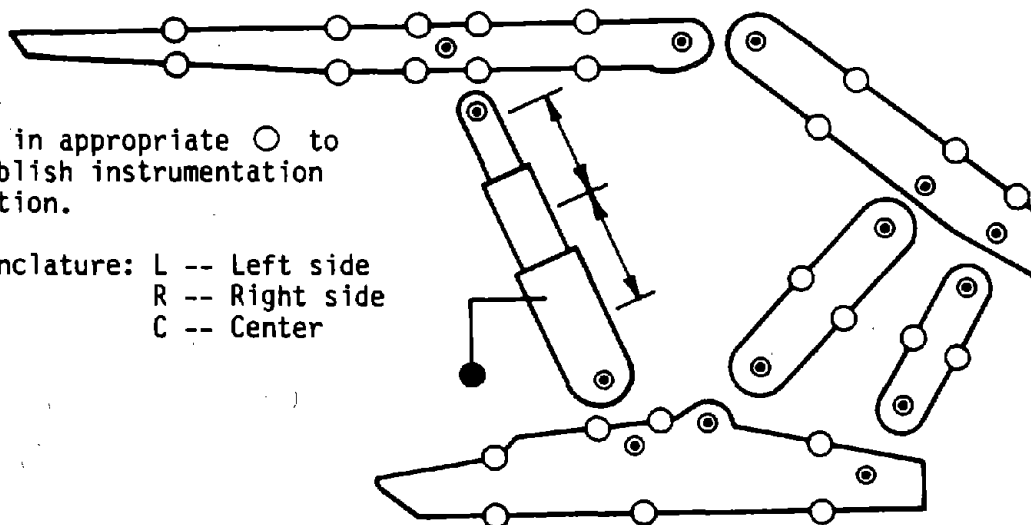


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### INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ☐ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## LEG MECHANICS

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Leg mechanics - Impact Load Yield. Test LEGYLD01

TEST SERIES: Resistance Characteristics        Stability         
 Shield Stiffness        Load Transfer         
 Leg Mechanics xx Structural Integrity       

OBJECTIVE: Determine ability of yield valves to effectively relieve pressure from impact loading without structural damage to casing or seal damage.

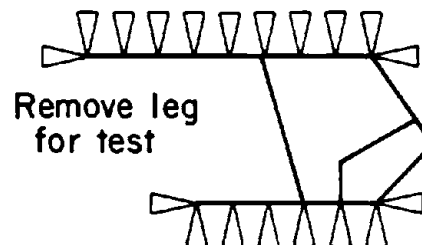
TEST PROCEDURE: Remove leg cylinder from shield. Install in fixture. Pressurize leg to yield pressure. Drop weight on leg to simulate impact loading. Conduct tests at two leg extensions. Note: Alternative procedure is to leave leg in shield and impact load entire shield. After test, inspect for seal leakage by loading leg and observing any bleedoff.

TEST FRAME: Static N/A Active N/A

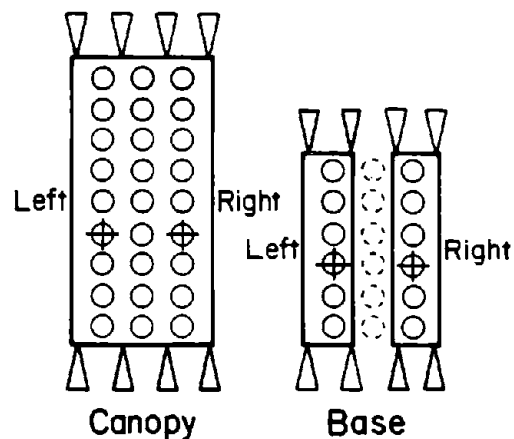
SHIELD CONFIGURATION: Shield Height H1,H2 in  
 Leg inclination 0 degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure yield psi

BOUNDARY CONDITIONS: → Constrained N/A Unconstrained N/A

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



## LOAD APPLICATION:

### CONTROL PARAMETERS AND LOADING RATES:

|                                       |                     |          |
|---------------------------------------|---------------------|----------|
| Vertical Force                        | _____               | kips/min |
| Face-to-waste Horizontal Force        | _____               | kips/min |
| Waste-to-face Horizontal Force        | _____               | kips/min |
| Vertical Displacement                 | _____ <u>Impact</u> | in/min   |
| Face-to-waste Horizontal Displacement | _____               | in/min   |
| Waste-to-face Horizontal Displacement | _____               | in/min   |
| Leg Pressure                          | _____               | psi/min  |
| Cycles per minute                     | _____               | cyc/min  |

### LOAD SEQUENCE:

|                                      |       |                      |       |
|--------------------------------------|-------|----------------------|-------|
| Vertical only                        | xxx   | Vertical--Horizontal | _____ |
| Horizontal only                      | _____ | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal | _____ |                      | _____ |

### DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |       |                            |       |
|------------------|--------------------------|-------|----------------------------|-------|
| Vertical Force   | vs Vertical Displacement | _____ | vs Horizontal Displacement | _____ |
| Horizontal Force | vs Vertical Displacement | _____ | vs Horizontal Displacement | _____ |
| Strain Channels  | vs Vertical Displacement | _____ | vs Horizontal Displacement | _____ |
| Strain Channels  | vs Vertical Force        | _____ | vs Horizontal Force        | _____ |
| Strain Channels  | vs Sum of Leg Pressures  | _____ | vs Individual Leg Pressure | _____ |
| Vertical Force   | vs Sum of Leg Pressures  | _____ | vs Individual Leg Pressure | xx    |
| Horizontal Force | vs Sum of Leg Pressures  | _____ | vs Individual Leg Pressure | _____ |
| Strain Channels  | vs Number of cycles      | _____ |                            |       |

### Comments:

Measure residual strain in leg cylinder casing.

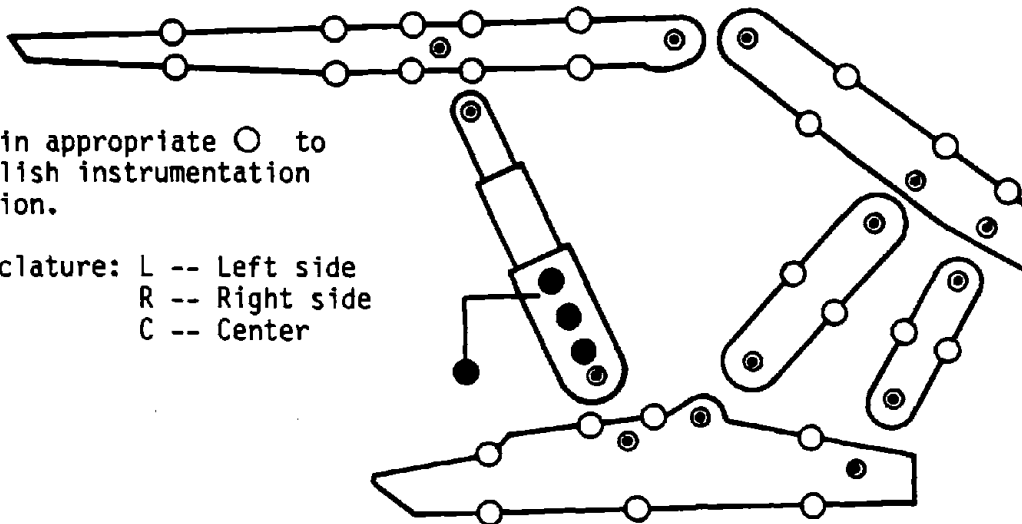
\_\_\_\_\_

\_\_\_\_\_

### INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ○ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## LEG MECHANICS

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Leg Mechanics - Leg Cylinder Area. Test LEGAC001

TEST SERIES: Resistance Characteristics \_\_\_\_\_ Stability \_\_\_\_\_  
 Shield Stiffness \_\_\_\_\_ Load Transfer \_\_\_\_\_  
 Leg Mechanics xx Structural Integrity \_\_\_\_\_

OBJECTIVE: Determine effective leg area for leg extension from active leg pressurization.

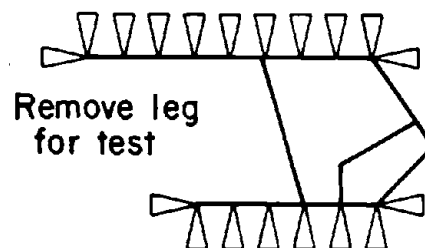
TEST PROCEDURE: Remove leg from shield. Install in test fixture in vertical orientation. Collapse leg to lowest position. Raise to height H1. Set leg at designated setting pressure. Measure setting force applied to test frame. Raise to height H2. Repeat test. Raise to height H3. Repeat test. Heights H2 or H3 should produce full extension of bottom leg stage.

TEST FRAME: Static \_\_\_\_\_ Active xxx

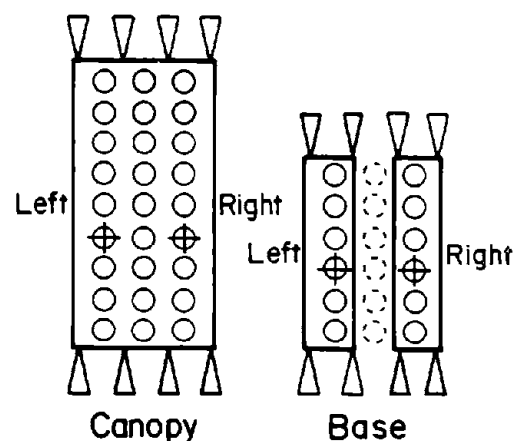
SHIELD CONFIGURATION: Shield Height H1,H2,H3 in \_\_\_\_\_  
 Leg inclination  $\alpha_1, \alpha_2, \alpha_3$  degrees from vertical \_\_\_\_\_  
 Canopy rotation 0 degrees from horizontal \_\_\_\_\_  
 Setting Pressure 3000 psi \_\_\_\_\_

BOUNDARY CONDITIONS: → Constrained N/A Unconstrained N/A

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



LOAD APPLICATION:CONTROL PARAMETERS  
AND LOADING RATES:

|                                       |             |          |
|---------------------------------------|-------------|----------|
| Vertical Force                        | _____       | kips/min |
| Face-to-waste Horizontal Force        | _____       | kips/min |
| Waste-to-face Horizontal Force        | _____       | kips/min |
| Vertical Displacement                 | <u>Hold</u> | in/min   |
| Face-to-waste Horizontal Displacement | _____       | in/min   |
| Waste-to-face Horizontal Displacement | _____       | in/min   |
| Leg Pressure                          | _____       | psi/min  |
| Cycles per minute                     | _____       | cyc/min  |

LOAD SEQUENCE:

|                                      |             |                      |       |
|--------------------------------------|-------------|----------------------|-------|
| Vertical only                        | <u>Hold</u> | Vertical--Horizontal | _____ |
| Horizontal only                      | _____       | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal |             |                      | _____ |

DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |       |                            |           |
|------------------|--------------------------|-------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | _____ | vs Horizontal Displacement | _____     |
| Horizontal Force | vs Vertical Displacement | _____ | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Displacement | _____ | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Force        | _____ | vs Horizontal Force        | _____     |
| Strain Channels  | vs Sum of Leg Pressures  | _____ | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | _____ | vs Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs Sum of Leg Pressures  | _____ | vs Individual Leg Pressure | _____     |
| Strain Channels  | vs Number of cycles      | _____ |                            |           |

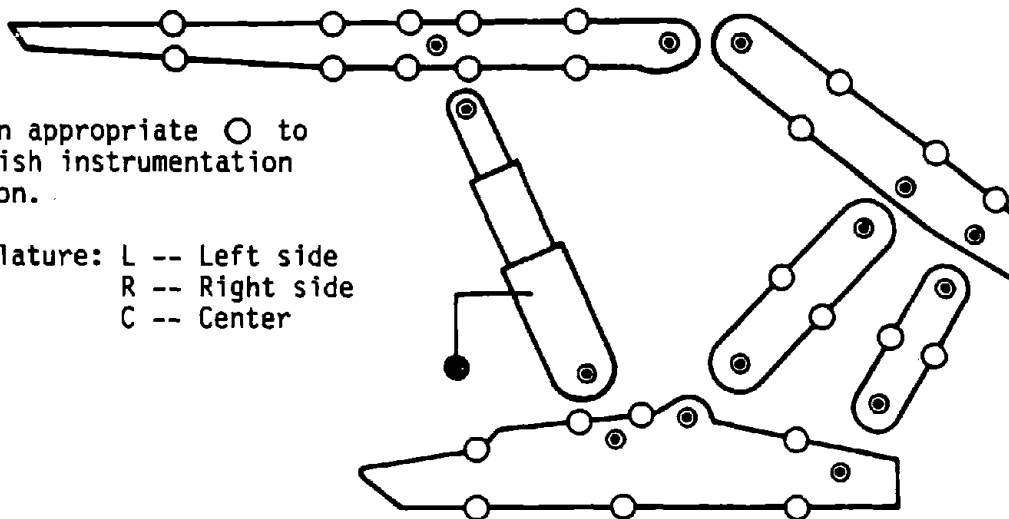
Comments:

Provide plot of effective leg area (computed as ratio of vertical force to leg pressure) as a function of leg height.

INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ○ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## LEG MECHANICS

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Leg Mechanics - leg Cylinder Area. Test LEGAC001.

TEST SERIES: Resistance Characteristics \_\_\_\_\_ Stability \_\_\_\_\_  
 Shield Stiffness \_\_\_\_\_ Load Transfer \_\_\_\_\_  
 Leg Mechanics xx Structural Integrity \_\_\_\_\_

OBJECTIVE: Determine effective leg area for leg convergence.

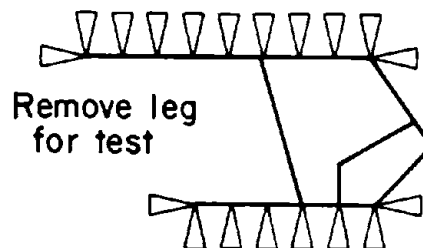
TEST PROCEDURE: Remove leg from shield. Install leg in test fixture in vertical orientation. Collapse leg to lowest position. Raise to height H1. Apply vertical displacement. Measure applied vertical force and leg pressure. Compute effective area as ratio of force to leg pressure. Raise to height H2. Repeat test. Raise to height H3. Repeat test.

TEST FRAME: Static \_\_\_\_\_ Active xxx

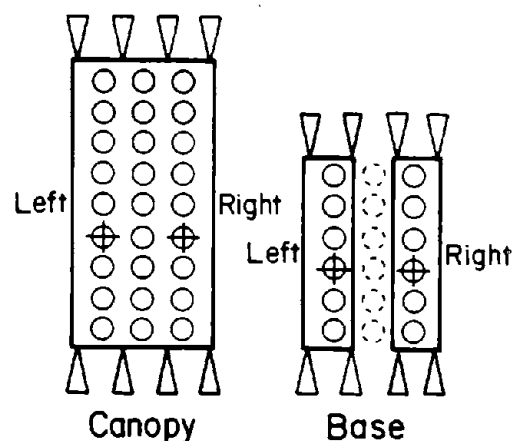
SHIELD CONFIGURATION: Shield Height H1,H2,H3 in  
 Leg inclination  $\alpha 1, \alpha 2, \alpha 3$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

BOUNDARY CONDITIONS:  Constrained N/A Unconstrained N/A

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



## LEG MECHANICS

89

### LOAD APPLICATION:

#### CONTROL PARAMETERS AND LOADING RATES:

|                                       |       |          |
|---------------------------------------|-------|----------|
| Vertical Force                        | _____ | kips/min |
| Face-to-waste Horizontal Force        | _____ | kips/min |
| Waste-to-face Horizontal Force        | _____ | kips/min |
| Vertical Displacement                 | 0.1   | in/min   |
| Face-to-waste Horizontal Displacement | _____ | in/min   |
| Waste-to-face Horizontal Displacement | _____ | in/min   |
| Leg Pressure                          | _____ | psi/min  |
| Cycles per minute                     | _____ | cyc/min  |

#### LOAD SEQUENCE:

|                                      |       |                      |       |
|--------------------------------------|-------|----------------------|-------|
| Vertical only                        | xxx   | Vertical--Horizontal | _____ |
| Horizontal only                      | _____ | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal |       |                      | _____ |

### DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |       |                            |       |
|------------------|--------------------------|-------|----------------------------|-------|
| Vertical Force   | vs Vertical Displacement | _____ | vs Horizontal Displacement | _____ |
| Horizontal Force | vs Vertical Displacement | _____ | vs Horizontal Displacement | _____ |
| Strain Channels  | vs Vertical Displacement | _____ | vs Horizontal Displacement | _____ |
| Strain Channels  | vs Vertical Force        | _____ | vs Horizontal Force        | _____ |
| Strain Channels  | vs Sum of Leg Pressures  | _____ | vs Individual Leg Pressure | _____ |
| Vertical Force   | vs Sum of Leg Pressures  | _____ | vs Individual Leg Pressure | xx    |
| Horizontal Force | vs Sum of Leg Pressures  | _____ | vs Individual Leg Pressure | _____ |
| Strain Channels  | vs Number of cycles      | _____ |                            |       |

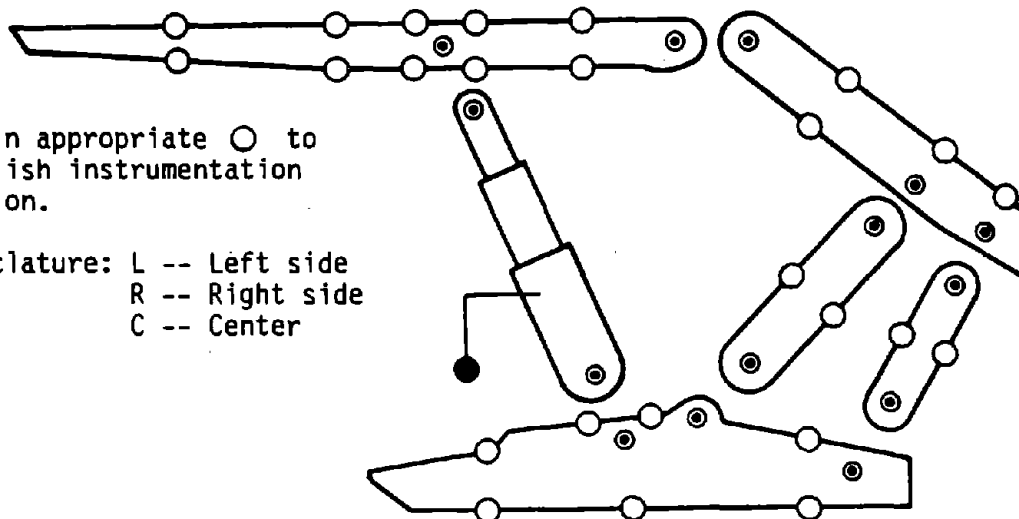
#### Comments:

Provide plot of effective leg area (computed as ratio  
vertical force to leg pressure) as a function of leg  
height.

### INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ○ to  
establish instrumentation  
location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## LEG MECHANICS

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Leg Mechanics - Setting Force. Tests LEGSET01 thru LEGSET03

TEST SERIES: Resistance Characteristics \_\_\_\_\_ Stability \_\_\_\_\_  
 Shield Stiffness \_\_\_\_\_ Load Transfer \_\_\_\_\_  
 Leg Mechanics xx Structural Integrity \_\_\_\_\_

OBJECTIVE: Determine shield setting force as a function of shield height for constant setting pressure.

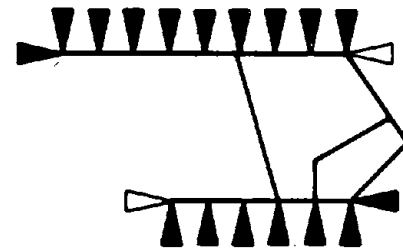
TEST PROCEDURE: Collapse shield completely. Raise to height H1. Set shield at designated setting pressure. Measure setting (vertical and horizontal) force applied to test frame. Raise shield to height H2. Repeat test. Raise to height H3. Repeat test. Do not lower shield between tests. At least one test height should produce full extension of bottom leg stage.

TEST FRAME: Static \_\_\_\_\_ Active xxx

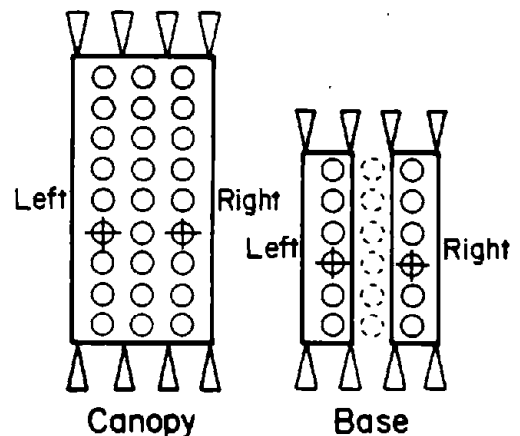
SHIELD CONFIGURATION: Shield Height H1,H2,H3 in \_\_\_\_\_  
 Leg inclination a1,a2,a3 degrees from vertical \_\_\_\_\_  
 Canopy rotation 0 degrees from horizontal \_\_\_\_\_  
 Setting Pressure \_\_\_\_\_ psi

BOUNDARY CONDITIONS: → Constrained \_\_\_\_\_ Unconstrained xxx

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



## LEG MECHANICS

91

### LOAD APPLICATION:

### CONTROL PARAMETERS AND LOADING RATES:

|                                       |             |          |
|---------------------------------------|-------------|----------|
| Vertical Force                        | _____       | kips/min |
| Face-to-waste Horizontal Force        | _____       | kips/min |
| Waste-to-face Horizontal Force        | _____       | kips/min |
| Vertical Displacement                 | <u>Hold</u> | in/min   |
| Face-to-waste Horizontal Displacement | _____       | in/min   |
| Waste-to-face Horizontal Displacement | _____       | in/min   |
| Leg Pressure                          | _____       | psi/min  |
| Cycles per minute                     | _____       | cyc/min  |

### LOAD SEQUENCE:

|                                      |             |                      |       |
|--------------------------------------|-------------|----------------------|-------|
| Vertical only                        | <u>Hold</u> | Vertical--Horizontal | _____ |
| Horizontal only                      | _____       | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal |             |                      | _____ |

### DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Horizontal Force | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | _____     |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Strain Channels  | vs Number of cycles      | _____     |                            |           |

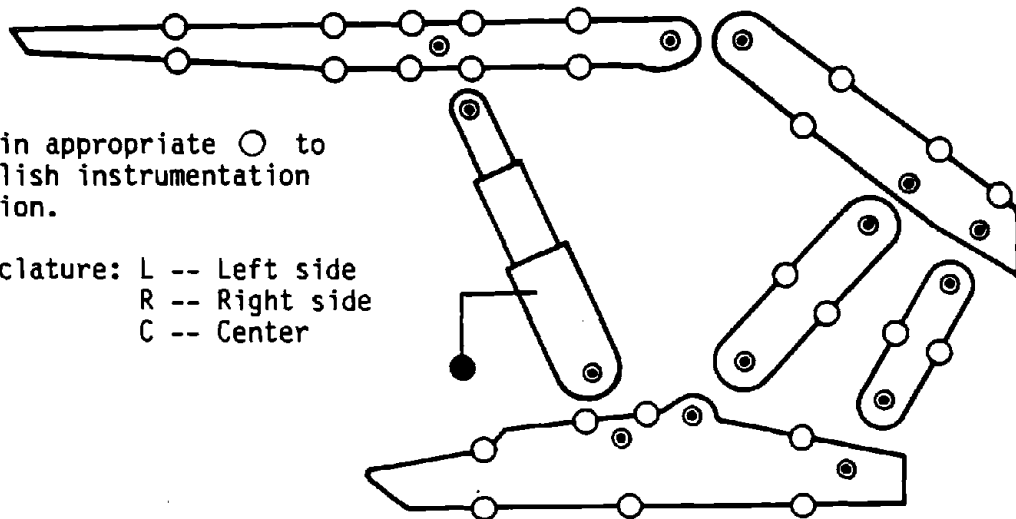
### Comments:

Provide plot of setting force as a function of shield  
height.

### INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ○ to  
establish instrumentation  
location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## STABILITY

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Shield Stability - Tip Resultant. STATIP01 and STATIP02

TEST SERIES: Resistance Characteristics \_\_\_\_\_ Stability xx  
 Shield Stiffness \_\_\_\_\_ Load Transfer \_\_\_\_\_  
 Leg Mechanics \_\_\_\_\_ Structural Integrity \_\_\_\_\_

OBJECTIVE: Evaluate shield stability for canopy contact forward of leg connection.  
 \_\_\_\_\_  
 \_\_\_\_\_

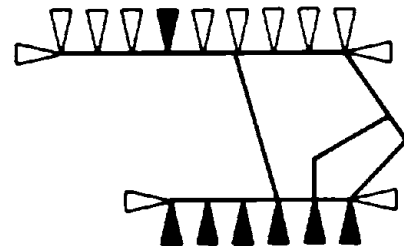
TEST PROCEDURE: Place contact at canopy leg connection. Apply vertical displacement until leg yields. Monitor canopy and base rotation. Observe rotations which change contact configuration. Move contact further towards tip and repeat test until instability is observed. Conduct test at low and high shield height.  
 \_\_\_\_\_  
 \_\_\_\_\_

TEST FRAME: Static \_\_\_\_\_ Active xxx

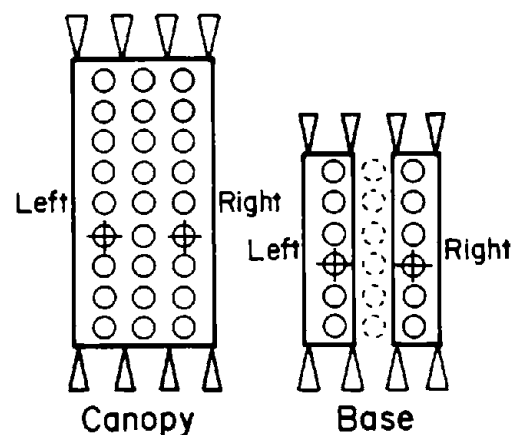
SHIELD CONFIGURATION: Shield Height H1,H2 in \_\_\_\_\_  
 Leg inclination  $\alpha 1, \alpha 2$  degrees from vertical \_\_\_\_\_  
 Canopy rotation 0 degrees from horizontal \_\_\_\_\_  
 Setting Pressure 3000 psi \_\_\_\_\_

BOUNDARY CONDITIONS:  Constrained \_\_\_\_\_ Unconstrained xxx

Fill in appropriate  to establish symmetric contact configuration



Fill in appropriate  to establish unsymmetric contact configuration



## LOAD APPLICATION:

### CONTROL PARAMETERS AND LOADING RATES:

|                                       |            |          |
|---------------------------------------|------------|----------|
| Vertical Force                        | _____      | kips/min |
| Face-to-waste Horizontal Force        | _____      | kips/min |
| Waste-to-face Horizontal Force        | _____      | kips/min |
| Vertical Displacement                 | <u>0.1</u> | in/min   |
| Face-to-waste Horizontal Displacement | _____      | in/min   |
| Waste-to-face Horizontal Displacement | _____      | in/min   |
| Leg Pressure                          | _____      | psi/min  |
| Cycles per minute                     | _____      | cyc/min  |

### LOAD SEQUENCE:

|                                      |            |                      |       |
|--------------------------------------|------------|----------------------|-------|
| Vertical only                        | <u>xxx</u> | Vertical--Horizontal | _____ |
| Horizontal only                      | _____      | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal |            |                      | _____ |

### DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |       |
|------------------|--------------------------|-----------|----------------------------|-------|
| Vertical Force   | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | _____ |
| Horizontal Force | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | _____ |
| Strain Channels  | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____ |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | _____ |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____ |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | _____ |
| Horizontal Force | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____ |
| Strain Channels  | vs Number of cycles      | _____     |                            |       |

### Comments:

\_\_\_\_\_

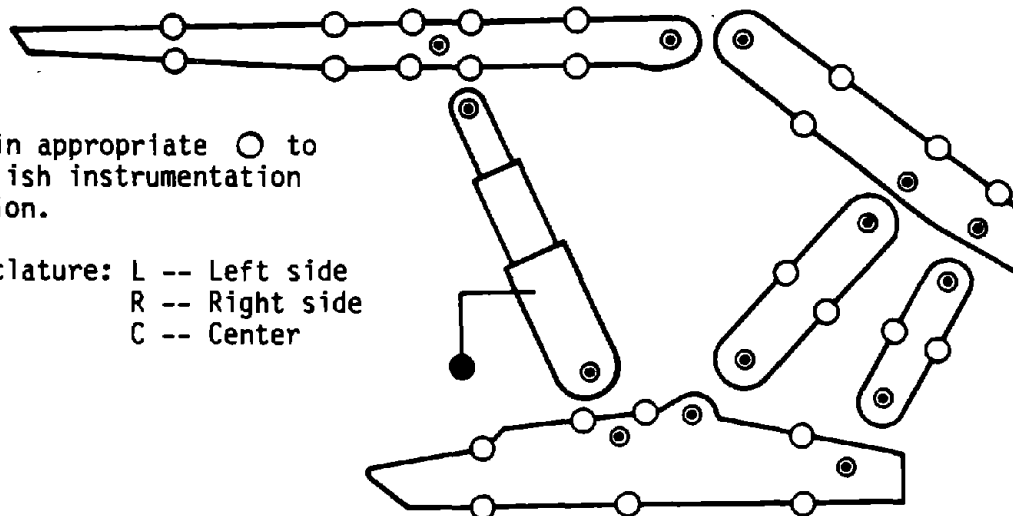
\_\_\_\_\_

\_\_\_\_\_

### INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ☐ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## STABILITY

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Shield Stability-Zero Horizontal Load. STAHOR01 and STAHOR02

TEST SERIES: Resistance Characteristics \_\_\_\_\_ Stability xx  
 Shield Stiffness \_\_\_\_\_ Load Transfer \_\_\_\_\_  
 Leg Mechanics \_\_\_\_\_ Structural Integrity \_\_\_\_\_

OBJECTIVE: Determine shield stability when there are no horizontal forces acting on the shield.

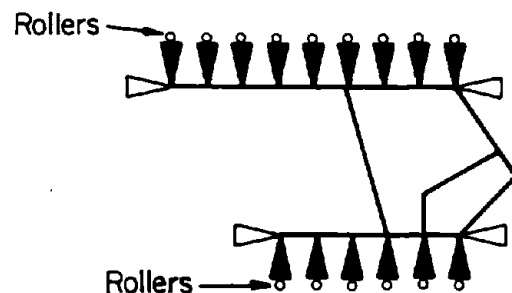
TEST PROCEDURE: Eliminate horizontal loading by allowing canopy and base to displace freely in horizontal direction by placing rollers on canopy and under base or by allowing loading platens to displace freely. Set shield. Apply vertical displacement to leg yield. Monitor horizontal displacement and link strain. Conduct tests at low and high shield height.

TEST FRAME: Static \_\_\_\_\_ Active xxx

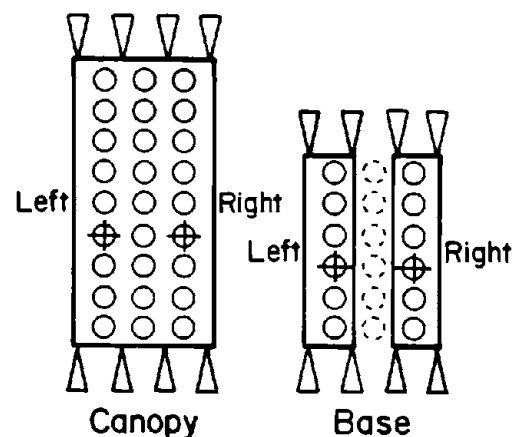
SHIELD CONFIGURATION: Shield Height H1,H2 in \_\_\_\_\_  
 Leg inclination  $\alpha 1, \alpha 2$  degrees from vertical \_\_\_\_\_  
 Canopy rotation 0 degrees from horizontal \_\_\_\_\_  
 Setting Pressure 3000 psi \_\_\_\_\_

BOUNDARY CONDITIONS: Constrained \_\_\_\_\_ Unconstrained xxx

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration





## STABILITY

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Shield Stability - Base-on-toe. STABOT01 and STABOT02

TEST SERIES: Resistance Characteristics \_\_\_\_\_ Stability \_\_\_\_\_  
 Shield Stiffness \_\_\_\_\_ Load Transfer xx  
 Leg Mechanics \_\_\_\_\_ Structural Integrity \_\_\_\_\_

OBJECTIVE: Determine shield stability for base-on-toe configuration  
 with waste-to-face horizontal displacement.

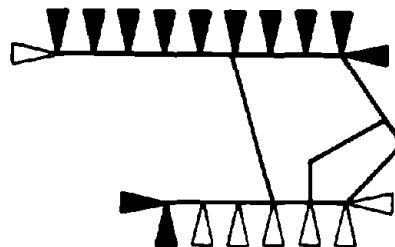
TEST PROCEDURE: Set shield in base-on-toe configuration. Apply vertical  
 displacement until leg pressure reaches 80 pct of yield  
 pressure. Apply waste-to-face horizontal displacement.  
 Monitor shield stability and link loading. Conduct test at  
 low and high shield height.

TEST FRAME: Static \_\_\_\_\_ Active xxx

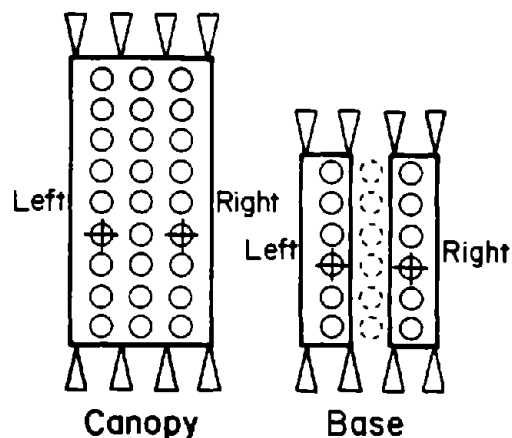
SHIELD CONFIGURATION: Shield Height H1,H2 in  
 Leg inclination  $\alpha 1, \alpha 2$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 0.80 yld psi

BOUNDARY CONDITIONS:  Constrained \_\_\_\_\_ Unconstrained xxx

Fill in appropriate  $\nabla$  to  
 establish symmetric  
 contact configuration



Fill in appropriate  $\bigcirc$  to  
 establish unsymmetric contact  
 configuration



# STABILITY

97

## LOAD APPLICATION:

### CONTROL PARAMETERS AND LOADING RATES:

|                                       |            |          |
|---------------------------------------|------------|----------|
| Vertical Force                        | _____      | kips/min |
| Face-to-waste Horizontal Force        | _____      | kips/min |
| Waste-to-face Horizontal Force        | _____      | kips/min |
| Vertical Displacement                 | <u>0.1</u> | in/min   |
| Face-to-waste Horizontal Displacement | _____      | in/min   |
| Waste-to-face Horizontal Displacement | <u>0.1</u> | in/min   |
| Leg Pressure                          | _____      | psi/min  |
| Cycles per minute                     | _____      | cyc/min  |

### LOAD SEQUENCE:

|                                      |       |                      |            |
|--------------------------------------|-------|----------------------|------------|
| Vertical only                        | _____ | Vertical--Horizontal | <u>xxx</u> |
| Horizontal only                      | _____ | Horizontal--Vertical | _____      |
| Simultaneous vertical and horizontal | _____ |                      | _____      |

### DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Horizontal Force | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Force        | <u>xx</u> | vs Horizontal Force        | <u>xx</u> |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | _____     |
| Horizontal Force | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | _____     |
| Strain Channels  | vs Number of cycles      | _____     |                            |           |

### Comments:

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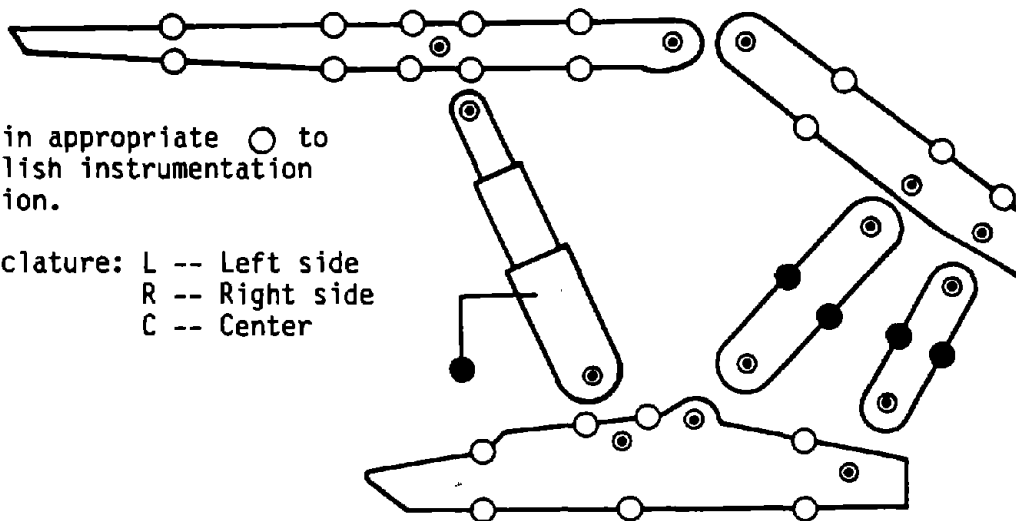


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### INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ☐ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## STABILITY

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Shield Stability - Base-on-rear. STABOR01 and STABOR02

TEST SERIES: Resistance Characteristics \_\_\_\_\_ Stability \_\_\_\_\_  
 Shield Stiffness \_\_\_\_\_ Load Transfer xx  
 Leg Mechanics \_\_\_\_\_ Structural Integrity \_\_\_\_\_

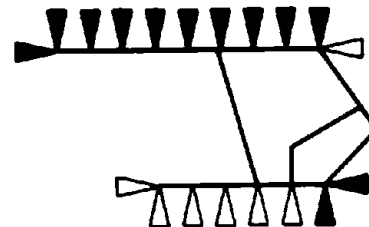
OBJECTIVE: Determine shield stability for base-on-rear configuration  
 with face-to-waste horizontal displacement.

TEST PROCEDURE: Set shield in base-on-rear configuration. Apply vertical displacement until leg pressure reaches 75 pct yield pressure. Apply face-to-waste horizontal displacement until leg pressure is reached or shield becomes unstable. Conduct tests at low and high shield height.

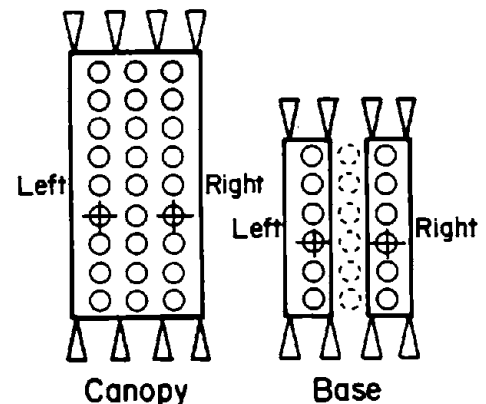
TEST FRAME: Static \_\_\_\_\_ Active xxx  
SHIELD CONFIGURATION: Shield Height H1,H2 in \_\_\_\_\_  
 Leg inclination  $\alpha 1, \alpha 2$  degrees from vertical \_\_\_\_\_  
 Canopy rotation 0 degrees from horizontal \_\_\_\_\_  
 Setting Pressure 3000 psi \_\_\_\_\_

BOUNDARY CONDITIONS:  Constrained \_\_\_\_\_ Unconstrained xxx

Fill in appropriate  to establish symmetric contact configuration



Fill in appropriate  to establish unsymmetric contact configuration



# STABILITY

99

## LOAD APPLICATION:

### CONTROL PARAMETERS AND LOADING RATES:

|                                       |            |          |
|---------------------------------------|------------|----------|
| Vertical Force                        | _____      | kips/min |
| Face-to-waste Horizontal Force        | _____      | kips/min |
| Waste-to-face Horizontal Force        | _____      | kips/min |
| Vertical Displacement                 | <u>0.1</u> | in/min   |
| Face-to-waste Horizontal Displacement | <u>0.1</u> | in/min   |
| Waste-to-face Horizontal Displacement | _____      | in/min   |
| Leg Pressure                          | _____      | psi/min  |
| Cycles per minute                     | _____      | cyc/min  |

### LOAD SEQUENCE:

|                                      |       |                      |            |
|--------------------------------------|-------|----------------------|------------|
| Vertical only                        | _____ | Vertical--Horizontal | <u>xxx</u> |
| Horizontal only                      | _____ | Horizontal--Vertical | _____      |
| Simultaneous vertical and horizontal | _____ |                      | _____      |

### DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |    |                       |           |    |                         |           |
|------------------|----|-----------------------|-----------|----|-------------------------|-----------|
| Vertical Force   | vs | Vertical Displacement | <u>xx</u> | vs | Horizontal Displacement | <u>xx</u> |
| Horizontal Force | vs | Vertical Displacement | <u>xx</u> | vs | Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs | Vertical Displacement | <u>xx</u> | vs | Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs | Vertical Force        | <u>xx</u> | vs | Horizontal Force        | <u>xx</u> |
| Strain Channels  | vs | Sum of Leg Pressures  | _____     | vs | Individual Leg Pressure | _____     |
| Vertical Force   | vs | Sum of Leg Pressures  | <u>xx</u> | vs | Individual Leg Pressure | _____     |
| Horizontal Force | vs | Sum of Leg Pressures  | <u>xx</u> | vs | Individual Leg Pressure | _____     |
| Strain Channels  | vs | Number of cycles      | _____     |    |                         |           |

### Comments:

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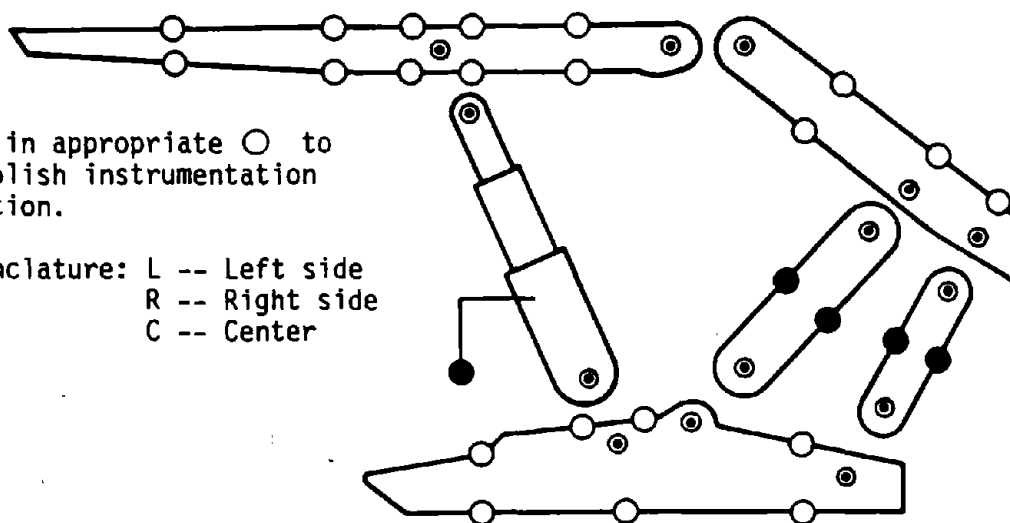


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### INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ☐ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## STABILITY

SUPPORT PERFORMANCE TEST REPORT

**TEST NAME:** Shield Stability - Leg Imbalance. STALEG01 and STALEG02

**TEST SERIES:** Resistance Characteristics \_\_\_\_\_ Stability \_\_\_\_\_  
 Shield Stiffness \_\_\_\_\_ Load Transfer xx  
 Leg Mechanics \_\_\_\_\_ Structural Integrity \_\_\_\_\_

**OBJECTIVE:** Determine shield stability for imbalanced leg pressure condition.

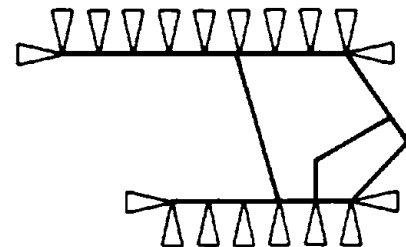
**TEST PROCEDURE:** Set shield with single point contact on canopy at one leg location. Relieve leg pressure in leg with no canopy contact and maintain zero leg pressure by routing hydraulic line to drain. Apply vertical displacement to shield until pressurized leg reaches yield or shield becomes unstable. Conduct tests at low and high shield height.

**TEST FRAME:** Static \_\_\_\_\_ Active xxx

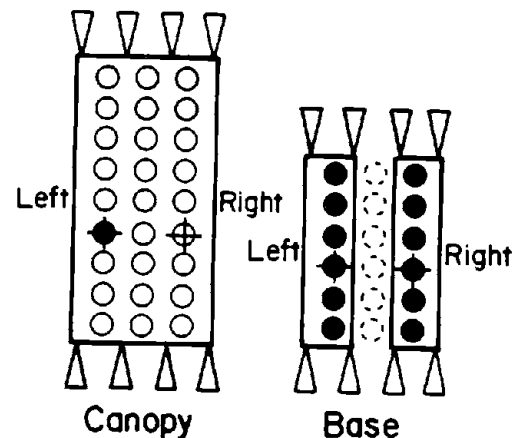
**SHIELD CONFIGURATION:** Shield Height H1,H2 in  
 Leg inclination a1,a2 degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

**BOUNDARY CONDITIONS:**  Constrained \_\_\_\_\_ Unconstrained xxx

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



## LOAD APPLICATION:

### CONTROL PARAMETERS AND LOADING RATES:

|                                       |            |          |
|---------------------------------------|------------|----------|
| Vertical Force                        | _____      | kips/min |
| Face-to-waste Horizontal Force        | _____      | kips/min |
| Waste-to-face Horizontal Force        | _____      | kips/min |
| Vertical Displacement                 | <u>0.1</u> | in/min   |
| Face-to-waste Horizontal Displacement | _____      | in/min   |
| Waste-to-face Horizontal Displacement | _____      | in/min   |
| Leg Pressure                          | _____      | psi/min  |
| Cycles per minute                     | _____      | cyc/min  |

### LOAD SEQUENCE:

|                                      |            |                      |            |
|--------------------------------------|------------|----------------------|------------|
| Vertical only                        | <u>xxx</u> | Vertical--Horizontal | <u>xxx</u> |
| Horizontal only                      | _____      | Horizontal--Vertical | _____      |
| Simultaneous vertical and horizontal | _____      |                      | _____      |

### DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |    |                       |           |    |                         |       |
|------------------|----|-----------------------|-----------|----|-------------------------|-------|
| Vertical Force   | vs | Vertical Displacement | <u>xx</u> | vs | Horizontal Displacement | _____ |
| Horizontal Force | vs | Vertical Displacement | <u>xx</u> | vs | Horizontal Displacement | _____ |
| Strain Channels  | vs | Vertical Displacement | <u>xx</u> | vs | Horizontal Displacement | _____ |
| Strain Channels  | vs | Vertical Force        | <u>xx</u> | vs | Horizontal Force        | _____ |
| Strain Channels  | vs | Sum of Leg Pressures  | _____     | vs | Individual Leg Pressure | _____ |
| Vertical Force   | vs | Sum of Leg Pressures  | <u>xx</u> | vs | Individual Leg Pressure | _____ |
| Horizontal Force | vs | Sum of Leg Pressures  | <u>xx</u> | vs | Individual Leg Pressure | _____ |
| Strain Channels  | vs | Number of cycles      | _____     |    |                         | _____ |

### Comments:

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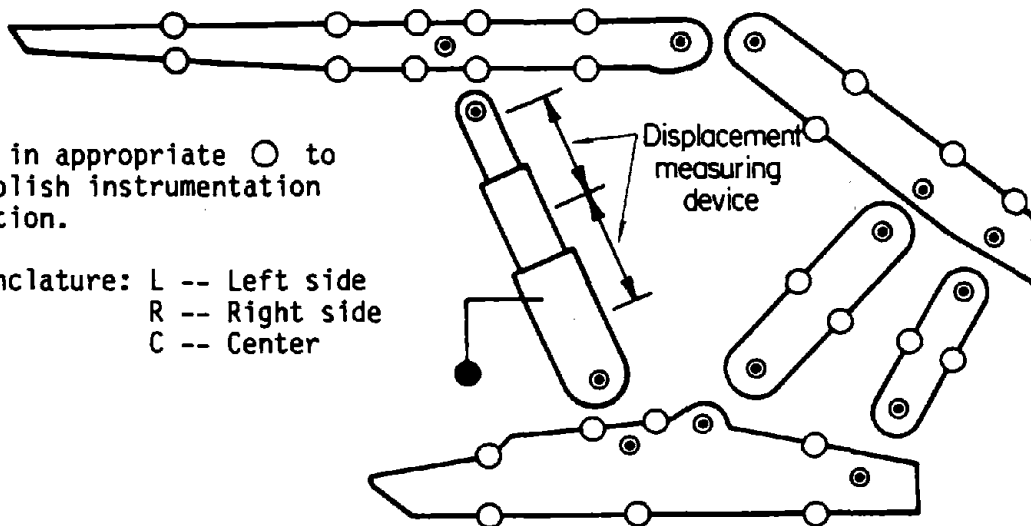


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### INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ☐ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## LOAD TRANSFER MECHANICS

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Load Transfer-Unconstrained Load Conditions. LTSUFW01 and 02

TEST SERIES: Resistance Characteristics \_\_\_\_\_ Stability \_\_\_\_\_  
 Shield Stiffness \_\_\_\_\_ Load Transfer xx  
 Leg Mechanics \_\_\_\_\_ Structural Integrity \_\_\_\_\_

OBJECTIVE: Determine load transfer mechanics for unconstrained shield conditions subject to vertical and face-to-waste horizontal displacements.

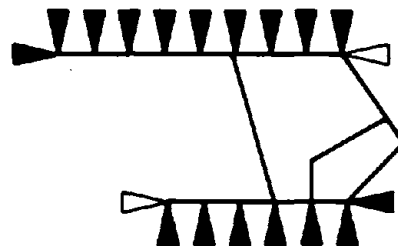
TEST PROCEDURE: Set shield in unconstrained configuration. Apply vertical displacement until leg pressure yield. Monitor loading in legs and caving shield - link assembly. Repeat tests for applied face-to-waste horizontal displacement.  
 Conduct tests at low and high shield height.

TEST FRAME: Static \_\_\_\_\_ Active xxx

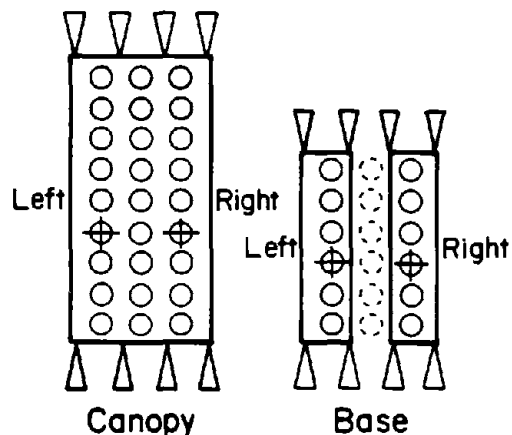
SHIELD CONFIGURATION: Shield Height H1,H2 in \_\_\_\_\_  
 Leg inclination  $\alpha 1, \alpha 2$  degrees from vertical \_\_\_\_\_  
 Canopy rotation 0 degrees from horizontal \_\_\_\_\_  
 Setting Pressure 3000 psi \_\_\_\_\_

BOUNDARY CONDITIONS:  Constrained \_\_\_\_\_ Unconstrained xxx

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



LOAD APPLICATION:CONTROL PARAMETERS  
AND LOADING RATES:

|                                       |            |          |
|---------------------------------------|------------|----------|
| Vertical Force                        | _____      | kips/min |
| Face-to-waste Horizontal Force        | _____      | kips/min |
| Waste-to-face Horizontal Force        | _____      | kips/min |
| Vertical Displacement                 | <u>0.1</u> | in/min   |
| Face-to-waste Horizontal Displacement | <u>0.1</u> | in/min   |
| Waste-to-face Horizontal Displacement | _____      | in/min   |
| Leg Pressure                          | _____      | psi/min  |
| Cycles per minute                     | _____      | cyc/min  |

LOAD SEQUENCE:

|                                      |            |                      |       |
|--------------------------------------|------------|----------------------|-------|
| Vertical only                        | <u>xxx</u> | Vertical--Horizontal | _____ |
| Horizontal only                      | <u>xxx</u> | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal |            |                      | _____ |

DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Horizontal Force | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | _____     |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Strain Channels  | vs Number of cycles      | _____     |                            |           |

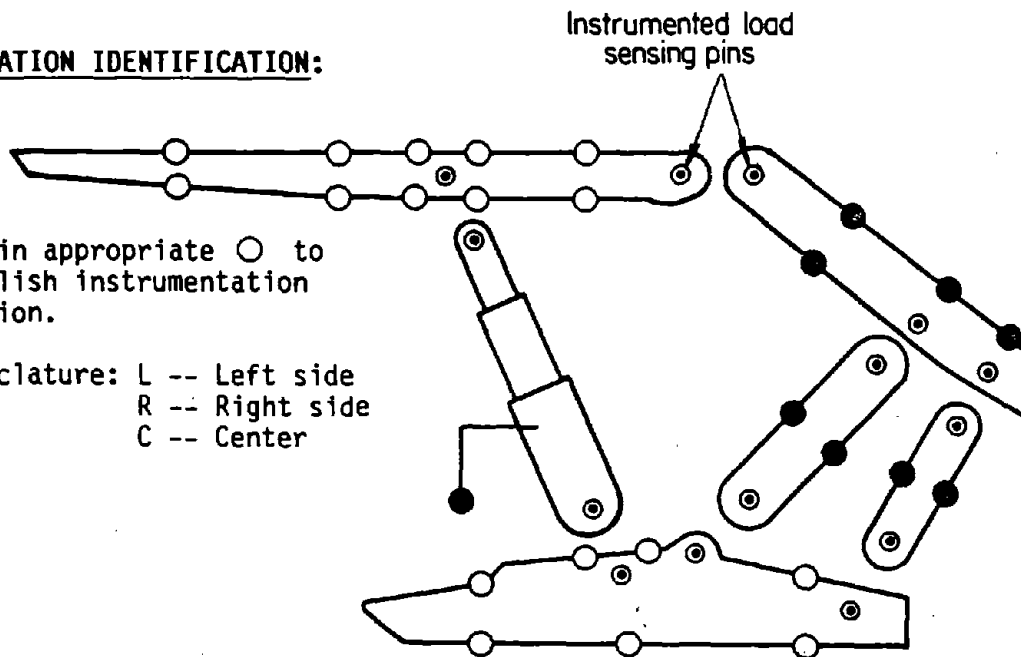
Comments:

Instrumented pin forces versus vertical displacement  
and horizontal displacement also available.

INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ☐ to  
establish instrumentation  
location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## LOAD TRANSFER MECHANICS

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Load Transfer-Unconstrained Load Conditions. LTSUWF01 and 02

TEST SERIES: Resistance Characteristics \_\_\_\_\_ Stability \_\_\_\_\_  
 Shield Stiffness \_\_\_\_\_ Load Transfer xx  
 Leg Mechanics \_\_\_\_\_ Structural Integrity \_\_\_\_\_

OBJECTIVE: Determine load transfer mechanics for unconstrained shield conditions subject to vertical and waste-to-face horizontal displacements.

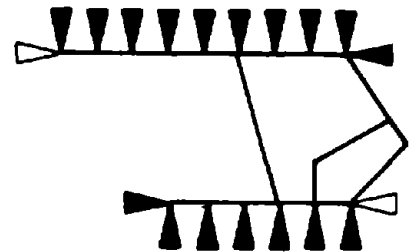
TEST PROCEDURE: Repeat tests LTSUFW01 and LTSUFW02 substituting waste-to-face horizontal displacement for face-to-waste horizontal displacement.

TEST FRAME: Static \_\_\_\_\_ Active xxx

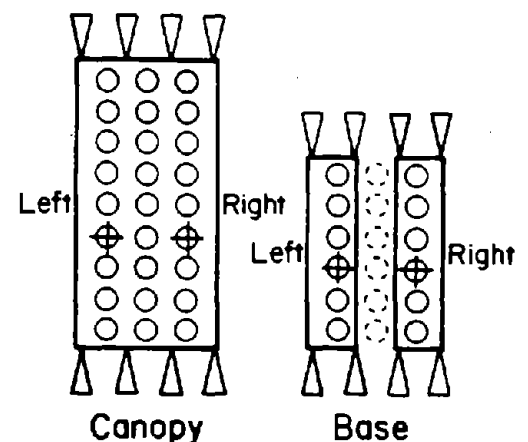
SHIELD CONFIGURATION: Shield Height H1,H2 in \_\_\_\_\_  
 Leg inclination  $\alpha 1, \alpha 2$  degrees from vertical \_\_\_\_\_  
 Canopy rotation 0 degrees from horizontal \_\_\_\_\_  
 Setting Pressure 3000 psi \_\_\_\_\_

BOUNDARY CONDITIONS:  Constrained \_\_\_\_\_ Unconstrained xxx

Fill in appropriate  to establish symmetric contact configuration



Fill in appropriate  to establish unsymmetric contact configuration



LOAD APPLICATION:CONTROL PARAMETERS  
AND LOADING RATES:

|                                       |            |          |
|---------------------------------------|------------|----------|
| Vertical Force                        | _____      | kips/min |
| Face-to-waste Horizontal Force        | _____      | kips/min |
| Waste-to-face Horizontal Force        | _____      | kips/min |
| Vertical Displacement                 | <u>0.1</u> | in/min   |
| Face-to-waste Horizontal Displacement | _____      | in/min   |
| Waste-to-face Horizontal Displacement | <u>0.1</u> | in/min   |
| Leg Pressure                          | _____      | psi/min  |
| Cycles per minute                     | _____      | cyc/min  |

LOAD SEQUENCE:

|                                      |            |                      |       |
|--------------------------------------|------------|----------------------|-------|
| Vertical only                        | <u>xxx</u> | Vertical--Horizontal | _____ |
| Horizontal only                      | <u>xxx</u> | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal |            |                      | _____ |

DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Horizontal Force | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | _____     |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Strain Channels  | vs Number of cycles      | _____     |                            |           |

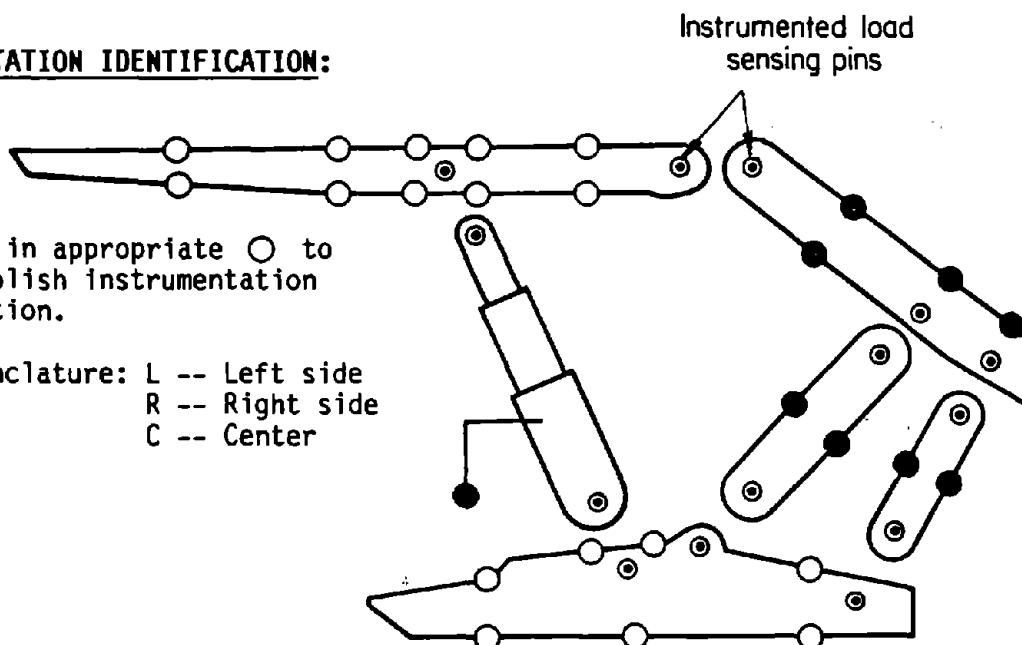
Comments:

Instrumented pin forces versus vertical displacement  
and horizontal displacement also available.

INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ○ to  
 establish instrumentation  
 location.

Nomenclature: L -- Left side  
 R -- Right side  
 C -- Center



## LOAD TRANSFER MECHANICS

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Load Transfer-Constrained Load Conditions. LTSCFW01 and 02

TEST SERIES: Resistance Characteristics \_\_\_\_\_ Stability \_\_\_\_\_  
 Shield Stiffness \_\_\_\_\_ Load Transfer xx  
 Leg Mechanics \_\_\_\_\_ Structural Integrity \_\_\_\_\_

OBJECTIVE: Determine load transfer mechanics for constrained shield  
 subjected to vertical and face-to-waste horizontal  
 displacement.

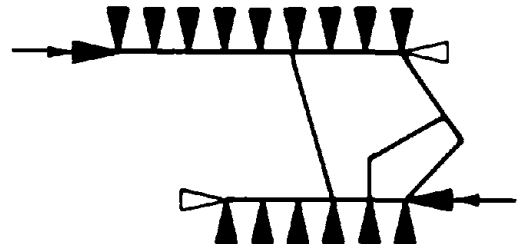
TEST PROCEDURE: Repeat Tests LTSUFW01 and LTSUFW02 for constrained initial  
 load conditions.

TEST FRAME: Static \_\_\_\_\_ Active xxx

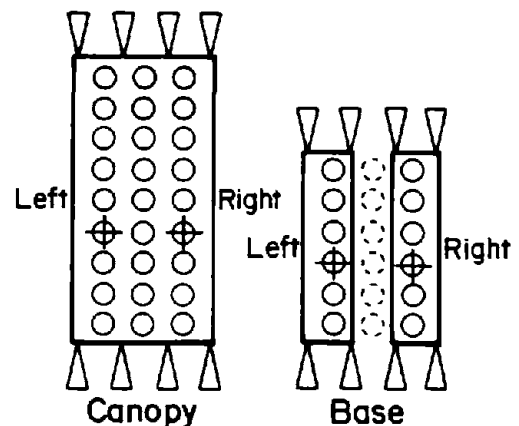
SHIELD CONFIGURATION: Shield Height H1,H2 in \_\_\_\_\_  
 Leg inclination  $\alpha_1, \alpha_2$  degrees from vertical \_\_\_\_\_  
 Canopy rotation 0 degrees from horizontal \_\_\_\_\_  
 Setting Pressure 3000 psi \_\_\_\_\_

BOUNDARY CONDITIONS:  Constrained xxx Unconstrained \_\_\_\_\_

Fill in appropriate  $\nabla$  to  
 establish symmetric  
 contact configuration



Fill in appropriate  $\bigcirc$  to  
 establish unsymmetric contact  
 configuration



LOAD APPLICATION:CONTROL PARAMETERS  
AND LOADING RATES:

|                                       |            |          |
|---------------------------------------|------------|----------|
| Vertical Force                        | _____      | kips/min |
| Face-to-waste Horizontal Force        | _____      | kips/min |
| Waste-to-face Horizontal Force        | _____      | kips/min |
| Vertical Displacement                 | <u>0.1</u> | in/min   |
| Face-to-waste Horizontal Displacement | <u>0.1</u> | in/min   |
| Waste-to-face Horizontal Displacement | _____      | in/min   |
| Leg Pressure                          | _____      | psi/min  |
| Cycles per minute                     | _____      | cyc/min  |

LOAD SEQUENCE:

|                                      |            |                      |       |
|--------------------------------------|------------|----------------------|-------|
| Vertical only                        | <u>xxx</u> | Vertical--Horizontal | _____ |
| Horizontal only                      | <u>xxx</u> | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal |            |                      | _____ |

DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Horizontal Force | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | _____     |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Strain Channels  | vs Number of cycles      | _____     |                            |           |

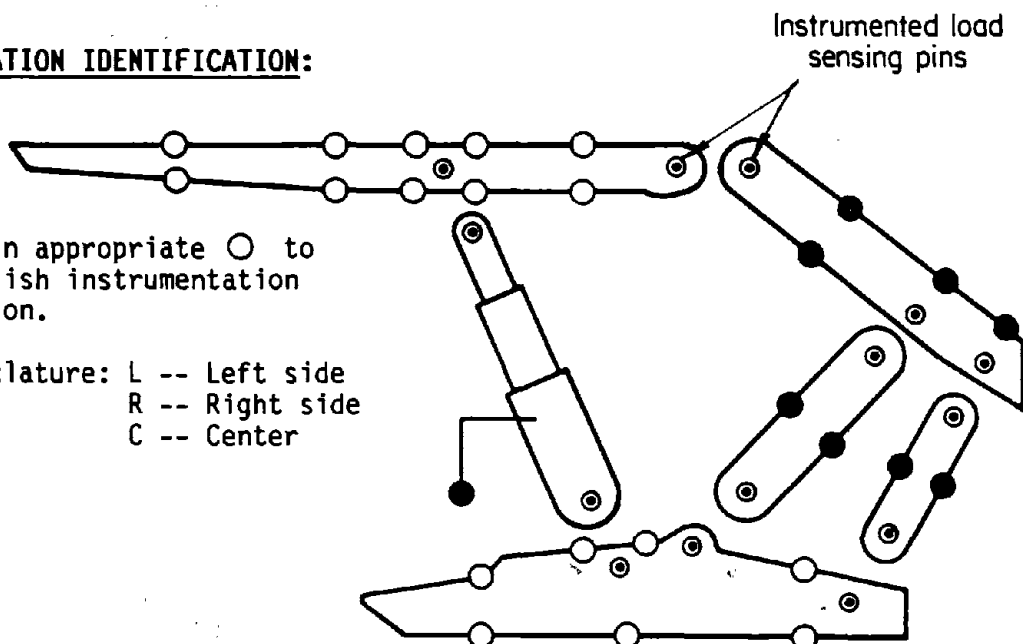
Comments:

Instrumented pin forces vs vertical displacement also  
available for analysis.

INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ○ to  
establish instrumentation  
location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## LOAD TRANSFER MECHANICS

SUPPORT PERFORMANCE TEST REPORTTEST NAME: Load Transfer - Constrained Load Conditions. LTSCWF01 and 02

TEST SERIES: Resistance Characteristics \_\_\_\_\_ Stability \_\_\_\_\_  
 Shield Stiffness \_\_\_\_\_ Load Transfer xx  
 Leg Mechanics \_\_\_\_\_ Structural Integrity \_\_\_\_\_

OBJECTIVE: Determine load transfer mechanics for constrained shield conditions subject to vertical and waste-to-face horizontal displacements.

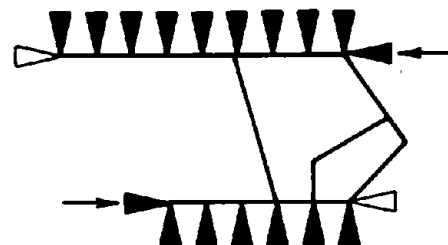
TEST PROCEDURE: Repeat tests LTSCFW01 and LTSCFW02 substituting waste-to-face horizontal displacement for face-to-waste horizontal displacement.

TEST FRAME: Static \_\_\_\_\_ Active xxx

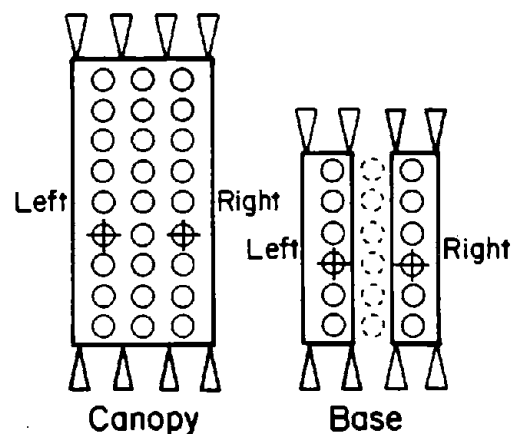
SHIELD CONFIGURATION: Shield Height H1,H2 in  
 Leg inclination  $\alpha_1, \alpha_2$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

BOUNDARY CONDITIONS:  Constrained xxx Unconstrained \_\_\_\_\_

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



# LOAD TRANSFER MECHANICS

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## LOAD APPLICATION:

### CONTROL PARAMETERS AND LOADING RATES:

|                                       |            |          |
|---------------------------------------|------------|----------|
| Vertical Force                        | _____      | kips/min |
| Face-to-waste Horizontal Force        | _____      | kips/min |
| Waste-to-face Horizontal Force        | _____      | kips/min |
| Vertical Displacement                 | <u>0.1</u> | in/min   |
| Face-to-waste Horizontal Displacement | _____      | in/min   |
| Waste-to-face Horizontal Displacement | <u>0.1</u> | in/min   |
| Leg Pressure                          | _____      | psi/min  |
| Cycles per minute                     | _____      | cyc/min  |

### LOAD SEQUENCE:

|                                      |            |                      |       |
|--------------------------------------|------------|----------------------|-------|
| Vertical only                        | <u>xxx</u> | Vertical--Horizontal | _____ |
| Horizontal only                      | <u>xxx</u> | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal |            |                      | _____ |

### DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Horizontal Force | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | _____     |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Strain Channels  | vs Number of cycles      | _____     |                            |           |

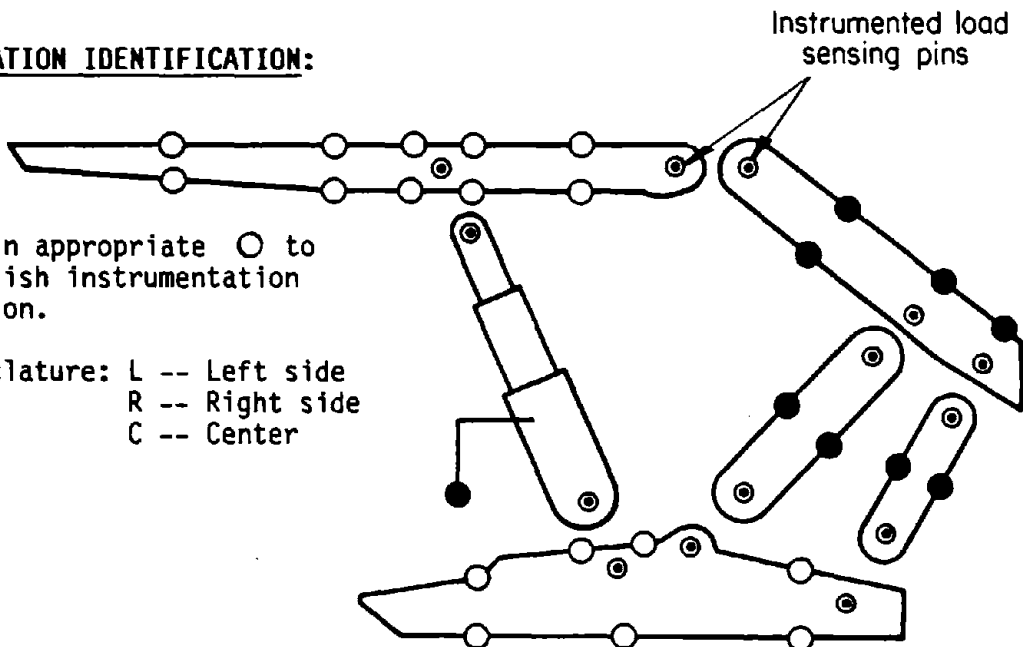
### Comments:

Instrumented pin forces versus vertical displacement  
and horizontal displacement also available.

### INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ☐ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## LOAD TRANSFER MECHANICS

SUPPORT PERFORMANCE TEST REPORTTEST NAME: Load Transfer-Unsymmetric Canopy Contact. LTSLEG

TEST SERIES: Resistance Characteristics \_\_\_\_\_ Stability \_\_\_\_\_  
 Shield Stiffness \_\_\_\_\_ Load Transfer xx  
 Leg Mechanics \_\_\_\_\_ Structural Integrity \_\_\_\_\_

OBJECTIVE: Determine load transfer mechanics for unsymmetric canopy contact at one leg location.

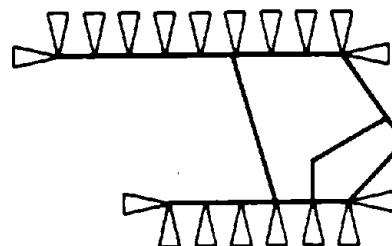
TEST PROCEDURE: Set shield in unsymmetric canopy contact at one leg location  
 Apply vertical and face-to-waste horizontal displacements.  
 Monitor load transfer through leg cylinders and individual lemniscate links.

TEST FRAME: Static \_\_\_\_\_ Active xxx

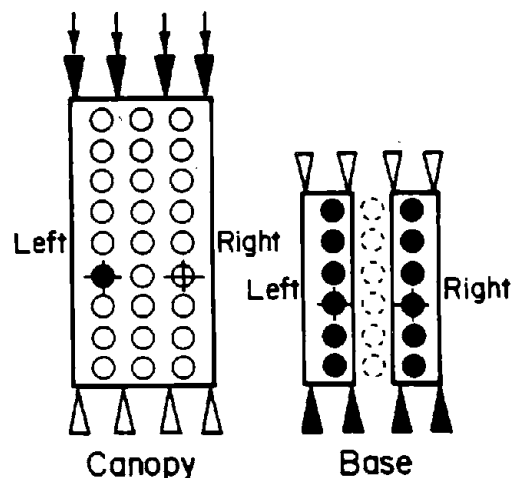
SHIELD CONFIGURATION: Shield Height H1 in  
 Leg inclination  $\alpha 1$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

BOUNDARY CONDITIONS:  Constrained xxx Unconstrained \_\_\_\_\_

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



LOAD APPLICATION:CONTROL PARAMETERS  
AND LOADING RATES:

|                                       |            |          |
|---------------------------------------|------------|----------|
| Vertical Force                        | _____      | kips/min |
| Face-to-waste Horizontal Force        | _____      | kips/min |
| Waste-to-face Horizontal Force        | _____      | kips/min |
| Vertical Displacement                 | <u>0.1</u> | in/min   |
| Face-to-waste Horizontal Displacement | <u>0.1</u> | in/min   |
| Waste-to-face Horizontal Displacement | _____      | in/min   |
| Leg Pressure                          | _____      | psi/min  |
| Cycles per minute                     | _____      | cyc/min  |

LOAD SEQUENCE:

|                                      |            |                      |       |
|--------------------------------------|------------|----------------------|-------|
| Vertical only                        | <u>xxx</u> | Vertical--Horizontal | _____ |
| Horizontal only                      | <u>xxx</u> | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal |            |                      | _____ |

DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Horizontal Force | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | _____     |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Strain Channels  | vs Number of cycles      | _____     |                            |           |

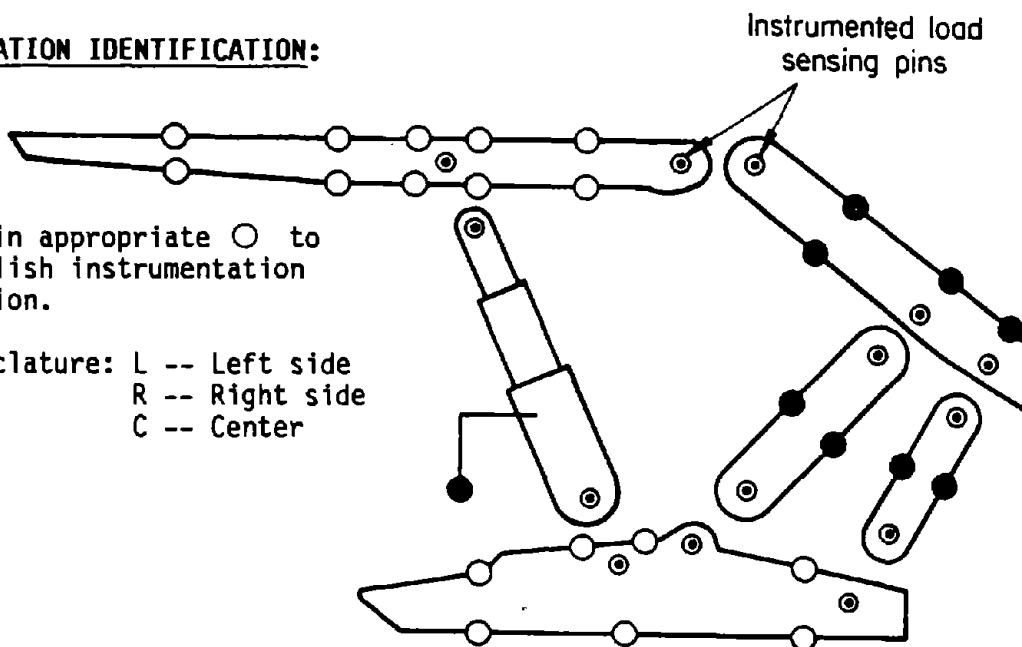
Comments:

Instrumented pin forces versus vertical displacement  
and horizontal displacement also available.

INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ○ to  
establish instrumentation  
location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## LOAD TRANSFER MECHANICS

## SUPPORT PERFORMANCE TEST REPORT

**TEST NAME:** Load Transfer-Unsymmetric Base-on-toe Contact. LTSBOT01

**TEST SERIES:** Resistance Characteristics \_\_\_\_\_ Stability \_\_\_\_\_  
 Shield Stiffness \_\_\_\_\_ Load Transfer xx  
 Leg Mechanics \_\_\_\_\_ Structural Integrity \_\_\_\_\_

**OBJECTIVE:** Determine load transfer mechanics for unsymmetric base-on-toe contact.

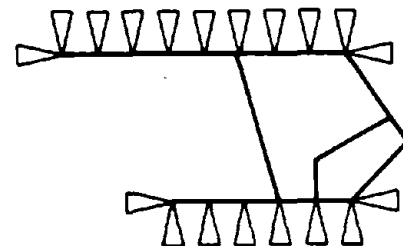
**TEST PROCEDURE:** Set shield in unsymmetric base-on-toe contact.  
 Apply vertical and face-to-waste horizontal displacements.  
 Monitor load transfer through leg cylinders and individual lemniscate links.

**TEST FRAME:** Static \_\_\_\_\_ Active xxx

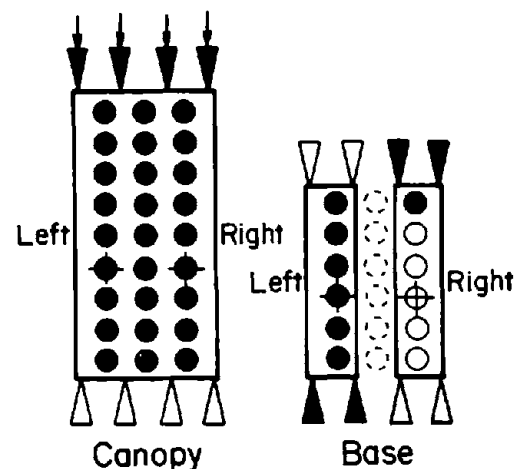
**SHIELD CONFIGURATION:** Shield Height H1 in  
 Leg inclination  $\alpha 1$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

**BOUNDARY CONDITIONS:**  $\rightarrow$  Constrained xxx Unconstrained \_\_\_\_\_

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



LOAD APPLICATION:CONTROL PARAMETERS  
AND LOADING RATES:

|                                       |            |          |
|---------------------------------------|------------|----------|
| Vertical Force                        | _____      | kips/min |
| Face-to-waste Horizontal Force        | _____      | kips/min |
| Waste-to-face Horizontal Force        | _____      | kips/min |
| Vertical Displacement                 | <u>0.1</u> | in/min   |
| Face-to-waste Horizontal Displacement | <u>0.1</u> | in/min   |
| Waste-to-face Horizontal Displacement | _____      | in/min   |
| Leg Pressure                          | _____      | psi/min  |
| Cycles per minute                     | _____      | cyc/min  |

LOAD SEQUENCE:

|                                      |            |                      |       |
|--------------------------------------|------------|----------------------|-------|
| Vertical only                        | <u>xxx</u> | Vertical--Horizontal | _____ |
| Horizontal only                      | <u>xxx</u> | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal |            |                      | _____ |

DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Horizontal Force | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | _____     |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Strain Channels  | vs Number of cycles      | _____     |                            |           |

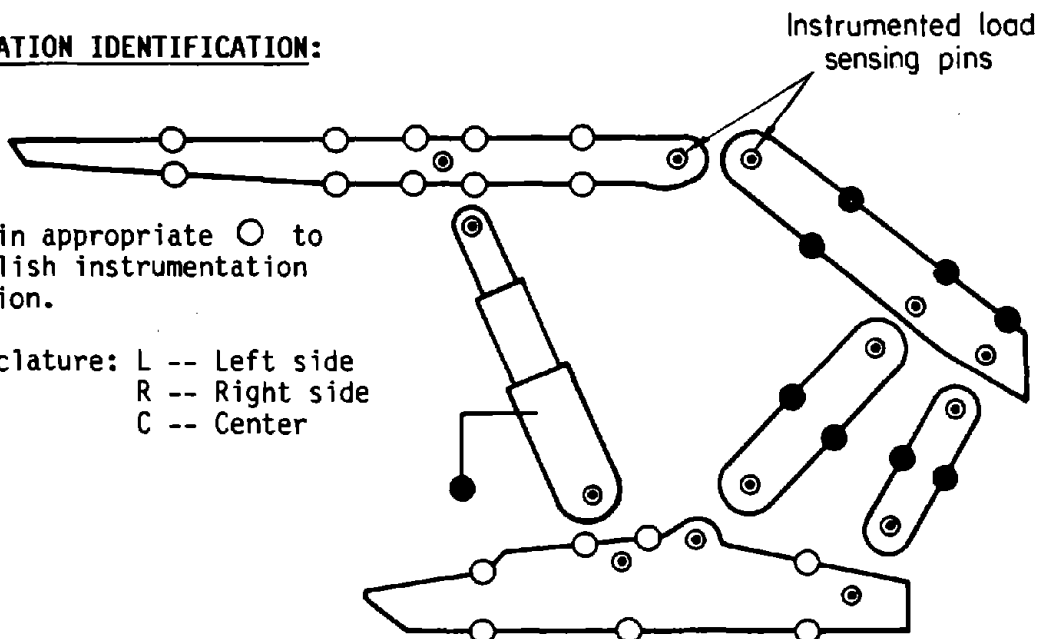
Comments:

Instrumented pin forces versus vertical displacement  
and horizontal displacement also available.

INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ○ to  
establish instrumentation  
location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## LOAD TRANSFER MECHANICS

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Load Transfer-Unsymmetric Base-on-rear Contact. LTSBOR01

TEST SERIES: Resistance Characteristics        Stability         
 Shield Stiffness        Load Transfer xx  
 Leg Mechanics        Structural Integrity       

OBJECTIVE: Determine load transfer mechanics for unsymmetric base-on-rear contact.

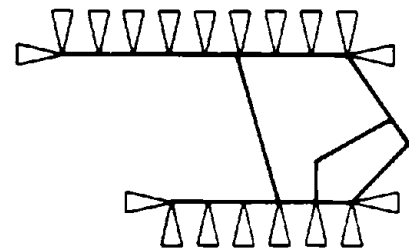
TEST PROCEDURE: Set shield in unsymmetric base-on-rear contact.  
 Apply vertical and face-to-waste horizontal displacements.  
 Monitor load transfer through leg cylinders and individual lemniscate links.

TEST FRAME: Static        Active xxx

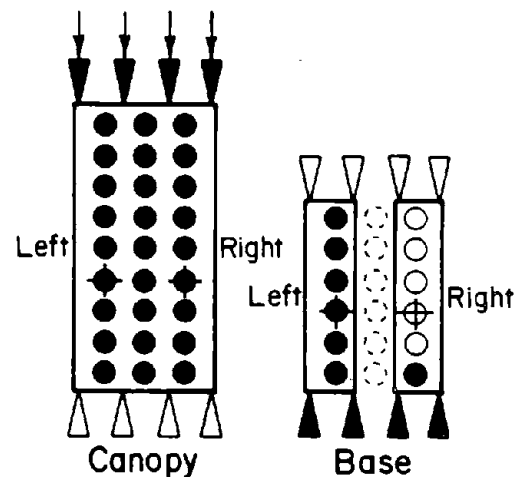
SHIELD CONFIGURATION: Shield Height H1 in  
 Leg inclination  $\alpha 1$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

BOUNDARY CONDITIONS:  $\rightarrow$  Constrained xxx Unconstrained       

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



LOAD APPLICATION:CONTROL PARAMETERS  
AND LOADING RATES:

|                                       |            |          |
|---------------------------------------|------------|----------|
| Vertical Force                        | _____      | kips/min |
| Face-to-waste Horizontal Force        | _____      | kips/min |
| Waste-to-face Horizontal Force        | _____      | kips/min |
| Vertical Displacement                 | <u>0.1</u> | in/min   |
| Face-to-waste Horizontal Displacement | <u>0.1</u> | in/min   |
| Waste-to-face Horizontal Displacement | _____      | in/min   |
| Leg Pressure                          | _____      | psi/min  |
| Cycles per minute                     | _____      | cyc/min  |

LOAD SEQUENCE:

|                                      |            |                      |       |
|--------------------------------------|------------|----------------------|-------|
| Vertical only                        | <u>xxx</u> | Vertical--Horizontal | _____ |
| Horizontal only                      | <u>xxx</u> | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal |            |                      | _____ |

DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Horizontal Force | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | _____     |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Strain Channels  | vs Number of cycles      | _____     |                            |           |

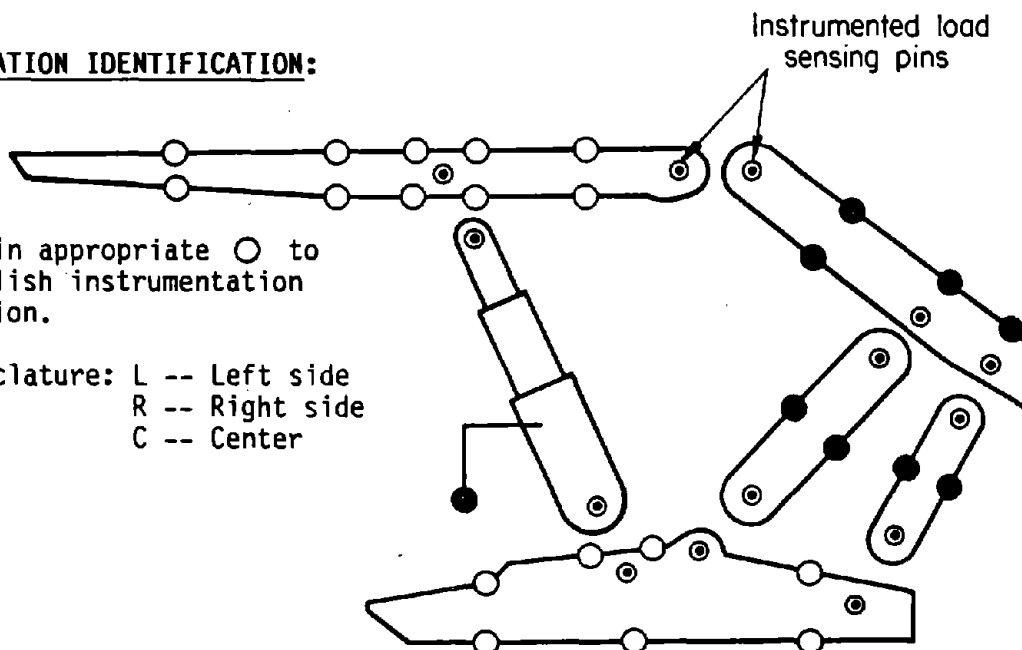
Comments:

Instrumented pin forces versus vertical displacement  
and horizontal displacement also available.

INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ○ to  
establish instrumentation  
location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## STRUCTURAL INTEGRITY

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Structural Integrity - Full Contact. STRFUL01 thru STRFUL10

TEST SERIES: Resistance Characteristics \_\_\_\_\_ Stability \_\_\_\_\_  
 Shield Stiffness \_\_\_\_\_ Load Transfer \_\_\_\_\_  
 Leg Mechanics \_\_\_\_\_ Structural Integrity xx

OBJECTIVE: Evaluate nominal stress development and basic shield response for full canopy and base contact and applied vertical and horizontal displacements.

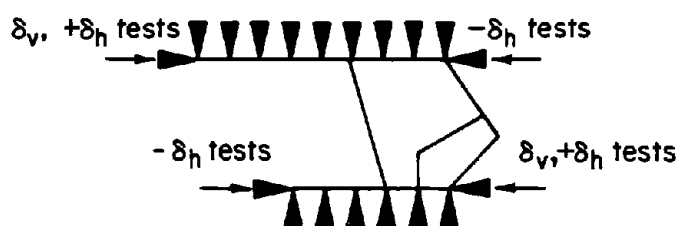
TEST PROCEDURE: Conduct five tests to evaluate all combinations of vertical ( $\delta_v$ ), face-to-waste horizontal ( $+\delta_h$ ), and waste-to-face horizontal displacement ( $-\delta_h$ ). Set shield and apply displacements as indicated. Maintain load application until leg yield or excessive component strain. Test 1:  $\delta_v$ . Test 2:  $+\delta_h$ . Test 3:  $-\delta_h$ . Test 4:  $\delta_v, +\delta_h$ . Test 5:  $\delta_v, -\delta_h$ .

TEST FRAME: Static \_\_\_\_\_ Active xxx

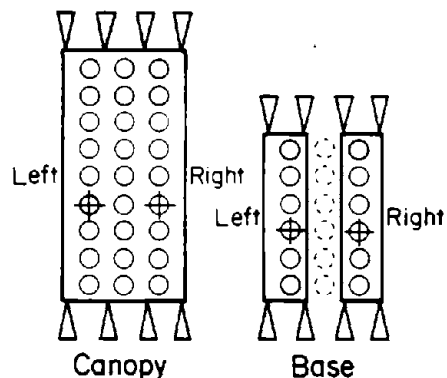
SHIELD CONFIGURATION: Shield Height H1,H2 in  
 Leg inclination  $\alpha 1, \alpha 2$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

BOUNDARY CONDITIONS:  $\rightarrow$  Constrained xxx Unconstrained \_\_\_\_\_

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



LOAD APPLICATION:CONTROL PARAMETERS  
AND LOADING RATES:

|                                       |            |          |
|---------------------------------------|------------|----------|
| Vertical Force                        | _____      | kips/min |
| Face-to-waste Horizontal Force        | _____      | kips/min |
| Waste-to-face Horizontal Force        | _____      | kips/min |
| Vertical Displacement                 | <u>0.1</u> | in/min   |
| Face-to-waste Horizontal Displacement | <u>0.1</u> | in/min   |
| Waste-to-face Horizontal Displacement | <u>0.1</u> | in/min   |
| Leg Pressure                          | _____      | psi/min  |
| Cycles per minute                     | _____      | cyc/min  |

LOAD SEQUENCE:

|                                      |                 |                      |                 |
|--------------------------------------|-----------------|----------------------|-----------------|
| Vertical only                        | <u>Test 1</u>   | Vertical--Horizontal | _____           |
| Horizontal only                      | <u>Test 2,3</u> | Horizontal--Vertical | _____           |
| Simultaneous vertical and horizontal |                 |                      | <u>Test 4,5</u> |

DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Horizontal Force | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Force        | <u>xx</u> | vs Horizontal Force        | <u>xx</u> |
| Strain Channels  | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Strain Channels  | vs Number of cycles      | _____     |                            |           |

Comments:


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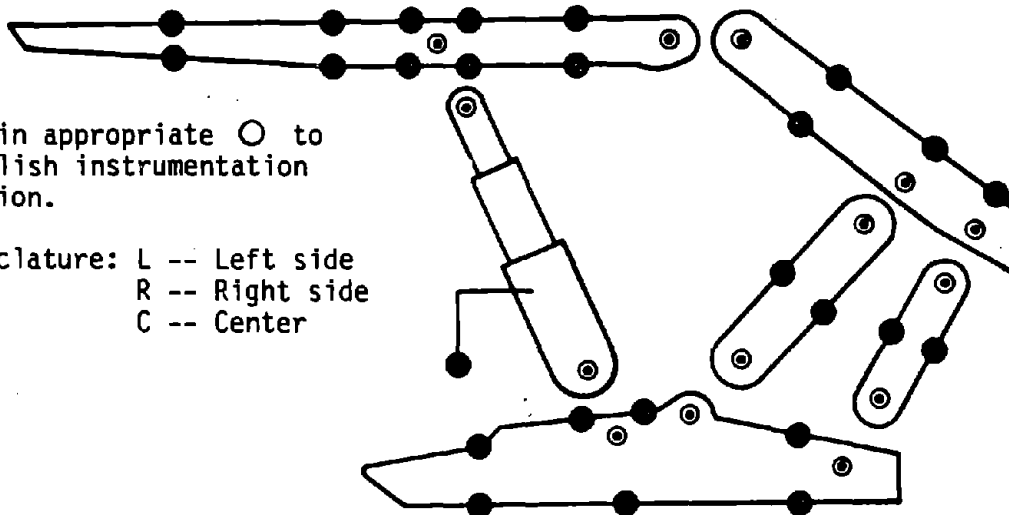


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INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ☐ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## STRUCTURAL INTEGRITY

## SUPPORT PERFORMANCE TEST REPORT

**TEST NAME:** Structural Integrity - Base-on-toe. STRBOL01 thru STRBOT10

**TEST SERIES:** Resistance Characteristics \_\_\_\_\_ Stability \_\_\_\_\_  
 Shield Stiffness \_\_\_\_\_ Load Transfer \_\_\_\_\_  
 Leg Mechanics \_\_\_\_\_ Structural Integrity xx

**OBJECTIVE:** Evaluate nominal stress development and basic shield response for symmetric base-on-toe contact and applied vertical and horizontal displacements.

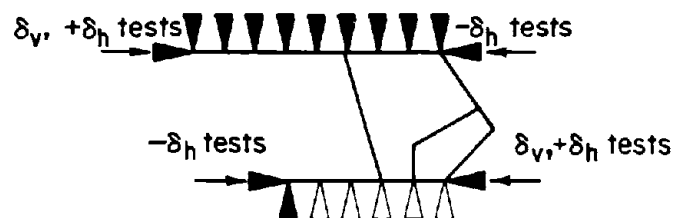
**TEST PROCEDURE:** Conduct five tests to evaluate all combinations of vertical ( $\delta_v$ ), face-to-waste horizontal ( $+\delta_h$ ), and waste-to-face horz. displacement ( $-\delta_h$ ). Set shield and apply displacements as indicated. Maintain load application until leg yield or excessive component strain. Test 1:  $\delta_v$ . Test 2:  $+\delta_h$ . Test 3:  $-\delta_h$ . Test 4:  $\delta_v, +\delta_h$ . Test 5:  $\delta_v, -\delta_h$ .

**TEST FRAME:** Static \_\_\_\_\_ Active xxx

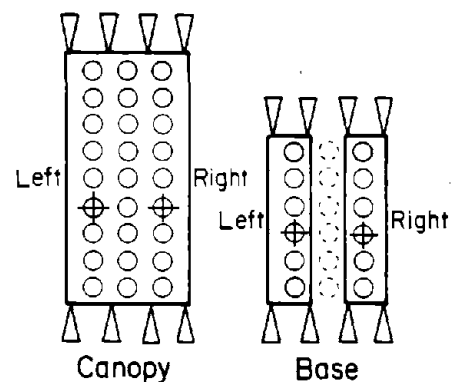
**SHIELD CONFIGURATION:** Shield Height H1, H2 in  
 Leg inclination  $\alpha_1, \alpha_2$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

**BOUNDARY CONDITIONS:**  $\rightarrow$  Constrained xxx Unconstrained \_\_\_\_\_

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



# STRUCTURAL INTEGRITY

119

## LOAD APPLICATION:

### CONTROL PARAMETERS AND LOADING RATES:

|                                       |       |          |
|---------------------------------------|-------|----------|
| Vertical Force                        | _____ | kips/min |
| Face-to-waste Horizontal Force        | _____ | kips/min |
| Waste-to-face Horizontal Force        | _____ | kips/min |
| Vertical Displacement                 | 0.1   | in/min   |
| Face-to-waste Horizontal Displacement | 0.1   | in/min   |
| Waste-to-face Horizontal Displacement | 0.1   | in/min   |
| Leg Pressure                          | _____ | psi/min  |
| Cycles per minute                     | _____ | cyc/min  |

### LOAD SEQUENCE:

|                                      |          |                      |          |
|--------------------------------------|----------|----------------------|----------|
| Vertical only                        | Test 1   | Vertical--Horizontal | _____    |
| Horizontal only                      | Test 2,3 | Horizontal--Vertical | _____    |
| Simultaneous vertical and horizontal |          |                      | Test 4,5 |

### DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |       |                            |    |
|------------------|--------------------------|-------|----------------------------|----|
| Vertical Force   | vs Vertical Displacement | xx    | vs Horizontal Displacement | xx |
| Horizontal Force | vs Vertical Displacement | xx    | vs Horizontal Displacement | xx |
| Strain Channels  | vs Vertical Displacement | xx    | vs Horizontal Displacement | xx |
| Strain Channels  | vs Vertical Force        | xx    | vs Horizontal Force        | xx |
| Strain Channels  | vs Sum of Leg Pressures  | xx    | vs Individual Leg Pressure | xx |
| Vertical Force   | vs Sum of Leg Pressures  | xx    | vs Individual Leg Pressure | xx |
| Horizontal Force | vs Sum of Leg Pressures  | xx    | vs Individual Leg Pressure | xx |
| Strain Channels  | vs Number of cycles      | _____ |                            |    |

### Comments:

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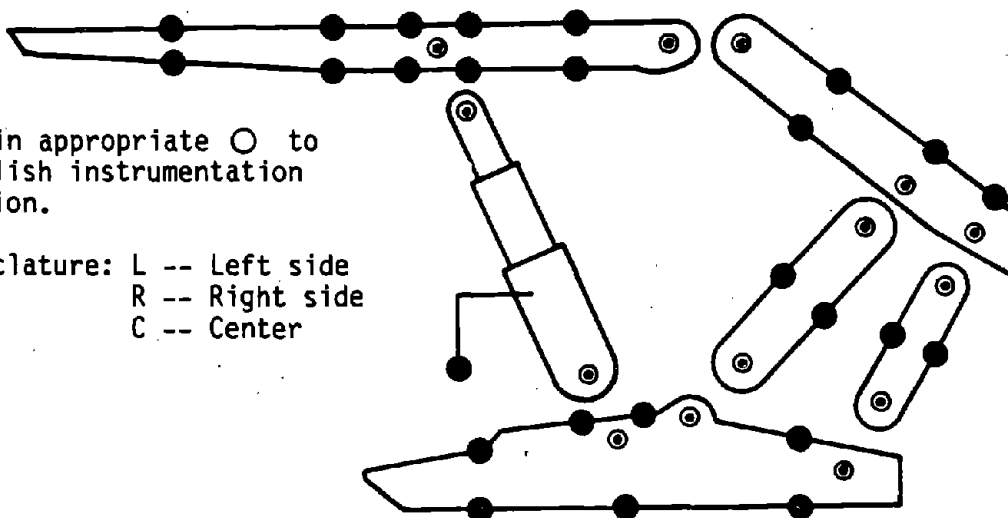


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### INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ○ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## STRUCTURAL INTEGRITY

SUPPORT PERFORMANCE TEST REPORT

**TEST NAME:** Structural Integrity - Base-on-rear. STRBOR01 thru STRBOR10

**TEST SERIES:** Resistance Characteristics        Stability         
 Shield Stiffness        Load Transfer         
 Leg Mechanics        Structural Integrity xx

**OBJECTIVE:** Evaluate nominal stress development and basic shield  
response for symmetric base-on-rear contact and applied  
vertical and horizontal displacements.

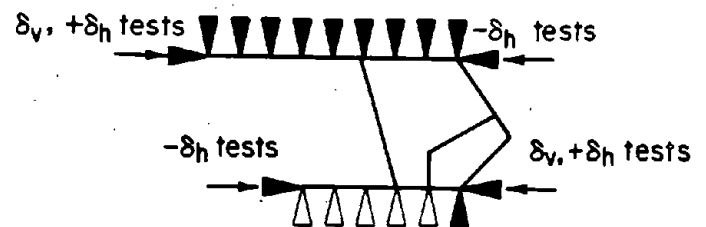
**TEST PROCEDURE:** Conduct five tests to evaluate all combinations of vertical  
( $\delta_v$ ), face-to-waste horizontal ( $+\delta_h$ ), and waste-to-face horz.  
displacement ( $-\delta_h$ ). Set shield and apply displacements as  
indicated. Maintain load application until leg yield or  
excessive component strain. Test 1:  $\delta_v$ . Test 2:  $+\delta_h$ .  
Test 3:  $-\delta_h$ . Test 4:  $\delta_v, +\delta_h$ . Test 5:  $\delta_v, -\delta_h$ .

**TEST FRAME:** Static        Active xxx

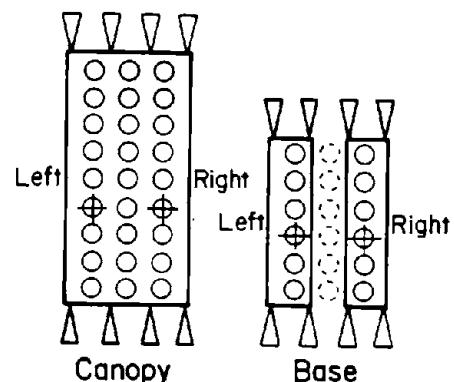
**SHIELD CONFIGURATION:** Shield Height H1,H2 in  
 Leg inclination  $\alpha_1, \alpha_2$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

**BOUNDARY CONDITIONS:** → Constrained xxx Unconstrained       

Fill in appropriate  $\nabla$  to  
 establish symmetric  
 contact configuration



Fill in appropriate  $\bigcirc$  to  
 establish unsymmetric contact  
 configuration



### CONTROL PARAMETERS AND LOADING RATES:

|                                       |            |          |
|---------------------------------------|------------|----------|
| Vertical Force                        | _____      | kips/min |
| Face-to-waste Horizontal Force        | _____      | kips/min |
| Waste-to-face Horizontal Force        | _____      | kips/min |
| Vertical Displacement                 | <u>0.1</u> | in/min   |
| Face-to-waste Horizontal Displacement | <u>0.1</u> | in/min   |
| Waste-to-face Horizontal Displacement | <u>0.1</u> | in/min   |
| Leg Pressure                          | _____      | psi/min  |
| Cycles per minute                     | _____      | cyc/min  |

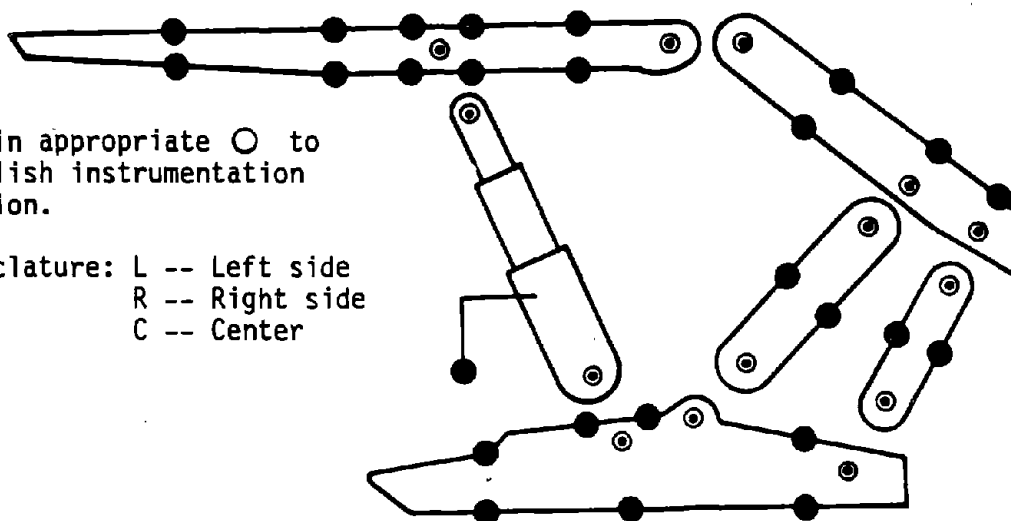
|                                      |                 |                      |                   |
|--------------------------------------|-----------------|----------------------|-------------------|
| Vertical only                        | <u>Test 1</u>   | Vertical--Horizontal | <u>          </u> |
| Horizontal only                      | <u>Test 2,3</u> | Horizontal--Vertical | <u>          </u> |
| Simultaneous vertical and horizontal |                 |                      | <u>Test 4,5</u>   |

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Horizontal Force | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Force        | <u>xx</u> | vs Horizontal Force        | <u>xx</u> |
| Strain Channels  | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Strain Channels  | vs Number of cycles      |           |                            |           |

*(continued)*

Fill in appropriate ☐ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## STRUCTURAL INTEGRITY

## SUPPORT PERFORMANCE TEST REPORT

**TEST NAME:** Structural Integrity-Two-point contact. STRBEN01 - STRBEN10

**TEST SERIES:** Resistance Characteristics \_\_\_\_\_ Stability \_\_\_\_\_  
 Shield Stiffness \_\_\_\_\_ Load Transfer \_\_\_\_\_  
 Leg Mechanics \_\_\_\_\_ Structural Integrity xx

**OBJECTIVE:** Evaluate nominal stress development and basic shield response for symmetric two-point canopy and base contact and applied vertical and horizontal displacements.

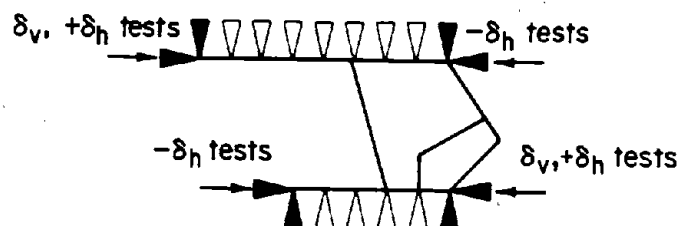
**TEST PROCEDURE:** Conduct five tests to evaluate all combinations of vertical ( $\delta_v$ ), face-to-waste horizontal ( $+\delta_h$ ), and waste-to-face horz. displacement ( $-\delta_h$ ). Set shield and apply displacements as indicated. Maintain load application until leg yield or excessive component strain. Test 1:  $\delta_v$ . Test 2:  $+\delta_h$ . Test 3:  $-\delta_h$ . Test 4:  $\delta_v, +\delta_h$ . Test 5:  $\delta_v, -\delta_h$ .

**TEST FRAME:** Static \_\_\_\_\_ Active xxx

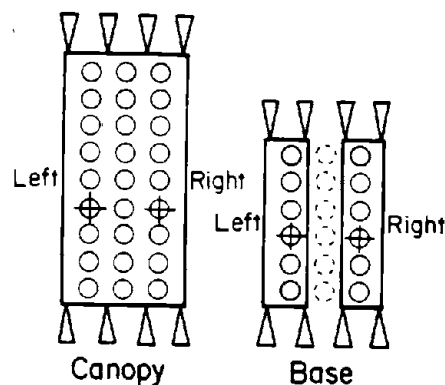
**SHIELD CONFIGURATION:** Shield Height H1, H2 in  
 Leg inclination  $\alpha_1, \alpha_2$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

**BOUNDARY CONDITIONS:**  $\rightarrow$  Constrained xxx Unconstrained \_\_\_\_\_

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



LOAD APPLICATION:CONTROL PARAMETERS  
AND LOADING RATES:

|                                       |            |          |
|---------------------------------------|------------|----------|
| Vertical Force                        | _____      | kips/min |
| Face-to-waste Horizontal Force        | _____      | kips/min |
| Waste-to-face Horizontal Force        | _____      | kips/min |
| Vertical Displacement                 | <u>0.1</u> | in/min   |
| Face-to-waste Horizontal Displacement | <u>0.1</u> | in/min   |
| Waste-to-face Horizontal Displacement | <u>0.1</u> | in/min   |
| Leg Pressure                          | _____      | psi/min  |
| Cycles per minute                     | _____      | cyc/min  |

LOAD SEQUENCE:

|                                      |          |                      |                 |
|--------------------------------------|----------|----------------------|-----------------|
| Vertical only                        | Test 1   | Vertical--Horizontal | _____           |
| Horizontal only                      | Test 2,3 | Horizontal--Vertical | _____           |
| Simultaneous vertical and horizontal |          |                      | <u>Test 4,5</u> |

DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Horizontal Force | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Force        | <u>xx</u> | vs Horizontal Force        | <u>xx</u> |
| Strain Channels  | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Strain Channels  | vs Number of cycles      | _____     |                            |           |

Comments:


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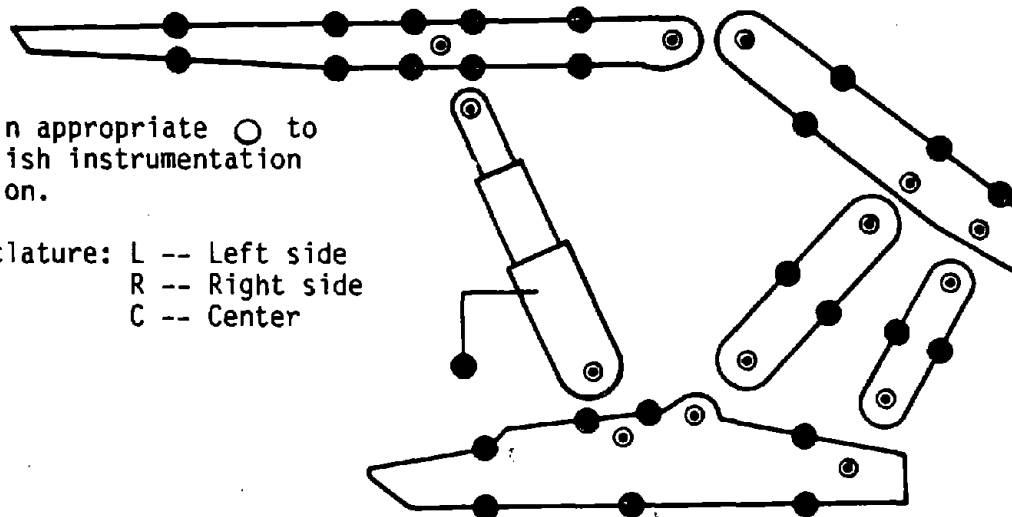


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INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ☐ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## STRUCTURAL INTEGRITY

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Structural Integrity-Unsymmetric contact. STRUBT01-STRUBT10

TEST SERIES: Resistance Characteristics        Stability         
 Shield Stiffness        Load Transfer         
 Leg Mechanics        Structural Integrity xx

OBJECTIVE: Evaluate nominal stress development and basic shield response for unsymmetric base-on-toe and unsymmetric canopy contact at leg location.

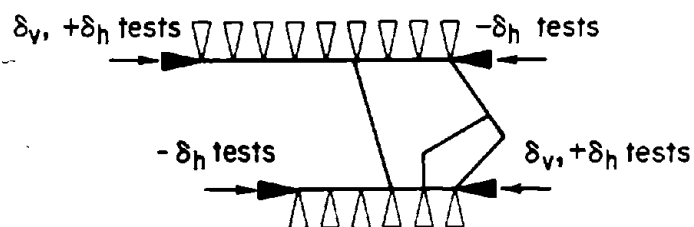
TEST PROCEDURE: Conduct five tests to evaluate all combinations of vertical ( $\delta_v$ ), face-to-waste horizontal ( $+\delta_h$ ), and waste-to-face horz. displacement ( $-\delta_h$ ). Set shield and apply displacements as indicated. Maintain load application until leg yield or excessive component strain. Test 1:  $\delta_v$ . Test 2:  $+\delta_h$ . Test 3:  $-\delta_h$ . Test 4:  $\delta_v, +\delta_h$ . Test 5:  $\delta_v, -\delta_h$ .

TEST FRAME: Static        Active xxx

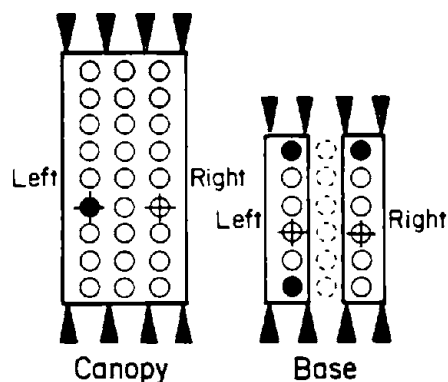
SHIELD CONFIGURATION: Shield Height H1,H2 in  
 Leg inclination  $\alpha 1, \alpha 2$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

BOUNDARY CONDITIONS: Constrained xxx Unconstrained       

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



LOAD APPLICATION:CONTROL PARAMETERS  
AND LOADING RATES:

|                                       |            |          |
|---------------------------------------|------------|----------|
| Vertical Force                        | _____      | kips/min |
| Face-to-waste Horizontal Force        | _____      | kips/min |
| Waste-to-face Horizontal Force        | _____      | kips/min |
| Vertical Displacement                 | <u>0.1</u> | in/min   |
| Face-to-waste Horizontal Displacement | <u>0.1</u> | in/min   |
| Waste-to-face Horizontal Displacement | <u>0.1</u> | in/min   |
| Leg Pressure                          | _____      | psi/min  |
| Cycles per minute                     | _____      | cyc/min  |

LOAD SEQUENCE:

|                                      |          |                      |                 |
|--------------------------------------|----------|----------------------|-----------------|
| Vertical only                        | Test 1   | Vertical--Horizontal | _____           |
| Horizontal only                      | Test 2,3 | Horizontal--Vertical | _____           |
| Simultaneous vertical and horizontal |          |                      | <u>Test 4,5</u> |

DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |    |                       |           |    |                         |           |
|------------------|----|-----------------------|-----------|----|-------------------------|-----------|
| Vertical Force   | vs | Vertical Displacement | <u>xx</u> | vs | Horizontal Displacement | <u>xx</u> |
| Horizontal Force | vs | Vertical Displacement | <u>xx</u> | vs | Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs | Vertical Displacement | <u>xx</u> | vs | Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs | Vertical Force        | <u>xx</u> | vs | Horizontal Force        | <u>xx</u> |
| Strain Channels  | vs | Sum of Leg Pressures  | <u>xx</u> | vs | Individual Leg Pressure | <u>xx</u> |
| Vertical Force   | vs | Sum of Leg Pressures  | <u>xx</u> | vs | Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs | Sum of Leg Pressures  | <u>xx</u> | vs | Individual Leg Pressure | <u>xx</u> |
| Strain Channels  | vs | Number of cycles      | _____     |    |                         |           |

Comments:


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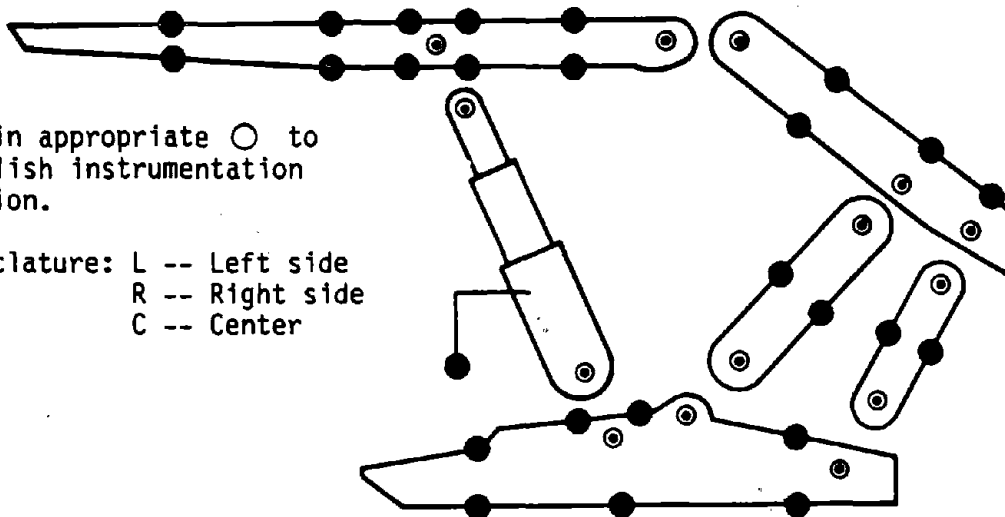


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INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ○ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## STRUCTURAL INTEGRITY

## SUPPORT PERFORMANCE TEST REPORT

**TEST NAME:** Structural Integrity-Unsymmetric contact. STRUBR01-STRUBR10

**TEST SERIES:** Resistance Characteristics \_\_\_\_\_ Stability \_\_\_\_\_  
 Shield Stiffness \_\_\_\_\_ Load Transfer \_\_\_\_\_  
 Leg Mechanics \_\_\_\_\_ Structural Integrity xx

**OBJECTIVE:** Evaluate nominal stress development and basic shield response for unsymmetric base-on-rear and unsymmetric canopy contact at leg location.

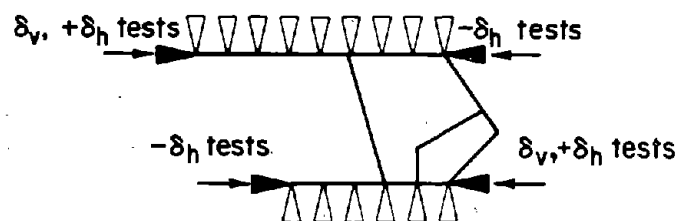
**TEST PROCEDURE:** Conduct five tests to evaluate all combinations of vertical ( $\delta_v$ ), face-to-waste horizontal ( $+\delta_h$ ), and waste-to-face horz. displacement ( $-\delta_h$ ). Set shield and apply displacements as indicated. Maintain load application until leg yield or excessive component strain. Test 1:  $\delta_v$ . Test 2:  $+\delta_h$ . Test 3:  $-\delta_h$ . Test 4:  $\delta_v, +\delta_h$ . Test 5:  $\delta_v, -\delta_h$ .

**TEST FRAME:** Static \_\_\_\_\_ Active xxx

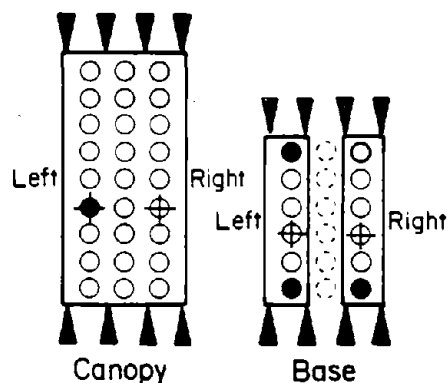
**SHIELD CONFIGURATION:** Shield Height H1,H2 in  
 Leg inclination  $\alpha_1, \alpha_2$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

**BOUNDARY CONDITIONS:**  Constrained xxx Unconstrained \_\_\_\_\_

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



LOAD APPLICATION:CONTROL PARAMETERS  
AND LOADING RATES:

|                                       |            |          |
|---------------------------------------|------------|----------|
| Vertical Force                        | _____      | kips/min |
| Face-to-waste Horizontal Force        | _____      | kips/min |
| Waste-to-face Horizontal Force        | _____      | kips/min |
| Vertical Displacement                 | <u>0.1</u> | in/min   |
| Face-to-waste Horizontal Displacement | <u>0.1</u> | in/min   |
| Waste-to-face Horizontal Displacement | <u>0.1</u> | in/min   |
| Leg Pressure                          | _____      | psi/min  |
| Cycles per minute                     | _____      | cyc/min  |

LOAD SEQUENCE:

|                                      |          |                      |                 |
|--------------------------------------|----------|----------------------|-----------------|
| Vertical only                        | Test 1   | Vertical--Horizontal | _____           |
| Horizontal only                      | Test 2,3 | Horizontal--Vertical | _____           |
| Simultaneous vertical and horizontal |          |                      | <u>Test 4,5</u> |

DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Horizontal Force | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Force        | <u>xx</u> | vs Horizontal Force        | <u>xx</u> |
| Strain Channels  | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Strain Channels  | vs Number of cycles      | _____     |                            |           |

Comments:


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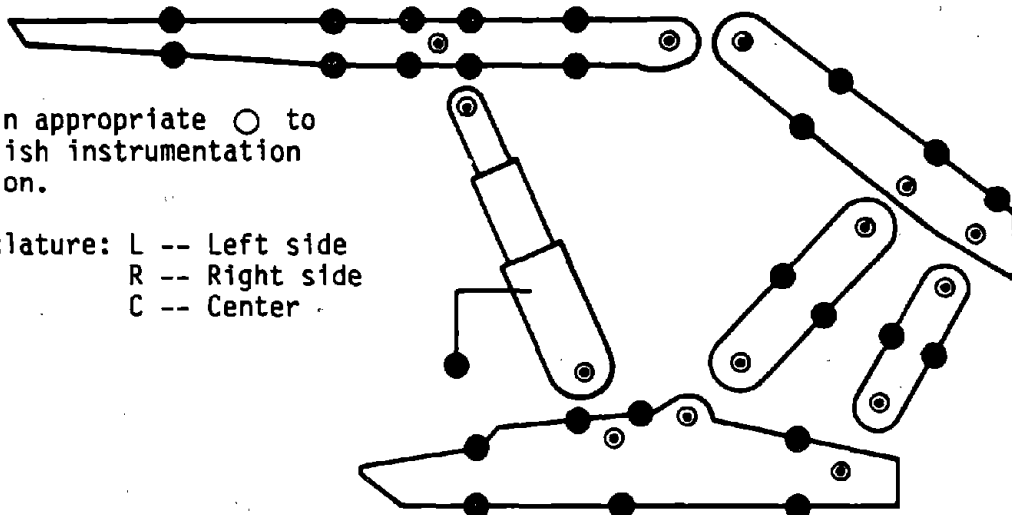


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INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ☐ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## STRUCTURAL INTEGRITY

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Structural Integrity-Unsymmetric contact. STRUBT11-STRUBT20

TEST SERIES: Resistance Characteristics \_\_\_\_\_ Stability \_\_\_\_\_  
 Shield Stiffness \_\_\_\_\_ Load Transfer \_\_\_\_\_  
 Leg Mechanics \_\_\_\_\_ Structural Integrity xx

OBJECTIVE: Evaluate nominal stress development and basic shield response for unsymmetric base-on-toe and symmetric canopy contact at leg location.

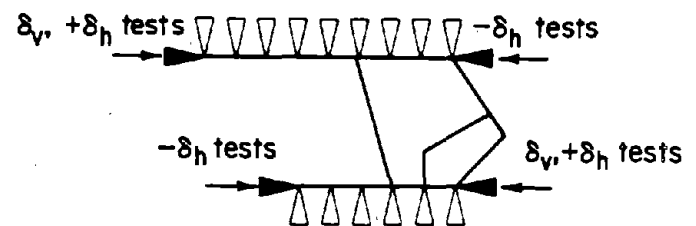
TEST PROCEDURE: Conduct five tests to evaluate all combinations of vertical ( $\delta_v$ ), face-to-waste horizontal ( $+\delta_h$ ), and waste-to-face horz. displacement ( $-\delta_h$ ). Set shield and apply displacements as indicated. Maintain load application until leg yield or excessive component strain. Test 1:  $\delta_v$ . Test 2:  $+\delta_h$ . Test 3:  $-\delta_h$ . Test 4:  $\delta_v, +\delta_h$ . Test 5:  $\delta_v, -\delta_h$ .

TEST FRAME: Static \_\_\_\_\_ Active xxx

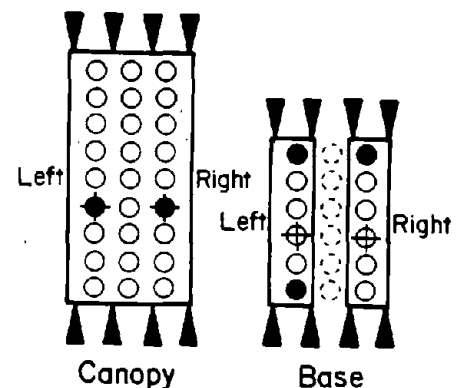
SHIELD CONFIGURATION: Shield Height H1, H2 in  
 Leg inclination  $\alpha_1, \alpha_2$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

BOUNDARY CONDITIONS:  $\rightarrow$  Constrained xxx Unconstrained \_\_\_\_\_

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



# STRUCTURAL INTEGRITY

129

## LOAD APPLICATION:

### CONTROL PARAMETERS AND LOADING RATES:

|                                       |            |          |
|---------------------------------------|------------|----------|
| Vertical Force                        | _____      | kips/min |
| Face-to-waste Horizontal Force        | _____      | kips/min |
| Waste-to-face Horizontal Force        | _____      | kips/min |
| Vertical Displacement                 | <u>0.1</u> | in/min   |
| Face-to-waste Horizontal Displacement | <u>0.1</u> | in/min   |
| Waste-to-face Horizontal Displacement | <u>0.1</u> | in/min   |
| Leg Pressure                          | _____      | psi/min  |
| Cycles per minute                     | _____      | cyc/min  |

### LOAD SEQUENCE:

|                                      |          |                      |                 |
|--------------------------------------|----------|----------------------|-----------------|
| Vertical only                        | Test 1   | Vertical--Horizontal | _____           |
| Horizontal only                      | Test 2,3 | Horizontal--Vertical | _____           |
| Simultaneous vertical and horizontal |          | Test 4,5             | <u>Test 4,5</u> |

### DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Horizontal Force | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Force        | <u>xx</u> | vs Horizontal Force        | <u>xx</u> |
| Strain Channels  | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Strain Channels  | vs Number of cycles      | _____     |                            |           |

### Comments:

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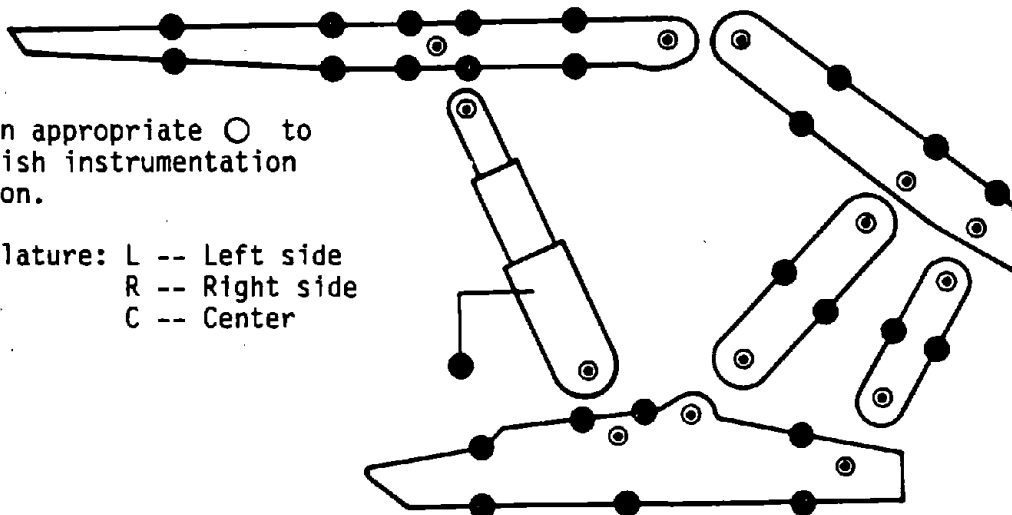


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### INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ☐ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## STRUCTURAL INTEGRITY

SUPPORT PERFORMANCE TEST REPORT

**TEST NAME:** Structural Integrity-Unsymmetric contact. STRUBR11-STRUBR20

**TEST SERIES:** Resistance Characteristics        Stability         
 Shield Stiffness        Load Transfer         
 Leg Mechanics        Structural Integrity xx

**OBJECTIVE:** Evaluate nominal stress development and basic shield  
response for unsymmetric base-on-rear and symmetric canopy  
contact at leg location.

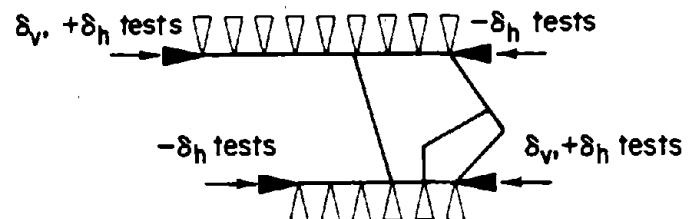
**TEST PROCEDURE:** Conduct five tests to evaluate all combinations of vertical  
( $\delta_v$ ), face-to-waste horizontal ( $+\delta_h$ ), and waste-to-face horz.  
displacement ( $-\delta_h$ ). Set shield and apply displacements as  
indicated. Maintain load application until leg yield or  
excessive component strain. Test 1:  $\delta_v$ . Test 2:  $+\delta_h$ .  
Test 3:  $-\delta_h$ . Test 4:  $\delta_v, +\delta_h$ . Test 5:  $\delta_v, -\delta_h$ .

**TEST FRAME:** Static        Active xxx

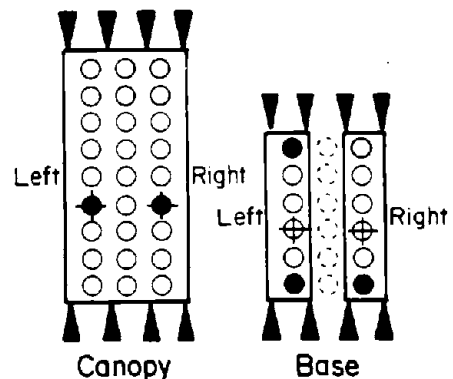
**SHIELD CONFIGURATION:** Shield Height H1,H2 in  
 Leg inclination  $\alpha_1, \alpha_2$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure 3000 psi

**BOUNDARY CONDITIONS:** → Constrained xxx Unconstrained       

Fill in appropriate  $\nabla$  to  
 establish symmetric  
 contact configuration



Fill in appropriate  $\bigcirc$  to  
 establish unsymmetric contact  
 configuration



LOAD APPLICATION:CONTROL PARAMETERS  
AND LOADING RATES:

|                                       |            |          |
|---------------------------------------|------------|----------|
| Vertical Force                        | _____      | kips/min |
| Face-to-waste Horizontal Force        | _____      | kips/min |
| Waste-to-face Horizontal Force        | _____      | kips/min |
| Vertical Displacement                 | <u>0.1</u> | in/min   |
| Face-to-waste Horizontal Displacement | <u>0.1</u> | in/min   |
| Waste-to-face Horizontal Displacement | <u>0.1</u> | in/min   |
| Leg Pressure                          | _____      | psi/min  |
| Cycles per minute                     | _____      | cyc/min  |

LOAD SEQUENCE:

|                                      |                 |                      |       |
|--------------------------------------|-----------------|----------------------|-------|
| Vertical only                        | <u>Test 1</u>   | Vertical--Horizontal | _____ |
| Horizontal only                      | <u>Test 2,3</u> | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal |                 | <u>Test 4,5</u>      |       |

DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Horizontal Force | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Displacement | <u>xx</u> | vs Horizontal Displacement | <u>xx</u> |
| Strain Channels  | vs Vertical Force        | <u>xx</u> | vs Horizontal Force        | <u>xx</u> |
| Strain Channels  | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Strain Channels  | vs Number of cycles      | _____     |                            |           |

Comments:


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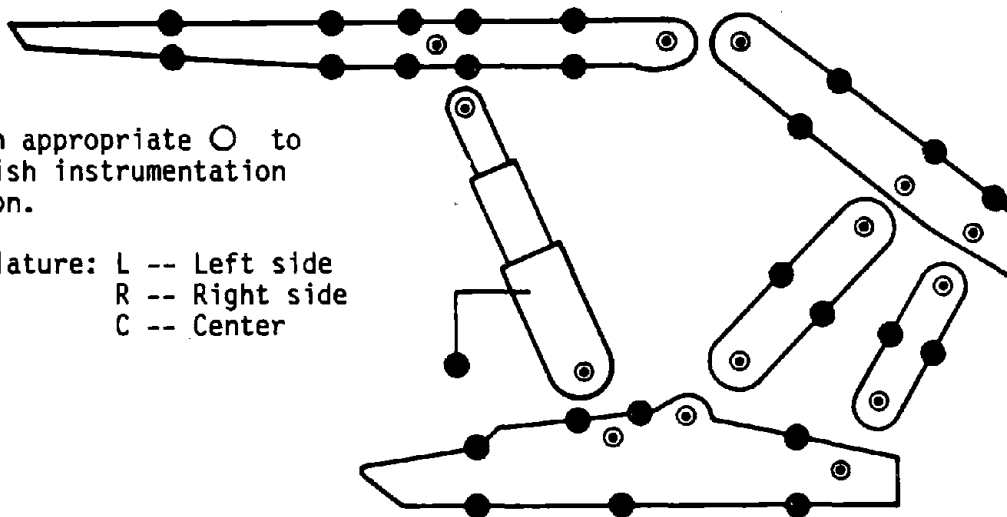


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INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ○ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## STRUCTURAL INTEGRITY

SUPPORT PERFORMANCE TEST REPORT

**TEST NAME:** Fatigue Failure - Full Contact. Test FATFUL01

**TEST SERIES:** Resistance Characteristics        Stability         
 Shield Stiffness        Load Transfer         
 Leg Mechanics        Structural Integrity xx

**OBJECTIVE:** Evaluate fatigue loading for full canopy and base contact.

\_\_\_\_\_

\_\_\_\_\_

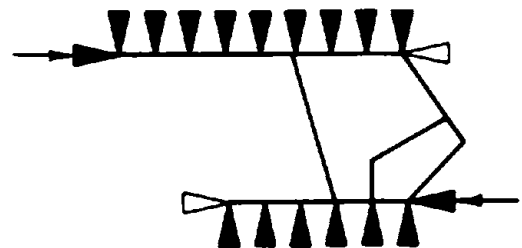
**TEST PROCEDURE:** Determine location and maximum crack length in shield compon  
ents prior to testing. Test at slightly higher than expected  
operating height. Cycle shield from 0 to 110 pct yield  
pressure for 10,000 cycles. Monitor crack formation and  
crack growth after every 1,000 cycles. Monitor nominal shield  
strains, residual strains, and permanent deformation.

**TEST FRAME:** Static xxx Active       

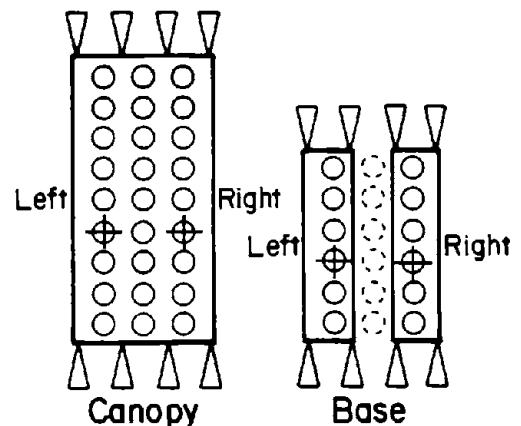
**SHIELD CONFIGURATION:** Shield Height H1 in  
 Leg inclination  $\alpha 1$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure yield psi

**BOUNDARY CONDITIONS:** → Constrained xxx Unconstrained       

Fill in appropriate  $\nabla$  to  
 establish symmetric  
 contact configuration



Fill in appropriate  $\bigcirc$  to  
 establish unsymmetric contact  
 configuration



### CONTROL PARAMETERS AND LOADING RATES:

LOAD SEQUENCE:

|                                      |       |                      |       |
|--------------------------------------|-------|----------------------|-------|
| Vertical only                        | _____ | Vertical--Horizontal | _____ |
| Horizontal only                      | _____ | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal |       |                      |       |

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Horizontal Force | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | _____     |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Strain Channels  | vs Number of cycles      | <u>xx</u> |                            |           |

Comments:

Fill in appropriate ☐ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center

The diagram shows a mechanical assembly with several components. At the top is a long horizontal bar with a pointed left end and a rounded right end, featuring 10 solid black dots. Below it is a vertical component with a rounded top and a flange at the bottom, with 2 solid black dots. To the right is a diagonal bar with 5 solid black dots. Below the vertical component is a horizontal bar with a pointed left end and a rounded right end, with 10 solid black dots. A line with a solid black dot at the end points to the vertical component. There are 10 open circles (instrumentation points) distributed across the components: 2 on the top bar, 1 on the vertical component, 2 on the diagonal bar, 1 on the bottom bar, and 4 on the right side of the assembly.

## STRUCTURAL INTEGRITY

SUPPORT PERFORMANCE TEST REPORTTEST NAME: Fatigue Failure - Canopy. Test FATCAN01

TEST SERIES: Resistance Characteristics \_\_\_\_\_ Stability \_\_\_\_\_  
 Shield Stiffness \_\_\_\_\_ Load Transfer \_\_\_\_\_  
 Leg Mechanics \_\_\_\_\_ Structural Integrity xx

OBJECTIVE: Evaluate fatigue loading of canopy unit.

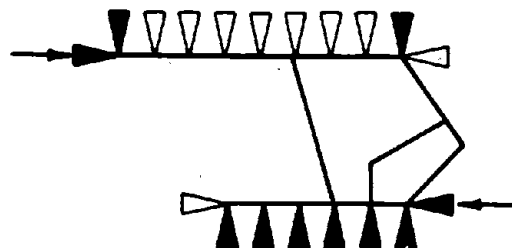
TEST PROCEDURE: Determine location and maximum crack length in canopy unit prior to testing. Test at slightly higher than expected operating height. Cycle shield from 0 to 110 pct yield pressure for 10,000 cycles. Monitor crack formation and crack growth after every 1,000 cycles. Monitor nominal canopy strains, residual strains, and permanent deformation.

TEST FRAME: Static xxx Active \_\_\_\_\_

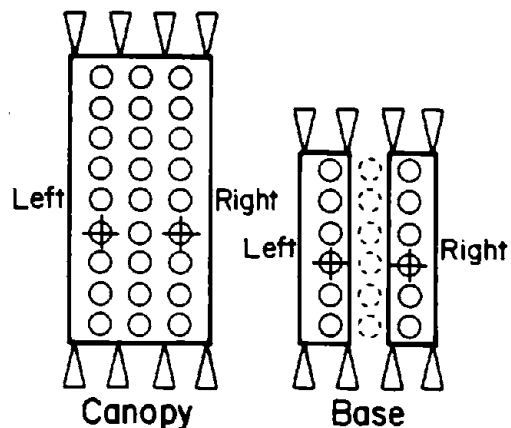
SHIELD CONFIGURATION: Shield Height H1 in  
 Leg inclination  $\alpha 1$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure yield psi

BOUNDARY CONDITIONS: Constrained xxx Unconstrained \_\_\_\_\_

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



**LOAD APPLICATION:****CONTROL PARAMETERS  
AND LOADING RATES:**

|                                       |              |       |          |
|---------------------------------------|--------------|-------|----------|
| Vertical Force                        | _____        | _____ | kips/min |
| Face-to-waste Horizontal Force        | _____        | _____ | kips/min |
| Waste-to-face Horizontal Force        | _____        | _____ | kips/min |
| Vertical Displacement                 | _____        | _____ | in/min   |
| Face-to-waste Horizontal Displacement | _____        | _____ | in/min   |
| Waste-to-face Horizontal Displacement | _____        | _____ | in/min   |
| Leg Pressure                          | <u>yield</u> | _____ | psi/min  |
| Cycles per minute                     | <u>1</u>     | _____ | cyc/min  |

**LOAD SEQUENCE:**

|                                      |       |                      |       |
|--------------------------------------|-------|----------------------|-------|
| Vertical only                        | _____ | Vertical--Horizontal | _____ |
| Horizontal only                      | _____ | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal | _____ |                      | _____ |

**DATA REDUCTION AVAILABLE FOR ANALYSIS:**

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Horizontal Force | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | _____     |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Strain Channels  | vs Number of cycles      | <u>xx</u> |                            |           |

**Comments:**


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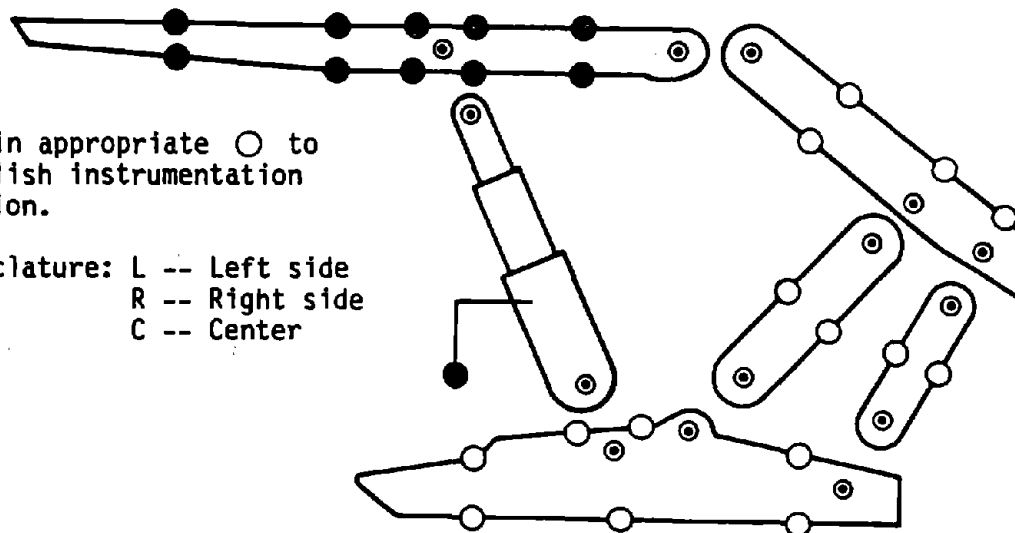


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**INSTRUMENTATION IDENTIFICATION:**

Fill in appropriate ☐ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## STRUCTURAL INTEGRITY

SUPPORT PERFORMANCE TEST REPORT

**TEST NAME:** Fatigue Failure - Base. Test FATBAS01

**TEST SERIES:** Resistance Characteristics        Stability         
 Shield Stiffness        Load Transfer         
 Leg Mechanics        Structural Integrity xx

**OBJECTIVE:** Evaluate fatigue loading of base unit.  
        
      

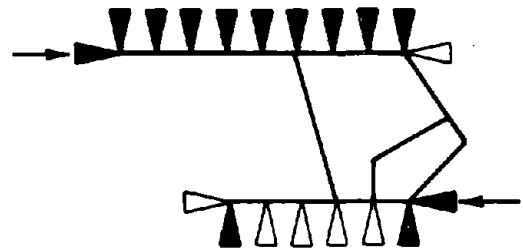
**TEST PROCEDURE:** Determine location and maximum crack length in base unit  
prior to testing. Test at slightly higher than expected  
operating height. Cycle shield from 0 to 110 pct yield  
pressure for 10,000 cycles. Monitor crack formation and  
crack growth after every 1,000 cycles. Monitor nominal base  
strains, residual strains, and permanent deformation.

**TEST FRAME:** Static xxx Active       

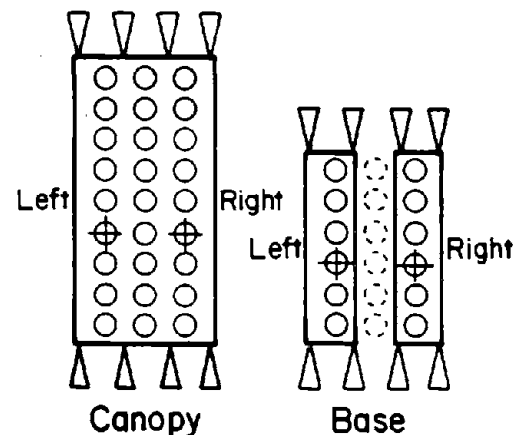
**SHIELD CONFIGURATION:** Shield Height H1 in  
 Leg inclination α1 degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure yield psi

**BOUNDARY CONDITIONS:** → Constrained xxx Unconstrained       

Fill in appropriate  $\nabla$  to  
 establish symmetric  
 contact configuration



Fill in appropriate  $\bigcirc$  to  
 establish unsymmetric contact  
 configuration



**LOAD APPLICATION:**

### CONTROL PARAMETERS AND LOADING RATES:

|                                       |              |          |
|---------------------------------------|--------------|----------|
| Vertical Force                        | _____        | kips/min |
| Face-to-waste Horizontal Force        | _____        | kips/min |
| Waste-to-face Horizontal Force        | _____        | kips/min |
| Vertical Displacement                 | _____        | in/min   |
| Face-to-waste Horizontal Displacement | _____        | in/min   |
| Waste-to-face Horizontal Displacement | _____        | in/min   |
| Leg Pressure                          | <u>yield</u> | psi/min  |
| Cycles per minute                     | <u>1</u>     | cyc/min  |

LOAD SEQUENCE:

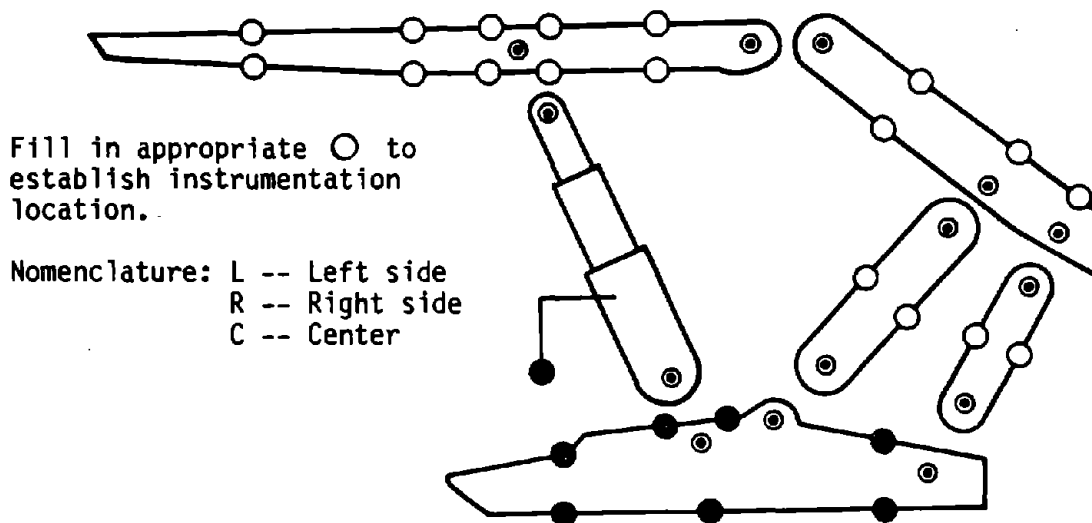
Vertical only \_\_\_\_\_ Vertical--Horizontal \_\_\_\_\_  
Horizontal only \_\_\_\_\_ Horizontal--Vertical \_\_\_\_\_  
Simultaneous vertical and horizontal \_\_\_\_\_

**DATA REDUCTION AVAILABLE FOR ANALYSIS:**

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Horizontal Force | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | _____     |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Strain Channels  | vs Number of cycles      | <u>xx</u> |                            |           |

**Comments:**

**INSTRUMENTATION IDENTIFICATION:**



## STRUCTURAL INTEGRITY

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Fatigue Failure - Zero Horizontal Loading Test FATHOR01

TEST SERIES: Resistance Characteristics        Stability         
 Shield Stiffness        Load Transfer         
 Leg Mechanics        Structural Integrity xx

OBJECTIVE: Evaluate fatigue loading of shield when subjected to load  
conditions which eliminate external horizontal loading.

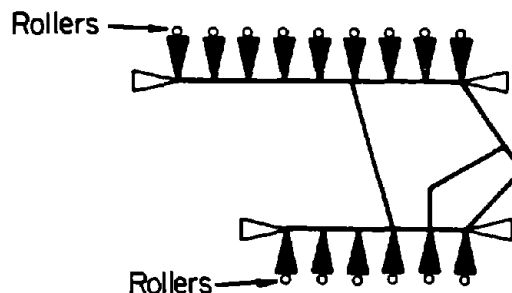
TEST PROCEDURE: Determine location and maximum crack length in shield compon  
ents prior to testing. Test at slightly higher than expected  
operating height. Cycle shield from 0 to 110 pct yield  
pressure for 10,000 cycles. Monitor crack formation and  
crack growth after every 1,000 cycles. Monitor nominal shield  
strains, residual strains, and permanent deformation.

TEST FRAME: Static xxx Active       

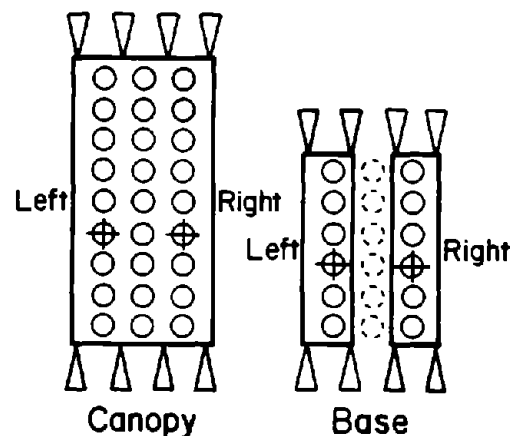
SHIELD CONFIGURATION: Shield Height H1 in  
 Leg inclination  $\alpha 1$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure yield psi

BOUNDARY CONDITIONS: → Constrained        Unconstrained xxx

Fill in appropriate  $\nabla$  to  
 establish symmetric  
 contact configuration



Fill in appropriate  $\bigcirc$  to  
 establish unsymmetric contact  
 configuration



**LOAD APPLICATION:****CONTROL PARAMETERS  
AND LOADING RATES:**

|                                       |              |          |
|---------------------------------------|--------------|----------|
| Vertical Force                        | _____        | kips/min |
| Face-to-waste Horizontal Force        | _____        | kips/min |
| Waste-to-face Horizontal Force        | _____        | kips/min |
| Vertical Displacement                 | _____        | in/min   |
| Face-to-waste Horizontal Displacement | _____        | in/min   |
| Waste-to-face Horizontal Displacement | _____        | in/min   |
| Leg Pressure                          | <u>yield</u> | psi/min  |
| Cycles per minute                     | <u>1</u>     | cyc/min  |

**LOAD SEQUENCE:**

|                                      |       |                      |            |
|--------------------------------------|-------|----------------------|------------|
| Vertical only                        | _____ | Vertical--Horizontal | _____      |
| Horizontal only                      | _____ | Horizontal--Vertical | _____      |
| Simultaneous vertical and horizontal |       |                      | <u>xxx</u> |

**DATA REDUCTION AVAILABLE FOR ANALYSIS:**

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Horizontal Force | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | _____     |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Strain Channels  | vs Number of cycles      | <u>xx</u> |                            |           |

**Comments:**


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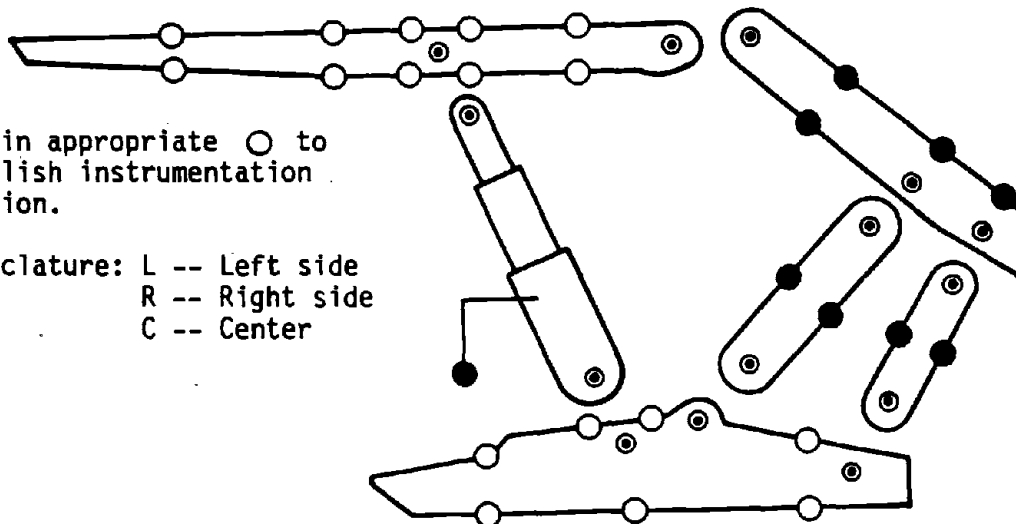


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**INSTRUMENTATION IDENTIFICATION:**

Fill in appropriate ☐ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## STRUCTURAL INTEGRITY

SUPPORT PERFORMANCE TEST REPORT

**TEST NAME:** Fatigue Failure - Base-on-toe Configuration. Test FATBOT01

**TEST SERIES:** Resistance Characteristics        Stability         
 Shield Stiffness        Load Transfer         
 Leg Mechanics        Structural Integrity xx

**OBJECTIVE:** Evaluate fatigue loading for symmetric base-on-toe configuration.

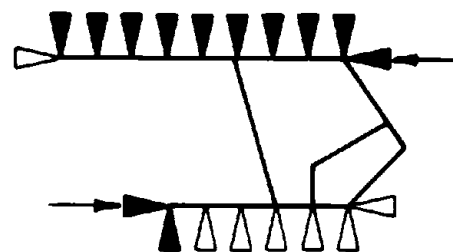
**TEST PROCEDURE:** Determine location and maximum crack length in shield components prior to testing. Test at slightly higher than expected operating height. Cycle shield from 0 to 110 pct yield pressure for 10,000 cycles. Monitor crack formation and crack growth after every 1,000 cycles. Monitor nominal shield strains, residual strains, and permanent deformation.

**TEST FRAME:** Static xxx Active       

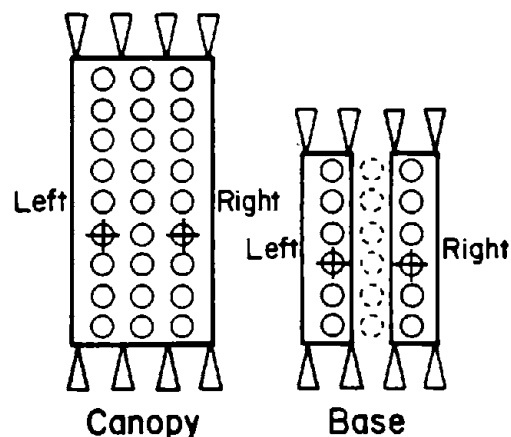
**SHIELD CONFIGURATION:** Shield Height H1 in  
 Leg inclination  $\alpha 1$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure yield psi

**BOUNDARY CONDITIONS:** → Constrained xxx Unconstrained       

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



LOAD APPLICATION:CONTROL PARAMETERS  
AND LOADING RATES:

|                                       |              |          |
|---------------------------------------|--------------|----------|
| Vertical Force                        | _____        | kips/min |
| Face-to-waste Horizontal Force        | _____        | kips/min |
| Waste-to-face Horizontal Force        | _____        | kips/min |
| Vertical Displacement                 | _____        | in/min   |
| Face-to-waste Horizontal Displacement | _____        | in/min   |
| Waste-to-face Horizontal Displacement | _____        | in/min   |
| Leg Pressure                          | <u>yield</u> | psi/min  |
| Cycles per minute                     | <u>1</u>     | cyc/min  |

LOAD SEQUENCE:

|                                      |       |                      |       |
|--------------------------------------|-------|----------------------|-------|
| Vertical only                        | _____ | Vertical--Horizontal | _____ |
| Horizontal only                      | _____ | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal | _____ |                      | _____ |

DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Horizontal Force | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | _____     |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Strain Channels  | vs Number of cycles      | <u>xx</u> |                            |           |

Comments:


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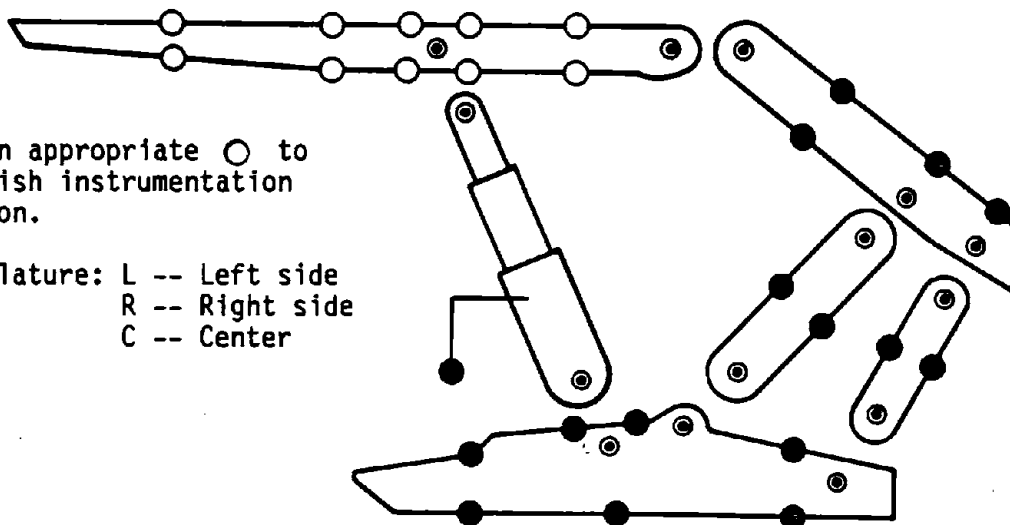


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INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ○ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## STRUCTURAL INTEGRITY

SUPPORT PERFORMANCE TEST REPORTTEST NAME: Fatigue Failure - Base-on-rear Configuration. Test FATBOR01

TEST SERIES: Resistance Characteristics \_\_\_\_\_ Stability \_\_\_\_\_  
 Shield Stiffness \_\_\_\_\_ Load Transfer \_\_\_\_\_  
 Leg Mechanics \_\_\_\_\_ Structural Integrity xx

OBJECTIVE: Evaluate fatigue loading for symmetric base-on-rear configuration.  
 \_\_\_\_\_  
 \_\_\_\_\_

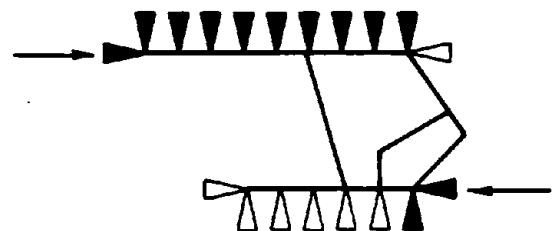
TEST PROCEDURE: Determine location and maximum crack length in shield components prior to testing. Test at slightly higher than expected operating height. Cycle shield from 0 to 110 pct yield pressure for 10,000 cycles. Monitor crack formation and crack growth after every 1,000 cycles. Monitor nominal shield strains, residual strains, and permanent deformation.

TEST FRAME: Static xxx Active \_\_\_\_\_

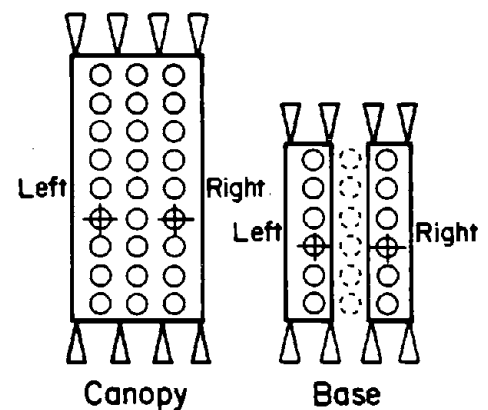
SHIELD CONFIGURATION: Shield Height H1 in  
 Leg inclination  $\alpha 1$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure yield psi

BOUNDARY CONDITIONS:  Constrained xxx Unconstrained \_\_\_\_\_

Fill in appropriate  to establish symmetric contact configuration



Fill in appropriate  to establish unsymmetric contact configuration



LOAD APPLICATION:CONTROL PARAMETERS  
AND LOADING RATES:

|                                       |              |          |
|---------------------------------------|--------------|----------|
| Vertical Force                        | _____        | kips/min |
| Face-to-waste Horizontal Force        | _____        | kips/min |
| Waste-to-face Horizontal Force        | _____        | kips/min |
| Vertical Displacement                 | _____        | in/min   |
| Face-to-waste Horizontal Displacement | _____        | in/min   |
| Waste-to-face Horizontal Displacement | _____        | in/min   |
| Leg Pressure                          | <u>yield</u> | psi/min  |
| Cycles per minute                     | <u>1</u>     | cyc/min  |

LOAD SEQUENCE:

|                                      |       |                      |       |
|--------------------------------------|-------|----------------------|-------|
| Vertical only                        | _____ | Vertical--Horizontal | _____ |
| Horizontal only                      | _____ | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal | _____ |                      | _____ |

DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Horizontal Force | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | _____     |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Strain Channels  | vs Number of cycles      | <u>xx</u> |                            |           |

Comments:


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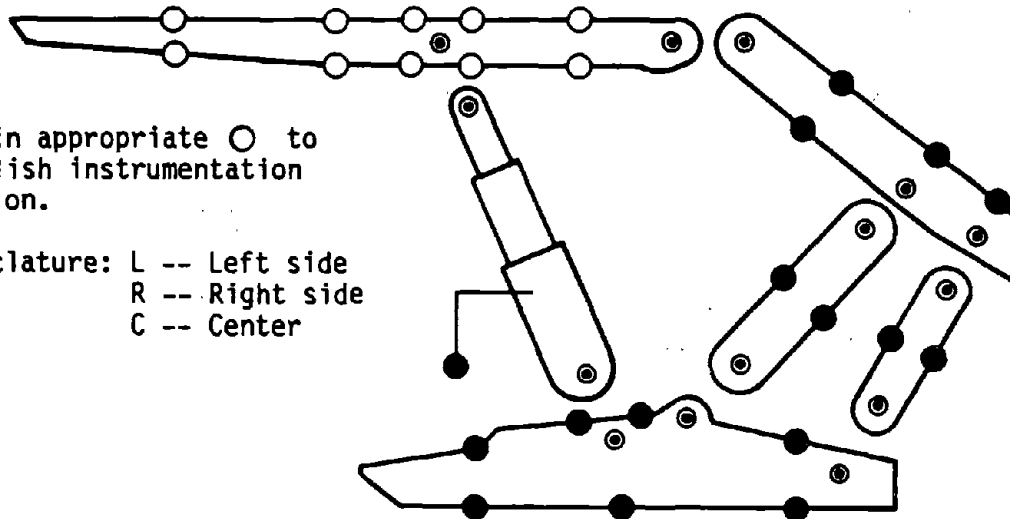


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INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ○ to  
establish instrumentation  
location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## STRUCTURAL INTEGRITY

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Fatigue Failure - Leg Socket Shear. Test FATBOR01

TEST SERIES: Resistance Characteristics \_\_\_\_\_ Stability \_\_\_\_\_  
 Shield Stiffness \_\_\_\_\_ Load Transfer \_\_\_\_\_  
 Leg Mechanics \_\_\_\_\_ Structural Integrity xx

OBJECTIVE: Evaluate fatigue loading for canopy and base contact  
 adjacent leg connection.

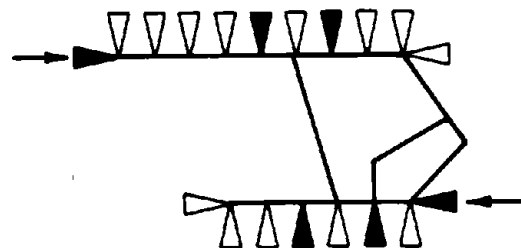
TEST PROCEDURE: Determine location and maximum crack length in shield components prior to testing. Test at slightly higher than expected operating height. Cycle shield from 0 to 110 pct yield pressure for 10,000 cycles. Monitor crack formation and crack growth after every 1,000 cycles. Monitor nominal shield strains, residual strains, and permanent deformation.

TEST FRAME: Static xxx Active \_\_\_\_\_

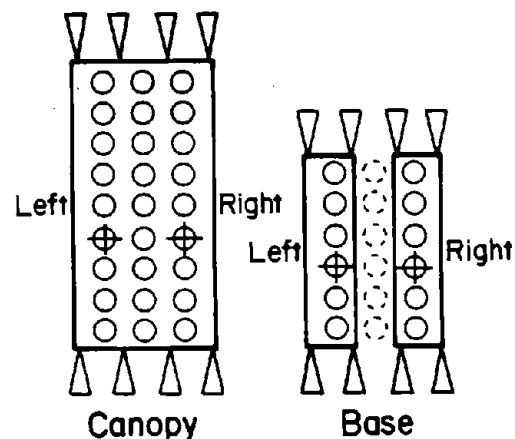
SHIELD CONFIGURATION: Shield Height H1 in  
 Leg inclination α1 degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure yield psi

BOUNDARY CONDITIONS: Constrained xxx Unconstrained \_\_\_\_\_

Fill in appropriate ▽ to  
 establish symmetric  
 contact configuration



Fill in appropriate ○ to  
 establish unsymmetric contact  
 configuration



LOAD APPLICATION:CONTROL PARAMETERS  
AND LOADING RATES:

|                                       |              |          |
|---------------------------------------|--------------|----------|
| Vertical Force                        | _____        | kips/min |
| Face-to-waste Horizontal Force        | _____        | kips/min |
| Waste-to-face Horizontal Force        | _____        | kips/min |
| Vertical Displacement                 | _____        | in/min   |
| Face-to-waste Horizontal Displacement | _____        | in/min   |
| Waste-to-face Horizontal Displacement | _____        | in/min   |
| Leg Pressure                          | <u>yield</u> | psi/min  |
| Cycles per minute                     | <u>1</u>     | cyc/min  |

LOAD SEQUENCE:

|                                      |       |                      |       |
|--------------------------------------|-------|----------------------|-------|
| Vertical only                        | _____ | Vertical--Horizontal | _____ |
| Horizontal only                      | _____ | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal | _____ |                      | _____ |

DATA REDUCTION AVAILABLE FOR ANALYSIS:

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Horizontal Force | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | _____     |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Strain Channels  | vs Number of cycles      | <u>xx</u> |                            |           |

Comments:


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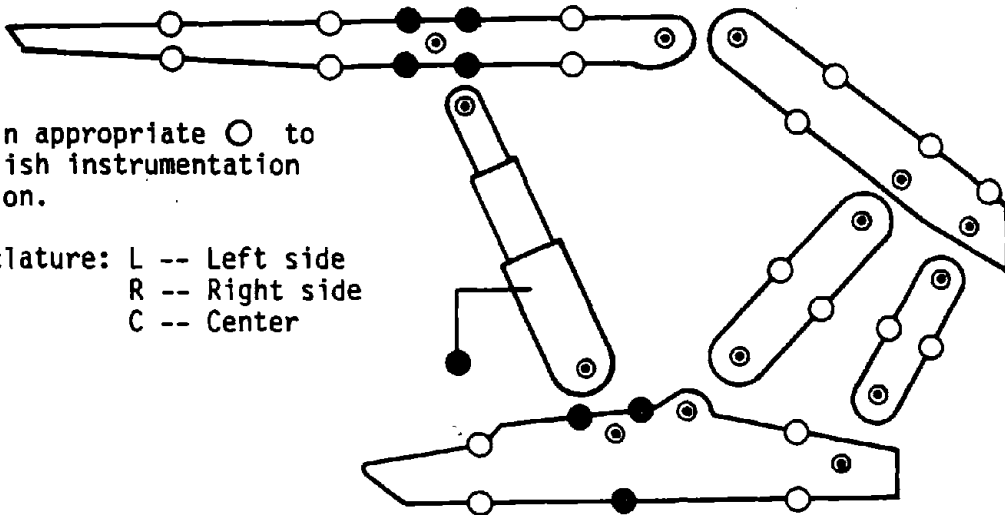


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INSTRUMENTATION IDENTIFICATION:

Fill in appropriate ○ to establish instrumentation location.

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## STRUCTURAL INTEGRITY

SUPPORT PERFORMANCE TEST REPORT

TEST NAME: Fatigue Failure-Unsymmetric Contact Configuration. FATUSY01

TEST SERIES: Resistance Characteristics        Stability         
 Shield Stiffness        Load Transfer         
 Leg Mechanics        Structural Integrity xx

OBJECTIVE: Evaluate fatigue loading for unsymmetric base-on-toe contact with unsymmetric canopy contact at leg location.

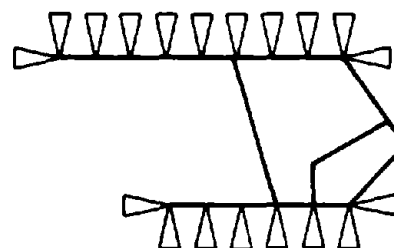
TEST PROCEDURE: Determine location and maximum crack length in shield components prior to testing. Test at slightly higher than expected operating height. Cycle shield from 0 to 110 pct yield pressure for 10,000 cycles. Monitor crack formation and crack growth after every 1,000 cycles. Monitor nominal shield strains, residual strains, and permanent deformation.

TEST FRAME: Static xxx Active       

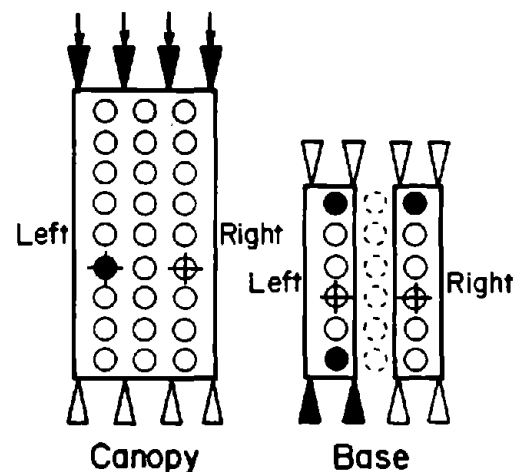
SHIELD CONFIGURATION: Shield Height H1 in  
 Leg inclination  $\alpha 1$  degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure yield psi

BOUNDARY CONDITIONS: → Constrained xxx Unconstrained       

Fill in appropriate  $\nabla$  to establish symmetric contact configuration



Fill in appropriate  $\bigcirc$  to establish unsymmetric contact configuration



### CONTROL PARAMETERS AND LOADING RATES:

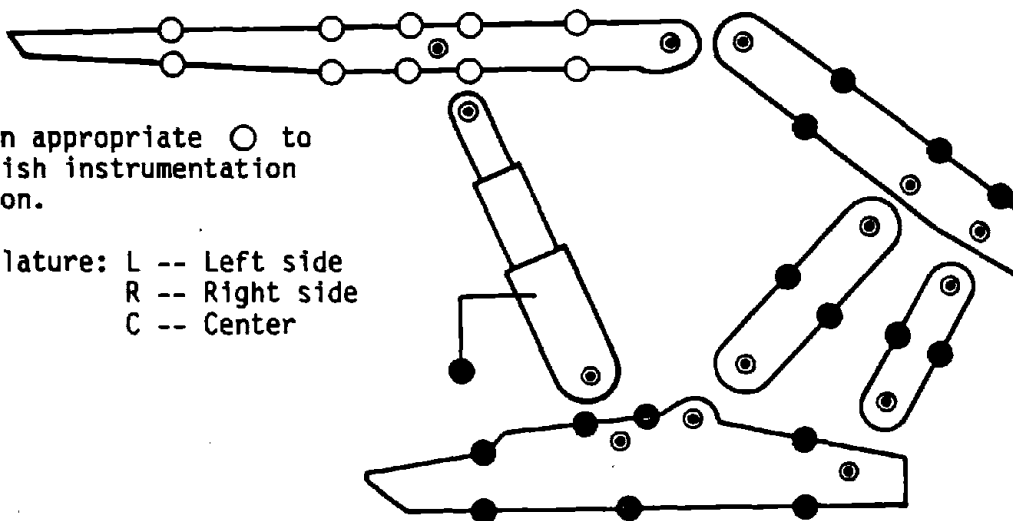
LOAD SEQUENCE:

|                                      |       |                      |       |
|--------------------------------------|-------|----------------------|-------|
| Vertical only                        | _____ | Vertical--Horizontal | _____ |
| Horizontal only                      | _____ | Horizontal--Vertical | _____ |
| Simultaneous vertical and horizontal |       |                      |       |

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Horizontal Force | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | _____     |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Strain Channels  | vs Number of cycles      | <u>xx</u> |                            |           |

**INSTRUMENTATION IDENTIFICATION:**

Nomenclature: L -- Left side  
R -- Right side  
C -- Center



## STRUCTURAL INTEGRITY

SUPPORT PERFORMANCE TEST REPORTTEST NAME: Fatigue Failure-Unsymmetric Contact Configuration. FATUSY02

TEST SERIES: Resistance Characteristics        Stability         
 Shield Stiffness        Load Transfer         
 Leg Mechanics        Structural Integrity xx

OBJECTIVE: Evaluate fatigue loading for unsymmetric base-on-rear  
contact with unsymmetric canopy contact at leg location.

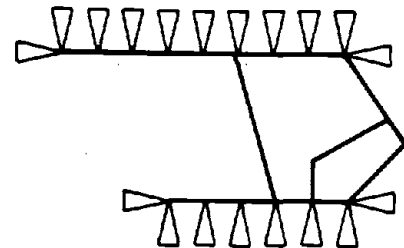
TEST PROCEDURE: Determine location and maximum crack length in shield compon  
ents prior to testing. Test at slightly higher than expected  
operating height. Cycle shield from 0 to 110 pct yield  
pressure for 10,000 cycles. Monitor crack formation and  
crack growth after every 1,000 cycles. Monitor nominal shield  
strains, residual strains, and permanent deformation.

TEST FRAME: Static xxx Active       

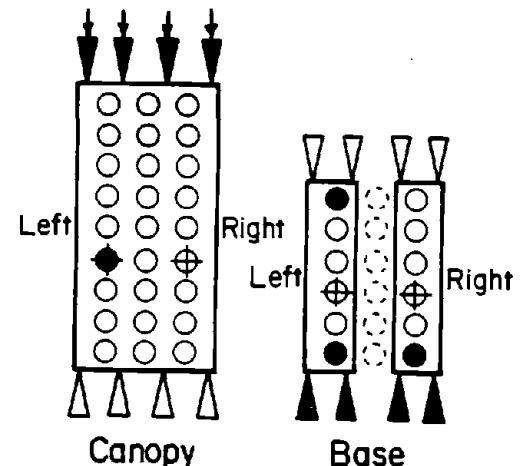
SHIELD CONFIGURATION: Shield Height H1 in  
 Leg inclination a1 degrees from vertical  
 Canopy rotation 0 degrees from horizontal  
 Setting Pressure yield psi

BOUNDARY CONDITIONS: → Constrained xxx Unconstrained       

Fill in appropriate  $\nabla$  to  
 establish symmetric  
 contact configuration



Fill in appropriate  $\bigcirc$  to  
 establish unsymmetric contact  
 configuration



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### CONTROL PARAMETERS AND LOADING RATES:

|                                       |              |          |
|---------------------------------------|--------------|----------|
| Vertical Force                        | _____        | kips/min |
| Face-to-waste Horizontal Force        | _____        | kips/min |
| Waste-to-face Horizontal Force        | _____        | kips/min |
| Vertical Displacement                 | _____        | in/min   |
| Face-to-waste Horizontal Displacement | _____        | in/min   |
| Waste-to-face Horizontal Displacement | _____        | in/min   |
| Leg Pressure                          | <u>yield</u> | psi/min  |
| Cycles per minute                     | <u>1</u>     | cyc/min  |

Vertical only \_\_\_\_\_ Vertical--Horizontal \_\_\_\_\_  
Horizontal only \_\_\_\_\_ Horizontal--Vertical \_\_\_\_\_  
Simultaneous vertical and horizontal \_\_\_\_\_

|                  |                          |           |                            |           |
|------------------|--------------------------|-----------|----------------------------|-----------|
| Vertical Force   | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Horizontal Force | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Displacement | _____     | vs Horizontal Displacement | _____     |
| Strain Channels  | vs Vertical Force        | _____     | vs Horizontal Force        | _____     |
| Strain Channels  | vs Sum of Leg Pressures  | _____     | vs Individual Leg Pressure | _____     |
| Vertical Force   | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Horizontal Force | vs Sum of Leg Pressures  | <u>xx</u> | vs Individual Leg Pressure | <u>xx</u> |
| Strain Channels  | vs Number of cycles      | <u>xx</u> |                            |           |

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Fill in appropriate ☐ to establish instrumentation location.

Diagram illustrating the placement of electrodes (represented by circles) on a prosthetic arm. The diagram shows the arm structure with various electrode locations marked. A legend indicates the side of the arm:

- L -- Left side
- R -- Right side
- C -- Center

