SAE Aerospace
An SAE International Group

# AEROSPACE STANDARD

SAE AS36102

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## Air Cargo Unit Load Devices - Testing Methods

### FOREWORD

Throughout this Aerospace Standard, the minimum essential criteria are identified by use of the key word “shall”. Recommended criteria are identified by use of the key word “should” and, while not mandatory, are considered to be of primary importance in providing acceptable ULD testing conditions. Deviation from recommended criteria should only occur after careful consideration and thorough evaluation in testing have shown alternate methods to provide an equivalent level of safety.



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1. SCOPE:

This SAE Aerospace Standard (AS) provides requirements on how to test air cargo Unit Load Devices (ULD).

1.1 Purpose:

The purpose of this Aerospace Standard is to establish acceptable ULD test methods and load distributions used to prove compliance with minimum performance requirements as established in AS36100.

1.2 Field of Application:

1.2.1 This Aerospace Standard applies to all airworthiness approved air cargo unit load devices intended for carriage on board civil transport airplanes type certified under Federal Aviation Regulations Title 14 CFR Part 25, "*Airworthiness Standards: Transport Category Airplanes*".

1.2.2 ULDs that are not covered in AS36100 should be tested according to this Aerospace Standard, but NAS 3610 revision 10 shall be used for applicable minimum performance requirements and test parameters in these cases.

2. REFERENCES:

2.1 Applicable Documents:

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 U.S. Government Publications: Available from U.S. Government Printing Office, Mail Stop SSOP, Washington, DC 20402-9325.

Federal Aviation Regulations Title 14 CFR Part 21 - Certification Procedures for Products and Parts, Subpart O - Technical Standard Order Authorizations
Technical Standard Order TSO C90 - Cargo Pallets, Nets and Containers
Federal Aviation Regulations Title 14 CFR Part 25 - Airworthiness Standards: Transport Category Airplanes

2.1.2 AIA Publications: Available from Aerospace Industries Association of America Inc., 1250 Eye Street NW, Washington, DC 20006.

National Aerospace Standard NAS 3610 - Cargo Unit Load Devices - Specification for - (Revision 10)

2.1.3 SAE Publications: Available from Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

| | |
|---|---|
| AS33601 | Track and Stud Fitting for Cargo Transport Aircraft, Standard Dimensions for |
| AS36100 | Air Cargo Unit Load Devices - Performance Requirements and Test Parameters |
| AS36101 | Air Cargo Unit Load Devices - Load Distribution Model |

2.1.4 ISO Publications: Available from ANSI, 11W 42nd Street, New York, NY 10036-8002.

| | |
|---|---|
| ISO 3394 | Dimensions of rigid rectangular packages - Transport packages |
| ISO 3676 | Packaging - Unit load sizes - Dimensions |
| ISO 7166 | Aircraft - Rail and stud configuration for passenger equipment and cargo restraint |
| ISO 8097 | Minimum airworthiness requirements and test conditions for certified air cargo unit load devices |
| ISO 9788 | Air cargo equipment - Cast components of double stud fitting assembly with a load capacity of 22250 N (5000 lb) for aircraft cargo restraint |



2.2 Definitions:

CONTAINER ( AIR CARGO - ): A rigid structure which interfaces directly with the aircraft cargo handling and restraint system and alone performs all the functions of a unit load device.

NET ( AIR CARGO PALLET - ): A webbing or rope net for restraining load onto an air cargo pallet.

2.2 (Continued):

PALLET ( AIR CARGO - ): A unit load device consisting of a flat platform with flat undersurface of standard dimensions, on which goods are assembled and secured by a net before being loaded as a unit on to the aircraft, and which interfaces directly with the aircraft handling and restraint system. To constitute a certified ULD, a certified pallet shall be equipped with a net, certified according to the relevant regulation.

UNIT LOAD DEVICE ( ULD ): Device for grouping, transferring and restraining cargo for transit. It may consist of a pallet with a net or it may be a container.

PANEL: Assembly of components to form a complete side of a ULD, base and roof included.

CENTER OF GRAVITY ( CG ): Location of the ULD payload's center of mass.The location is defined in AS36100 - *Air cargo unit load devices - Performance requirements and test parameters.*

LIMIT LOAD ( LL ): The maximum load to be expected in service as a result of an aircraft's certified allowable flight envelope (see Title 14 CFR Part 25, § 25.301(a)).

ULTIMATE LOAD ( (UL ): The limit load multiplied by a safety factor of 1.5 (see Title 14 CFR Part 25, § 25.303). It shall be used for calculation of the ULD test load, based on the ultimate load value defined in AS36100, in each direction of restraint, for the relevant ULD configuration.

TEST LOAD ( TL ): The combined load to be used for testing a ULD in a given direction of restraint, including:

- applicable ultimate load.
- maximum allowable CG offset for the relevant ULD configuration.
- appropriate environmental degradation factor.

ENVIRONMENTAL DEGRADATION FACTOR: A test load factor that shall be the result of an assessment of materials used in the construction of pallets, nets and containers for potential in-service performance degradation resulting from environmental conditions.

NUMERIC SIMULATION: Simulation of physical test condition and reaction of ULD employing numerical analysis, computational geometry and computer graphics to obtain proof support and design verification, validated by demonstration that parameters, algorithms and analytical methods used provide results of at least equivalent reliability to the outcome of a specified actual test.

2.2 (Continued):

REFERENCE LOAD ITEM: A rectangular cargo box with dimensions of 600x400x250 mm (24x16x10 in), loaded in any direction. This size is defined as a minimum common size of cargo items, based on ISO 3394 cross-checked with ISO 3676 and consistent with industry practise.

3. TYPES OF LOADS:

3.1 Alternative Load Application:

3.1.1 Fixed Loads:

ULD is loaded with test load before test is initiated. This test does not indicate exactly at which point a possible failure occurs since the ULD either pass or fails, but it is easier to perform in a repeatable manner. For typical load media, see 3.2.1 - 3.2.3.

3.1.2 Increasing Loads:

Increase load gradually until test load has been reached or until failure of ULD. This method gives greater control over when failure occurs, but can be more time consuming. Load increase should take place in steps, with a minimum of 3 second stabilization between each step. Time taken to apply the load should be recorded for inclusion in test report if using increasing loads. For typical load media, see 3.2.3 - 3.2.5.

3.2 Typical Load Media:

Detailed below are typical load materials used for the purpose of applying specified test loads onto the ULD panels. A combination of the defined load materials may be used. Any load media shall not restrict panel deflection under test load. Adequate clearance between adjacent load media should be considered to insure unrestricted movement of the load media.

3.2.1 Flexible load transfer media =< 25 kg [55 lb]:

Flexible load transfer media shall cover the full panel surface. It shall be used for levelling and protecting the panel surface.

3.2.2 Small load media =< 50 kg [110 lb]:

Small load media easily build CG eccentricity.

3.2.3 Large load media > 50 kg [110 lb]:

Large load media are ideally used when having large test loads and restricted internal ULD volume. They can also be used to minimize manual handling. One or more layers of small load media should be used underneath in order to avoid large concentrated loads.

3.2.4 Air Pressurized Bladders:

Air pressurized bladders can be used when having large loads and limited internal ULD volume. The bladders shall cover the full panel surface. To replicate CG eccentricity, the load shall be applied to a limited area only by positioning an appropriately sized bladder. The bladder shall be a box type construction that will only expand towards the panel to be tested. This ensures that the test load will be evenly distributed. It shall be considered that the side parts of the bladder will allow enough expansion in order not to restrict the panel deflection under test load. To support the bladder at the side opposite to the panel sheet, a solid panel of the same size as the bladder and an adequate number of struts shall be used. The struts shall be fixed outside the ULD, i.e. at the test fixture. If necessary, clearance holes in the accordant panel sheets can be used. The necessary air pressure to constitute the required test load is a function of the area of the bladder. For measuring the air pressure, only calibrated and inspected instruments shall be used. See Appendix A for typical test setup and physical test.

Necessary pressure = Required test load / Bladder footprint.

3.2.5 Hydraulic Systems:

Hydraulic systems are ideally used for load application limited to specific key interface points. It can also be used when having different forces at the specific key interface replicating the CG eccentricity. An offset lever arrangement utilizing a single hydraulic source can optionally be used. The force shall not be supported by the ULD, but at the test fixture. For measuring the hydraulic pressure, only calibrated and inspected instruments shall be used. See Appendix B for examples of testing with hydraulic systems.



4. PHYSICAL TESTING:

4.1 Environmental Conditions:

Depending on material used, applicable environmental criteria (temperature, humidity, etc.) should be taken into consideration.

4.2 Testing of Containers:

4.2.1 Test Method:

4.2.1.1 Assembled container shall be restrained in a rigid test fixture manufactured to provide restraint condition according to AS36100 specification, including relevant lock head designs and arrangements. See Appendix C for example of container test setup.

4.2.1.2 For all load directions, the orientation of the test unit shall be fixed so that the applicable panel is tested in load direction only.

4.2.1.3 Container is loaded according to section 4.2.2 - “Application of Test Load”, and with a CG according to section 4.2.3 - “Application of Eccentricity in Center of Gravity (CG).

4.2.1.4 The container, restrained in the test fixture, shall be freely suspended or loaded with the test panel remaining in a horizontal or vertical position. This can be achieved by using crane, hydraulic systems or other appropriate equipment.

4.2.2 Application of Test Load:

4.2.2.1 Test loads shall be in accordance with definition specified in section 2.2 - “Definitions”.

4.2.2.2 The load media shall be evenly distributed over the required panel surface, not taking any undue advantage of the container frame structure.

4.2.3 Application of Eccentricity in Center of Gravity (CG):

CG eccentricity shall be applied to the applicable ultimate test load in accordance with AS36100. CG eccentricity model is defined in AS36101 *“Air cargo unit load devices - Load distribution model”.*

4.2.4 Approval Criteria for Passing Container Test:

4.2.4.1 For each applicable direction, container attached to test fixture shall be freely suspended or loaded for a minimum of 3 seconds in accordance with Title 14 CFR Part 25,§ 25.305 (b).

4.2.4.2 Under test load, the container or parts thereof may exhibit damage or permanent deformation, but shall not deform or rupture to the extent of discharging its contents. Contents are defined as a reference load item (see 2.2 - “Definitions”) in any direction.

4.2.5 Recording Deformations:

After unloading container, with container resting on ground, any significant permanent deformation or other damage should be measured and recorded for inclusion in the test report.

4.3 Testing of Pallets:

4.3.1 Test Method:

4.3.1.1 The pallet shall be restrained in a rigid test fixture manufactured to provide restraint condition according to AS36100 specification, including relevant lock designs and arrangements. See Appendix B, Figure B3, for example of pallet test.

4.3.1.2 The pallet shall be tested in all load directions, unless a “worst case scenario” can be proved for one direction. The Upload Condition will usually be the “worst case scenario”.

4.3.1.3 The pallet can be tested in conjunction with a qualified net of the same configuration code according to AS36100, or without a net but with for example a mechanical loading configuration (see Figure B7).

4.3.1.4 The orientation of the test unit shall be fixed so that the pallet is tested in load direction only.

4.3.1.5 The pallet is loaded according to section 4.3.2 - “Application of Test Load”, and with a CG according to section 4.3.3 - “Application of Eccentricity in Center of Gravity (CG).

4.3.1.6 The test load shall be transferred into the pallet assembly by using standard net fittings conforming to ISO 9788 (or AS33601 or ISO 7166 in case of single studs, if applicable).

4.3.1.7 The load application point shall be applied in accordance with AS36100 configuration drawings.

4.3.1.8 The connection between pallet and net fittings shall be tested separately. The test shall be applied in accordance with the test requirements in AS36100 paragraph 4.10.3.3 - 4.10.3.5.

4.3.1.9 The pallet, restrained in the test fixture, shall be freely suspended or loaded in a horizontal or vertical position. This can be achieved by using crane, hydraulic systems or other appropriate equipment.

4.3.2 Application of Test Load:

Test loads shall be in accordance with definition specified in section 2.2 - “Definitions”.

4.3.3 Application of Eccentricity in Center of Gravity (CG):

CG eccentricity shall be applied to the applicable ultimate test load in accordance with AS36100. CG eccentricity model is defined in AS36101 *“Air cargo unit load devices - Load distribution model”*.

4.3.4 Approval Criteria for Passing Pallet Test:

4.3.4.1 The pallet attached to test fixture shall be freely suspended for a minimum of 3 seconds in accordance with Title 14 CFR Part 25, § 25.305 (b).

4.3.4.2 Under test load, the pallet or parts thereof may exhibit damage or permanent deformation, but shall not fracture or slip out of the restraints.

4.3.5 Recording Deformations:

After unloading the pallet, with pallet resting on ground, any significant permanent deformation or other damage should be measured and recorded for inclusion in the test report.

4.4 Testing of Pallet Nets:

4.4.1 Test Method:

4.4.1.1 Assembled pallet net shall be attached to a test fixture via the integral attachment fittings at the relevant pallet fixing positions to provide the restraint condition according to AS36100 specification. The net envelope will be supported to the maximum permissible base size of the pallet by either the test load or the test frame structure. The net shall be reefed evenly on all panel sides by a minimum of one mesh, thus simulating the reduction in load height. See Appendix D for example of pallet net test setup.

4.4.1.2 The test fixture and any other test hardware, where directly interfacing with the net, shall have a smooth surface and corners with a nominal surface radius of 76 mm [3 in] or more at any point of contact with the net mesh.

4.4.1.3 The test fixture is loaded according to section 4.4.2 - “Application of Test Load”, including a CG eccentricity according to section 4.4.3 - “Application of Eccentricity in Center of Gravity (CG)” to form the test load.

4.4.1.4 For the up load case, the net, restrained in the test fixture, shall be freely suspended or loaded with the roof panel remaining in a horizontal position. This can be achieved by using crane, hydraulic systems or other appropriate equipment.

4.4.1.5 For the forward, side or rear load cases, the net, restrained in the test fixture, shall be freely suspended or loaded with tested panel remaining in a horizontal or vertical position. This can be achieved by using a crane, hydraulic systems or other appropriate equipment.

4.4.2 Application of Test Load:

4.4.2.1 Test loads shall be in accordance with definition specified in section 2.2 - “Definitions”.

4.4.2.2 The load media shall be evenly distributed over the required panel surface, not taking any undue advantage of the test frame structure.

4.4.3 Application of Eccentricity in Center of Gravity (CG):

CG eccentricity shall be applied to the applicable ultimate test load in accordance with AS36100. CG eccentricity model is defined in AS36101 *“Air cargo unit load devices - Load distribution model”.*

4.4.4 Approval Criteria for Passing Pallet Net Test:

4.4.4.1 For each applicable direction, the pallet net shall be freely suspended or loaded for a minimum of 3 seconds in accordance with Title 14 CFR Part 25, § 25.305 (b).

4.4.4.2 Under test load, the net may exhibit damage or permanent deformation, but shall not deform or rupture to the extent of discharging its contents. Contents are defined as a reference load item (see 2.2 - “Definitions”) in any direction.

4.4.5 Recording Deformations:

After completing the test, any significant permanent deformation or damage should be measured when tension is released and net is laid flat and recorded for inclusion in the test report.

5. COMPUTER ANALYSIS:

5.1 Analysis Method:

Analysis software may be used to evaluate the geometry and examine the loads acting on ULD assemblies or individual elements of a defined structure such as pallet nets. The analysis shall verify the performance in the same test manner and with parameters as detailed in Section 4 - “Physical Testing”. See Appendix E for typical analysis results.

5.2 Material Data:

To enable the analysis to be performed, material data based on component material properties shall be obtained. This data shall consist of actual strength and elongation test results for each individual component.

5.3 Validation:

To validate the data model being created by the analysis software, two tests shall be performed to ensure the data is accurate. The tests may consist of subassemblies, interfaces and complete assemblies. A specific data model is defined by the ULD design criteria, such as materials, components, construction and manufacturing processes. Such a specific data model also covers all other ULD configurations with the same design criteria. For any deviation from the specific data model, a new validation is required.

5.3.1 Subassemblies and Interfaces Analysis:

Validation of the subassemblies and interfaces data model shall be carried out by direct comparison of analysis results against measured physical test results, including strength and elongation. The output results from each source shall be within a tolerance of 5%.

5.3.2 Assembly Analysis:

Validation of the assembly data model shall be carried out by direct comparison of analysis results against physical test results in all directions. The output data from the software analysis shall show that the assembly is capable of fulfilling the certification test requirement.

6. TEST OR ANALYSIS REPORT:

6.1 Purpose:

The main purpose of the test or analysis report is, together with any analytical and/or numerical deductions, to serve as proof that the ULD meets AS36100 minimum performance requirements.

6.2 Report Layout:

The test report should include the following sections if they are applicable:

6.2.1 Purpose of Test: A statement describing the purpose and stating the specifications, AS36100 ULD configuration and testing condition that were referenced and used in developing and performing the test.

6.2.2 Test Specimen: A detailed description of the ULD, preferably according to a drawing enclosed in Appendices, in addition to ULD part number.

6.2.3 Test Requirement: A description of the requirement according to AS36100, such as loads, CG eccentricity, restraint configuration, load application configuration drawings and degradation factor specified for the ULD test.

6.2.4 Test Equipment: A detailed description of the test fixture and other equipment that is used to perform the test.

6.2.5 Tests Procedure: A description of each of the tests performed, including a reference to types of loads.

6.2.6 Test Results: A description of the results of each of the tests performed, with actual load, location of CG, how long the ULD was held clear of support including photographic or video proof, information about any deformations and references to any drawings and/or pictures of test arrangements.

6.2.7 Conclusion: Statement that the ULD either pass or fail the specified requirement.

6.2.8 Appendices: Any drawings, pictures and/or other material needed for reference purposes.



PREPARED UNDER THE JURISDICTION OF
SAE SUBCOMMITTEE AGE-2A, CARGO HANDLING OF
COMMITTEE AGE-2, AIR CARGO & AIRCRAFT GROUND EQUIPMENT & SYSTEMS

APPENDIX A: AIR PRESSURIZED BLADDERS - TYPICAL TEST SET-UPS

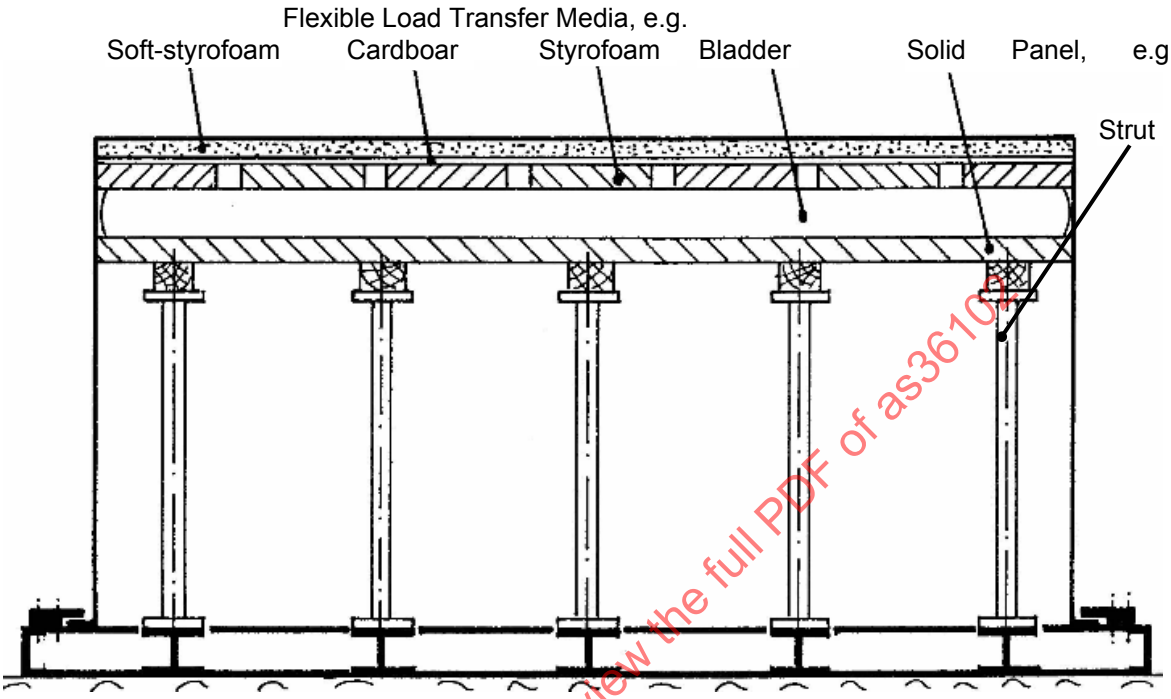


FIGURE A1 - Roof Test

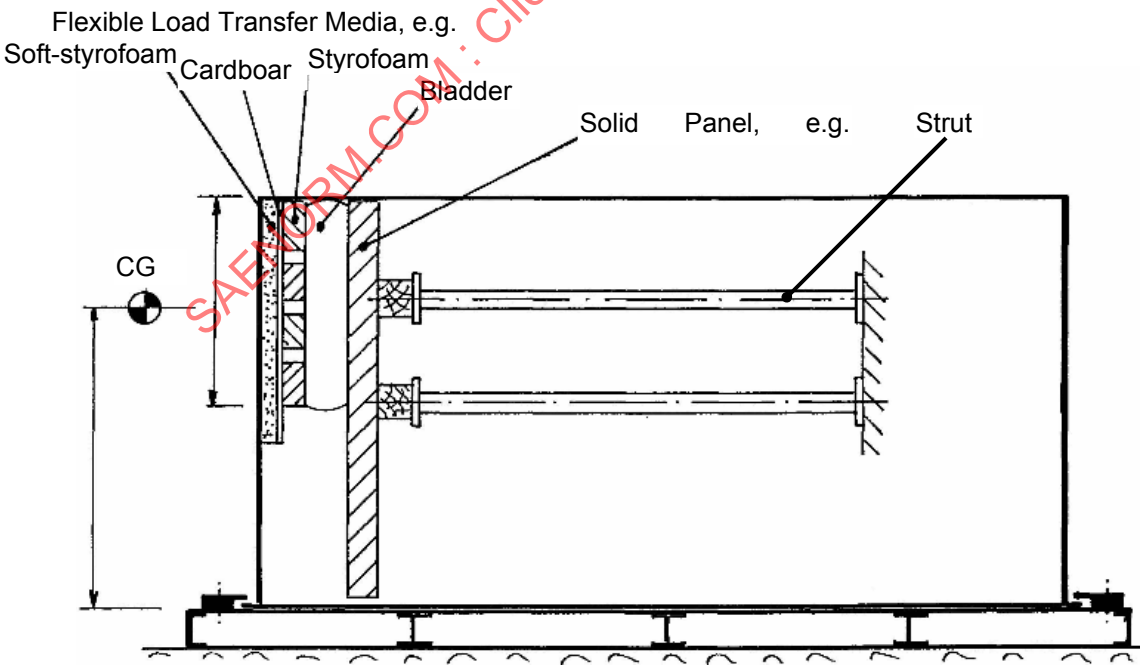


FIGURE A2 - Sidewall Test

AIR PRESSURIZED BLADDERS - PHYSICAL TESTING

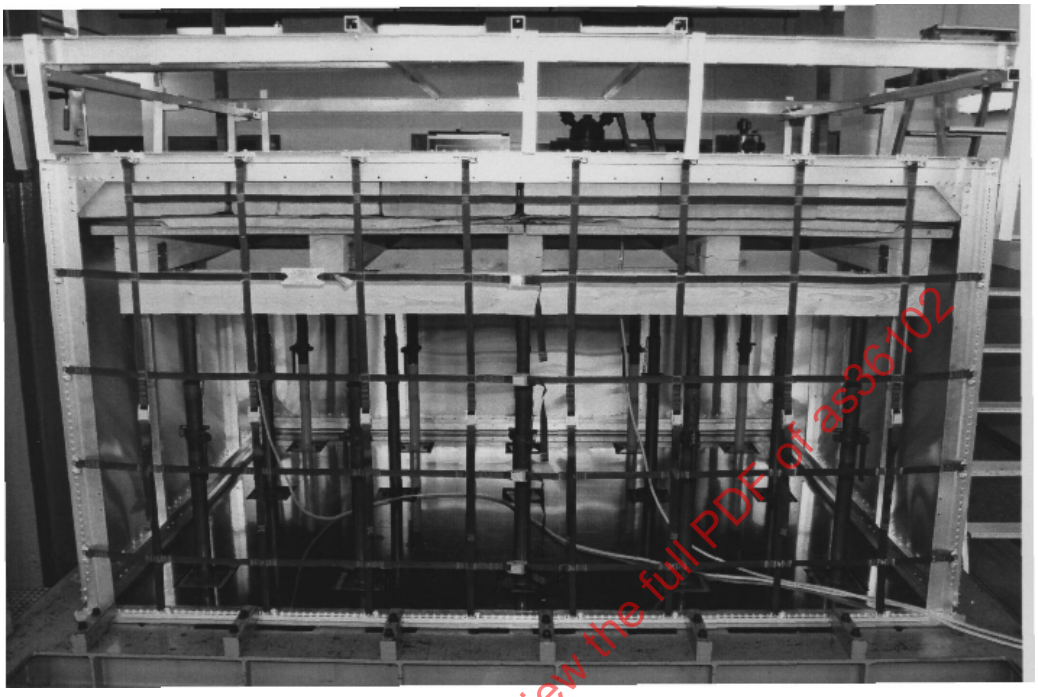

FIGURE A3 - Roof Test, Unpressurized

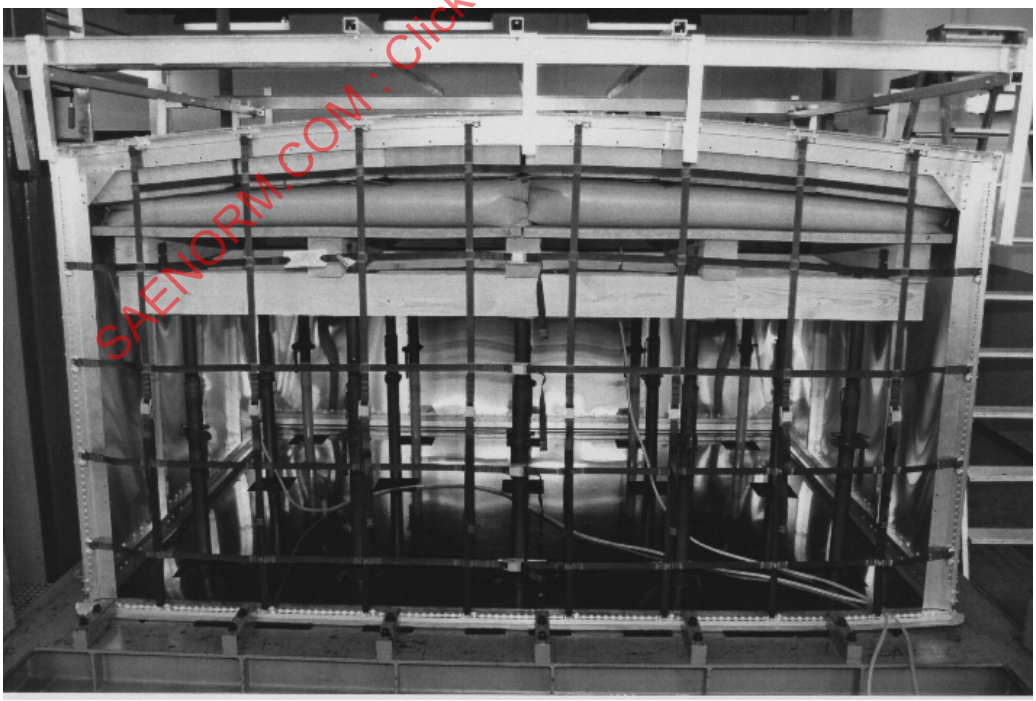

FIGURE A4 - Roof Test, Pressurized

APPENDIX B: HYDRAULIC SYSTEMS - PHYSICAL TESTING

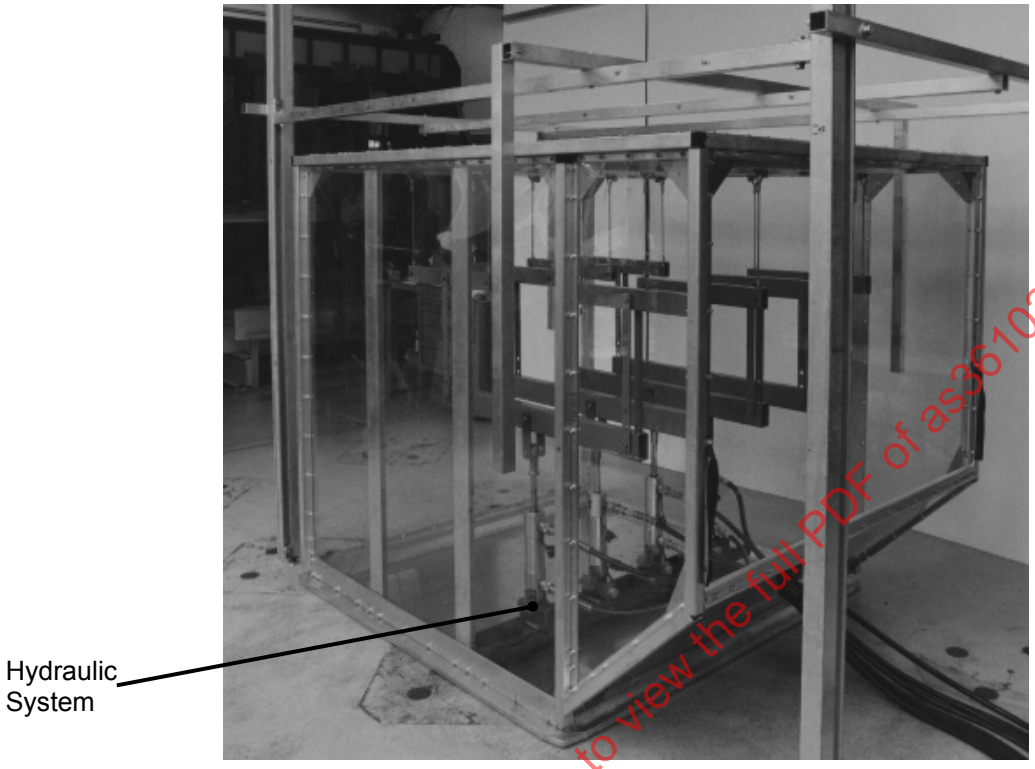


FIGURE B1 - Typical Hydraulic System


FIGURE B2 - Typical Lever System Attachment