Purdue University
Forestry and Natural Resources
Furniture Manufacturing

Performance Test Method for Intensive Use Chairs –FNEW 83-269:

A Description of the Test Method with Drawings

By Carl A. Eckelman and Yusuf Z. Erdil

1. Introduction

In 1978-79, the Wood Research Laboratory, a part of the Department of Forestry and Natural Resources of Purdue University, was asked by the General Services Administration of the Federal Government to develop performance tests for intensive use task chairs. At the time, these tests were to be used by the General Service Administration in its furniture procurement programs to qualify chairs that were to be used by air traffic controllers. The resulting standard, FNEW83-269, has been in use since the early1980's. Although its purpose was to evaluate the fitness for use of what were essentially very heavy-duty office chairs in specified use environments, the method of test has also proven to be a valuable aid in the engineering design of general purpose office chairs.

It has, for example, been used for such wide-ranging purposes as evaluating new tilt mechanism designs; evaluating new joint constructions and new fasteners; and evaluating new materials of construction. Most importantly, it has provided a method of test that yields information that can be incorporated into the product engineering process.

The equipment needed to conduct the tests is relatively inexpensive, simple, foolproof, and easily maintained. It can be constructed from readily available materials without precision machining. Furthermore, the simple-joint systems used allow the load heads to follow the complex motions of the various parts of the furniture and re-index into the proper position at the end of each load cycle—a degree of freedom of movement that is difficult to obtain with such simple low cost equipment.

Largely as a result of its value as an aid to engineering design and the simplicity of the equipment needed to conduct the tests, there has been a steady demand for information both about the test method and the construction of the equipment needed to carry out the tests. This document was prepared in order to make this information readily available to the furniture industry, and, in particular, to provide detailed drawings of the test equipment.

2. Overview of Test Method

This test method describes procedures for evaluating performance characteristics of intensive use chairs. Intensive use chairs are designed to be used 24 hours per day in a severe use environment.

A chair is subjected to one or more loads that are applied to the seat, back, arms, or legs at selected positions at a rate of twenty cycles per minute. The test is continued at this load level until 25,000 cycles have been completed. Loads are then increased by a given load increment and the test continued for another 25,000 cycles. This process is repeated until some part of the chair suffers disabling damage or a desired level of performance has been achieved. The performance rating of the chair is taken as the highest load level it was able to successfully complete 25,000 cycles.

3. Definitions

3.1 Disabling Damage

Damage to the chair or component that is sufficiently great to prevent the chair or component from performing its intended functions or would in any way cause personal injury to the occupant or bystanders.

3.2 Acceptance Level

The performance level required to pass the test.

3.3 Test Platform

The work surface, floor, or table on which the unit to be tested is placed during testing.

3.4 Structural Breakage

The failure of any structural component that carries load or restricts motion.

4. Description of Tests

4.1 Cyclic Back and Back Tilt Mechanism Fatigue Test for Chairs with Spring Type Tension Controls

4.1.1 Summary of Method

The cyclic back and back tilt mechanism fatigue test for intensive use chairs consists of subjecting the backs of the chairs to repeated front to back loads to evaluate the resistance of the back system.

4.1.2 Test Set-Up

Testing is carried out in the testing machine frame as shown in Figure 1. The entire chair is mounted on a test platform by means of chain hold-downs to prevent the chair from sliding backwards or overturning. A small chain binder is used to provide enough tension on each chain to hold the chair in place. A front to back load is applied to the back of the chair by means of an air cylinder. Loads are applied at a point 16 inches above the seat, or, to the top of the back if the back is lower than 16 inches. The load is applied in such a manner that it is normal to the plane of the back at the most rearward position. A length of strap, chain, or rope may be looped around the backrest of the chair to provide a means of connecting the air cylinder to the chair. The strap (or, chain, etc.) is then attached to the rod-end of the air cylinder by means of a small clevis. The air cylinder itself is attached to the main testing machine frame by means of an air cylinder attachment assembly.

Instead of pulling backward on the backrest as just described, loads may be applied to the front surface of the backrest in a front to back direction by means of a backrest load frame as shown in Figure 2.

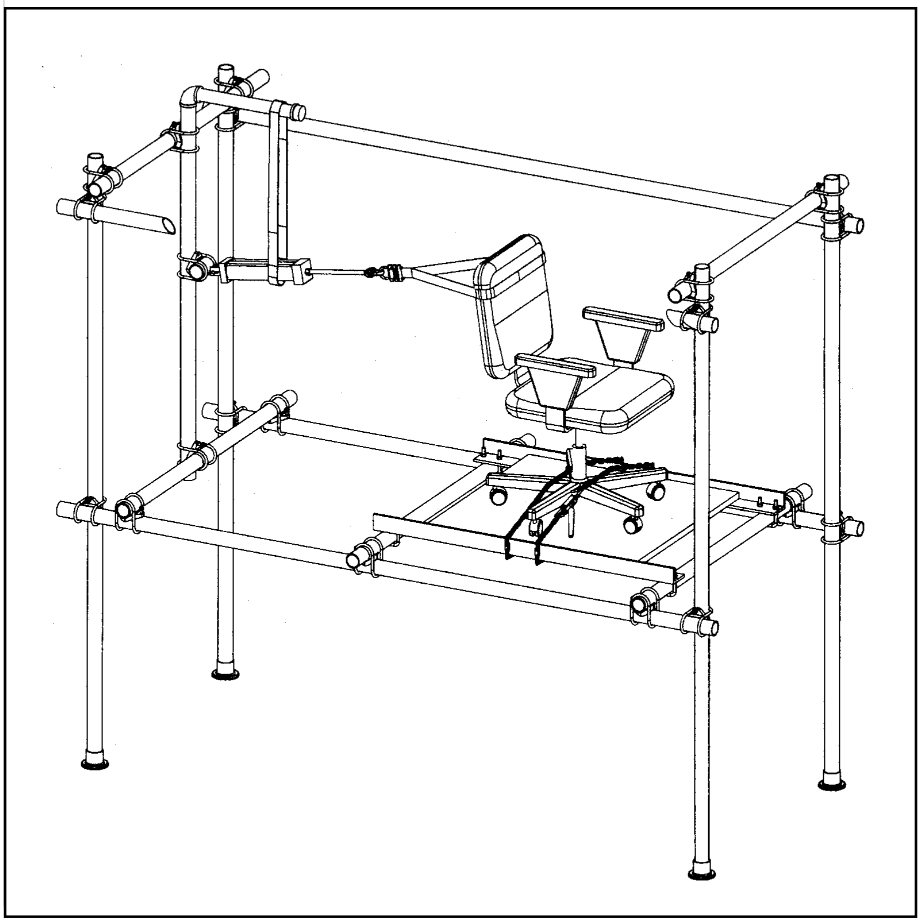

Figure 1. Cyclic back and back tilt mechanism test.

4.1.3 Procedures

The tilt mechanism shall be adjusted so that the top of the back moves 4 inches +/-1 inch rearward under the action of a 40-pound load. The test is carried out at a 50-pound load level at 20 cycles per minute and is continued until the back or tilt mechanism suffers disabling damage or until the required acceptance level is achieved.

4.2 Cyclic Increasing Back Load Test

4.2.1 Summary of Method

This test consists of applying cyclic front to back loads to the backrest of the chair—which simulates the action of a user leaning backwards. The test can be carried out with the same equipment used in the cyclic back and back tilt mechanism fatigue test (4.1). In this test, however, cyclic stepped loads are used to evaluate the strength of the back system.

4.2.2 Test Set-Up

The test is carried out in the testing machine frame as shown in Figure 1. The chair is secured to the test platform with a length of chain looped twice around the base. A small chain binder is used to provide sufficient tension on the chain to hold the chair in place. Front to back loads are applied to the back of the chair by means of an air cylinder. Loads are applied at a point 16 inches above the seat, or, to the top of the back if the back is lower than 16 inches. The load is applied in such a manner that it is normal to the plane of the back when the back is at its most rearward position. A length of strap (a chain or rope may also be used) is looped around the backrest of the chair to provide a structure for attaching the rod of the air cylinder to the chair. The rod end of the air cylinder is then attached to the strap by means of a small clevis. The air cylinder itself is attached to the main testing machine frame by means of an air cylinder attachment assembly. Instead of pulling backward on the backrest as just described, loads may be applied to the front surface of the backrest in a front to back direction by means of a backrest load frame as shown in Figure 2.

4.2.3 Procedures

If the chair uses a spring type tension control, the control is adjusted to its loosest position. If the chair uses an air cylinder or other mechanism that locks the chair inclination in a fixed position, the control is adjusted to the far backward position. The test is started at the 75-pound load level with the load increased in increments of 25 pounds after 25,000 cycles have been completed at each preceding load level. Testing continues until some type of disabling damage occurs or the chair meets the required acceptance level.

4.3 Cyclic Pneumatic Back Tilt or Seat Inclination Adjustment Mechanism Test

4.3.1 Summary of Method

This test evaluates the fatigue strength of the back tilt or seat inclination adjustment system by testing each one of these systems individually.

4.3.2 Test Set-Up

A. Seat Inclination Adjustment Mechanism Test: The test is carried out in the testing machine frame as shown in Figure 3. The chair is secured to the test platform with a length of chain looped twice around the base. A small chain binder is used to provide sufficient tension on the chain to hold the chair in place. An air cylinder is attached to the main frame in a vertical direction directly above the seat of the chair. The rod end of the cylinder is attached to a 50-pound weight by means of a short length of chain. The length of the chain is chosen so that the cylinder is able to lift the weight off the seat when air is applied to the cylinder, or to allow the 50-pound weight to rest on the seat, free of support, when air is not applied.

A small cylinder is then clamped in a vertical position to the arm of the chair, Figure 3. The rod end of this cylinder is attached to the seat inclination adjustment lever by means of a length of small chain. This cylinder is used to activate the seat inclination adjustment mechanism.

B. Back Inclination Adjustment Mechanism Test: The test is carried out in the testing machine frame as

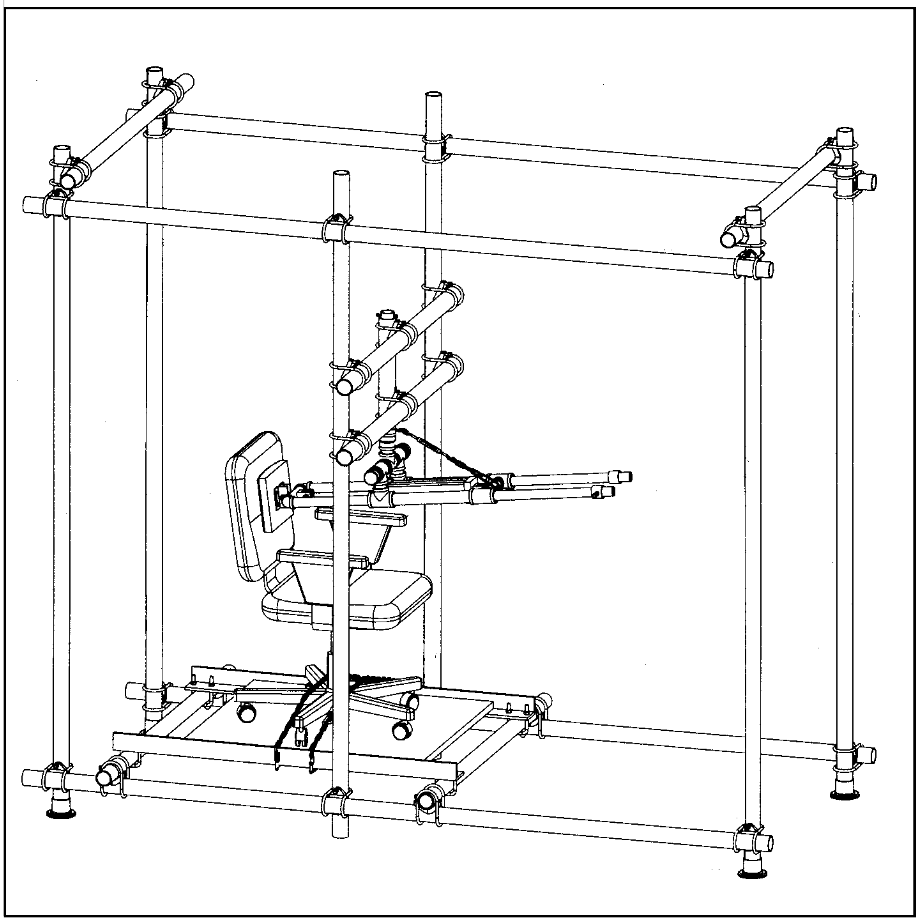

Figure 2. Alternative set-up for cyclic back and back tilt mechanism test.

shown in Figure 4. The chair is secured to the test platform with a length of chain looped twice around the base. A small chain binder is used to provide sufficient tension on the chain to hold the chair in place. Front to back loads are applied to the back of the chair by means of an air cylinder. Front to back loads are applied at a point 16 inches above the seat, or, to the top of the back if the back is lower than 16 inches. The load is applied in such a manner that it is normal to the plane of the back when the back is at its most rearward position. A length of strap (a chain or rope may also be used) is looped around the backrest of the chair to provide a point of attachment for the rod end of the air cylinder on the chair. The rod end of the air cylinder is then attached to the strap by means of a small clevis. The air cylinder itself is attached to the main testing machine frame by means of an air cylinder attachment assembly.

A small cylinder is then clamped in a vertical position to the arm of the chair, Figure 4. The rod end of this cylinder is attached to the back inclination adjustment lever by means of a length of small chain. This cylinder is used to activate the back inclination adjustment mechanism. In those cases where the chair has no arm, a bracket must be clamped to the seat that will provide a point of support for the cylinder in much the same manner as an arm provides support.

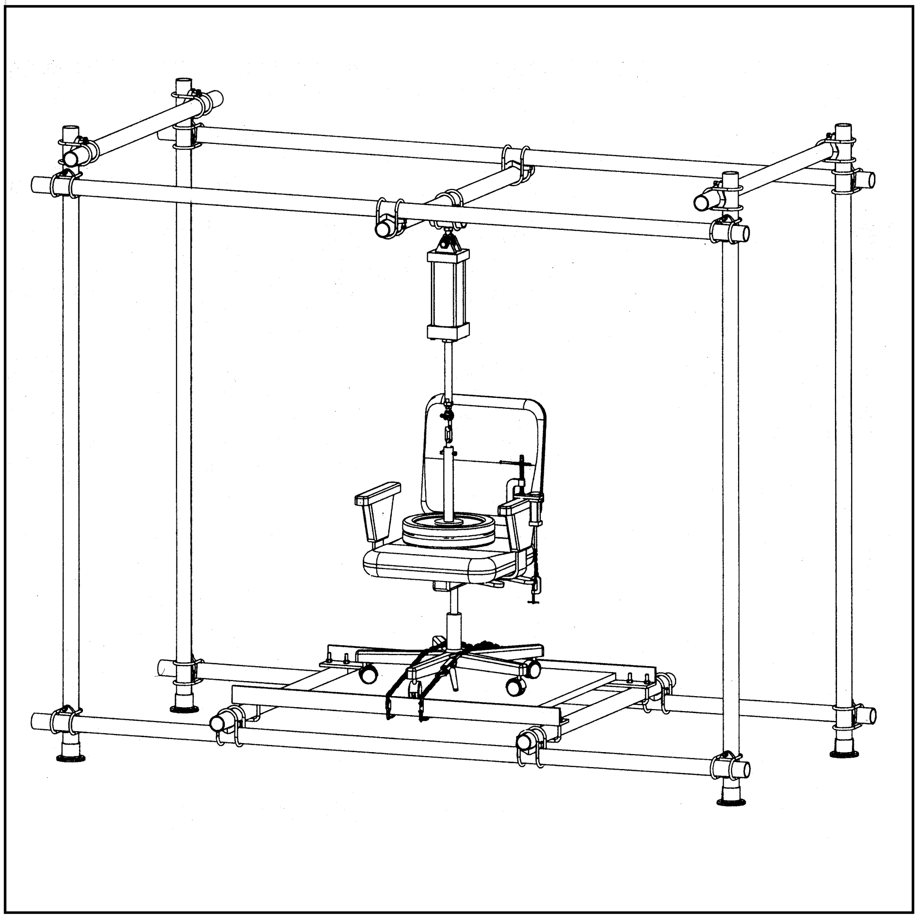

Figure 3. Test set-up for seat inclination adjustment test.

4.3.3 Procedures

If a chair has a pneumatic back tilt or pneumatic seat inclination adjustment mechanism, each is tested. The test uses a four-part cycle as follows:

A. A 50-pound load is applied to the seat (seat inclination test) or back (back inclination test) normal to the plane of the seat, or, to the plane of the back. The load is applied to the seat or back at that location that will most easily cause the seat or back to tilt when the tilt activator is operated.

B. The load is removed.

C. The load is reapplied and the adjustment mechanism is activated while the chair is under load.

D. The load is removed—while the adjustment mechanism remains activated—until the seat or back mechanism returns to its normal position. Once the normal position is reached, the adjustment mechanism is deactivated.

The complete cycle is repeated at a rate of 5 cycles per minute. The test is continued until some part of the adjustment system malfunctions or the chair meets the required acceptance level.

4.4 Cyclic Vertical Load Test on One Arm

4.4.1 Summary of Method

The vertical arm test is set up to evaluate the resistance of chair to vertical loads exerted on the arm as occur, for example, when a user pushes on the arm while sitting down or getting up, or, when a user actually sits on the arm. This test not only evaluates the strength of the arm and arm assembly, it also evaluates the strength of the chair spindle.

4.4.2. Test Set-Up

The test is carried out in the testing machine frame as shown in Figure 5. The chair is secured to the test platform with a length of chain looped twice around the base. A small chain binder is used to provide sufficient tension on the chain to hold the chair in place. Vertical loads are applied at the approximate center or front edge of either arm by means of an air cylinder. A length of strap or chain is looped around the arm and then attached to the rod-end of the air cylinder by means of a clevis, Figure 5. The air cylinder itself is attached, in a vertical position, to a cross pipe in the main frame by means of an air cylinder attachment assembly. Details of the strap or chain attachment and cylinder attachment assembly are shown in Figure 28 and Figure 29, respectively.

4.4.3 Procedures

A vertical downward load is applied at the approximate center of one armrest of a chair at a cyclic rate of 20 cycles per minute. The test is begun at a load level of 100 pounds and increased in increments of 50 pounds after 25,000 cycles have been completed at the preceding load level. Loads are increased every 25,000 cycles until the chair suffers disabling damage or meets desired acceptance level.

4.5 Cyclic Side Thrust Load Test on Arms

4.5.1 Summary of Method

This test is used to evaluate the strength of the chair when side thrust loads are applied to an arm. Such loads occur when the user sits down or gets up from the chair, or when the chair is pulled or pushed sideways.

4.5.2 Test Set-Up

The test is carried out in the testing machine frame as shown in Figure 6. The chair is secured to the test platform with a length of chain looped twice around the base. A small chain binder is used to provide sufficient tension on the chain to hold the chair in place. A length of chain or strap is looped around each arm in such a manner that the loads are applied at the center of the armrests. On one arm, the strap or chain is attached to the rod end of the air cylinder by means of a clevis; the strap on the other arm is attached to the main frame by means of a clevis that is secured by a cylinder attachment assembly. It should be noted that the loaded arm and reaction arm are in line so that both arms are, in effect, loaded identically. Presumably, therefore, the weaker of the two arms will fail in the test.

4.5.3 Procedures

A cyclic outward side thrust load is applied to an arm of the chair at a rate of 20 cycles per minute. The load is applied to the approximate midpoint along the length of the arm normal to the vertical plane of the arm. The test is begun at the 50-pound load level. Loads are increased in increments of 25 pounds after 25,000 cycles have been completed at each preceding load level. Loads are increased every 25,000 cycles until the chair suffers disabling damage or meets the desired acceptance level.

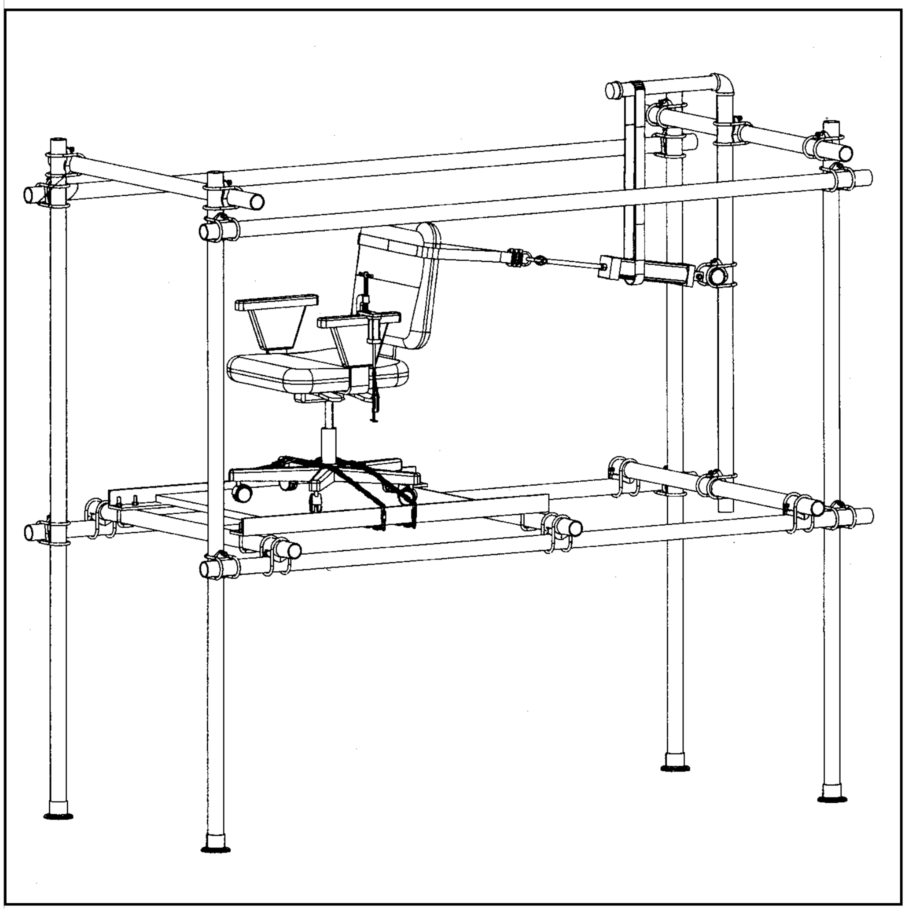

Figure 4. Back inclination adjustment test set-up.

4.6 Cyclic Vertical Load Test on Seats, Bases and Casters

4.6.1 Summary of Method

This test consists of subjecting the seat of the chair to cyclic vertical increasing stepped loads by means of a vertical load frame, Figures 7 and 19. This test evaluates the strength of the seat structure as well as the seat understructure—usually composed of swivel column, base, and casters.

4.6.2 Test Set-Up

The test is carried out in the testing machine frame as shown in Figure 7. The chair is secured to the test platform with a length of chain looped twice around the base. A small chain binder is used to provide sufficient tension on the chain to hold the chair in place. In addition to chains, small squares of plywood with holes cut in them may be attached to the face of the platform to contain the casters and keep the chair from rolling. The load frame is attached to a cross pipe at the top of the main testing frame by means of a scaffolding clamp. The load frame is equipped with a dual wheel load head in order to distribute the load over a portion of the seat corresponding to the area normally occupied by a human subject.

4.6.3 Procedures

Vertical loads are applied to the seat at a rate of 20 cycles per minute at a point 2 inches in front of the longitudinal axis of the spindle. The test is started at the 200-pound load level; loads are increased in increments of 100 pounds after 25,000 cycles have been completed at each preceding load level. The casters are turned at right angles to the legs so that all legs are subjected to torsional forces. Testing continues until some type of disabling damage occurs or the chair meets the desired acceptance level.

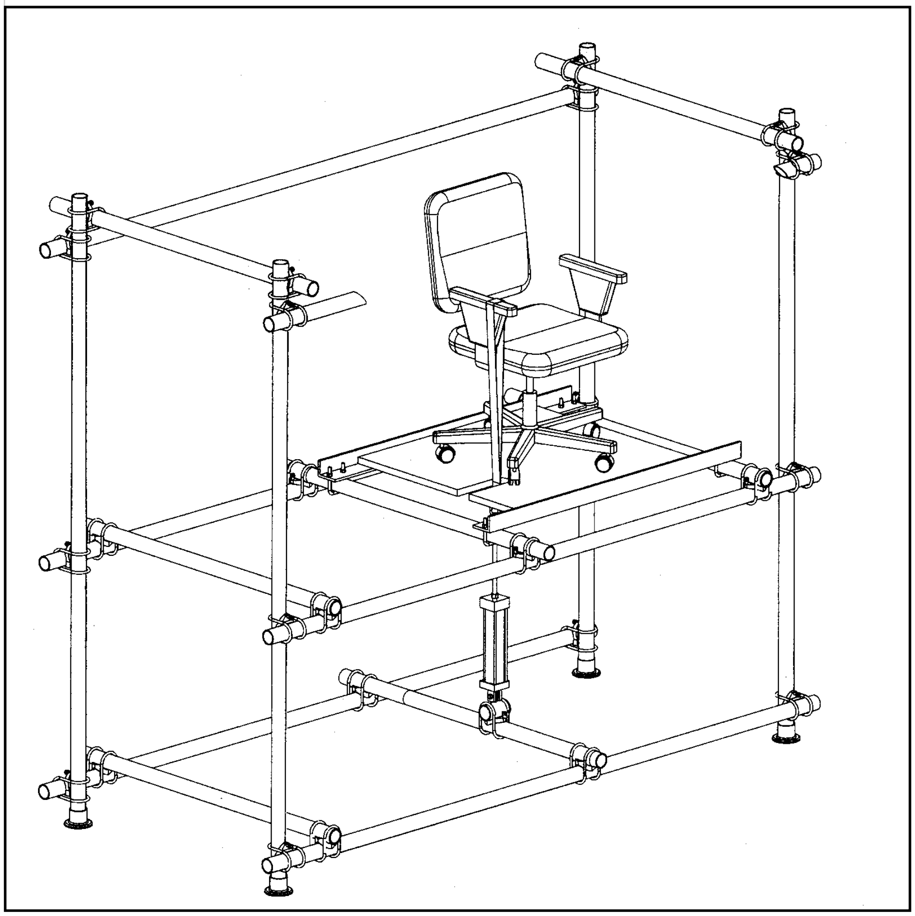

Figure 5. Test set-up for cyclic vertical load test on one arm.

4.7 Cyclic Fatigue Test of Swivel Bearings

4.7.1 Summary of Method

This test evaluates the endurance of the swivel system to cyclic rotating actions. It consists of fully rotating the base 360 degrees in alternate directions while keeping the seat fixed in position.

4.7.2 Test Set-Up

The test set-up is shown in Figure 8. An exploded view of the test platform is shown in Figure 9. The platform is rotated by means of a 20-inch diameter pulley and belt, driven by an air gear motor or a reversible electric gear motor equipped with a 2-inch diameter drive pulley. The motor is secured to a base plate that is connected to two 1-1/2 inch upright pipes by means of U-bolts. One end of the plate is mounted to a length of 2-inch diameter pipe that fits over one of the two 1-1/2 inch uprights and is free to rotate. The bottom of this pipe rests on the floor flange used to connect the 1-1/2 inch upright to the platform on which the complete assembly rests. The other end of the plate is attached to the other 1-1/2-inch upright by means of a single U-bolt. The nuts on this U-bolt are tightened, or adjusted, in order to obtain the desired belt tension.

The rotating platform sits on four casters that support the platform on its undersides. Small squares of plywood with holes cut into them are attached to the face of the rotating platform to contain the casters and keep the chair from rolling out of the testing platform. Straps are looped around the arms and then attached to the pipes to keep the seat from rotating during the test. An air cylinder is used to lift the load off the seat when the chair is being inserted or removed from the test jig. This cylinder is attached to an overhead crossbar of the testing machine frame by means of a cylinder attachment assembly, Figure 28.

4.7.3 Procedures

The chair is secured to a platform that is rotated a full 360 degrees in each direction at a rate of 10 times per minute. A static load of 200 pounds is placed on the chair with its center of gravity located 4 inches in front of the longitudinal axis of the spindle. The load is increased every 25,000 cycles by 25 pounds. The rotating platform—with the chair base attached—is rotated beneath the chair while the loaded seat is prevented from rotating. The amount of torque required to cause the chair to rotate from a stopped position is measured every 25,000 cycles. The 200-pound load is left in place while the torque measurement is taken. Testing is continued until the torque rises above the acceptance level or the chair completes the desired number of test cycles.

4.8 Cyclic Pneumatic Height Adjustment Durability Test

4.8.1 Summary of Method

This test determines the durability of the seat height adjustment mechanism. It consists of applying loads to the seat of the chair in a prescribed sequence both while the adjustment mechanism is activated and deactivated.

4.8.2 Test Set-Up

The test is carried out in the testing machine frame as shown in Figure 10. The chair is secured to the test platform with a length of chain looped twice around the base. A small chain binder is used to provide sufficient tension on the chain to hold the chair in place. An air cylinder is attached in a vertical position to a crossbar of the main testing machine frame by means of a cylinder attachment assembly, Figure 28. The rod end of the cylinder is attached to a short length of chain that, in turn, is attached to the dead weights that are used to load the seat of the chair.

A small cylinder is then clamped in a vertical position to the arm of the chair. The rod end of this cylinder is attached to the seat height adjustment lever by means of a length of small chain. This cylinder is used to activate the seat height adjustment mechanism. In those cases where the chair has no arm, a bracket must be clamped to the seat that will provide a point of support for the cylinder in much the same manner as an arm provides support.

4.8.3 Procedures

The test is begun with the seat in its highest position and the seat adjustment deactivated. The height adjustment mechanism is tested using a four-part cycle as follows:

A. Seat is loaded with 250 pounds.

B. Load is removed.

C. Load is reapplied and adjustment mechanism is activated.

D. Load is removed and adjustment mechanism remains activated until seat ascends to highest position, whereupon it is inactivated.

The entire cycle is repeated at a rate of 5 cycles per minute. The test is continued until some part of the adjustment system malfunctions or the chair meets a desired acceptance level.

4.9 Front Stability Test

4.9.1 Summary of Method

The front stability test consists of applying vertical downward loads to the front edge of the chair seat until the chair begins to tilt forward as evidenced by the lifting of the rear casters from the floor.

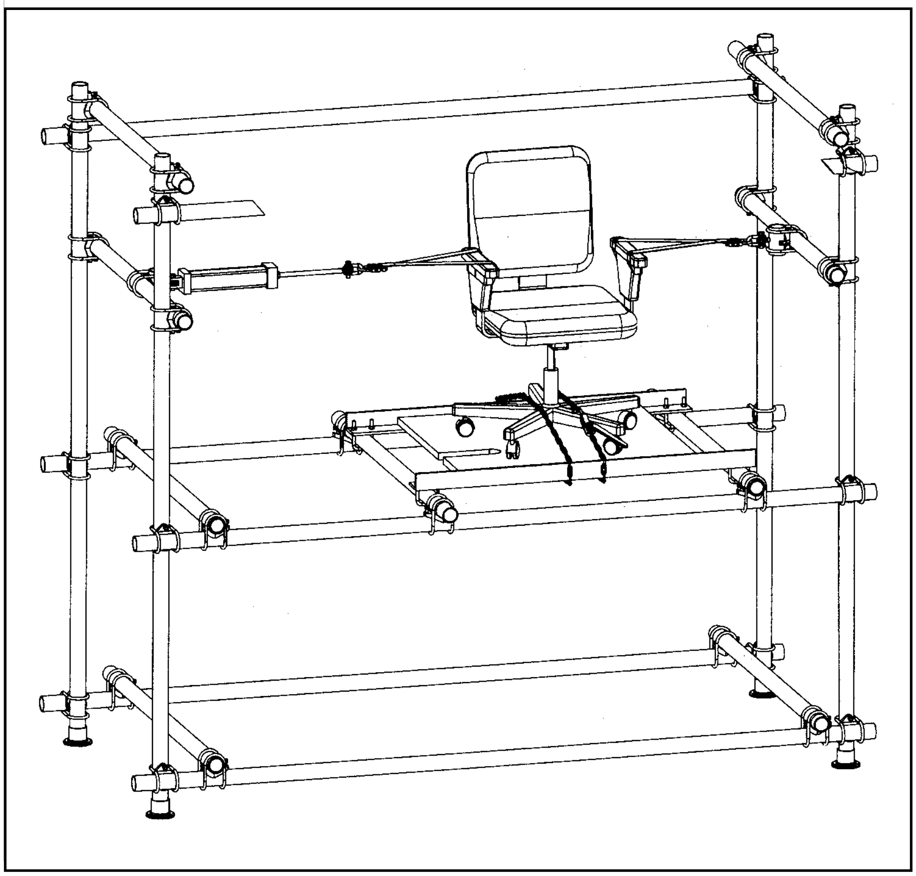

Figure 6. Cyclic side thrust load test on arms set-up.

4.9.2 Test Set-Up

The test is carried out in the testing machine frame as shown in Figure 11. A length of strap, or chain, is looped around the chair back and the free ends allowed to droop over the front edge of the seat at the center point of the front edge of the seat. The free ends then extend vertically downward and pass through an opening cut in the platform base. They are then secured to a simple end-connection for straps to which dead weights may be attached. The base and the casters are turned to produce the most unstable condition; i.e., a line drawn from the projection of the longitudinal axis of the chair stem on the platform base to the strap drooping over the front edge of the seat should bisect the angle between two legs of the chair, and the casters should be turned toward the back of the chair. An eyebolt attached to the lower end of the strap provides a construction on which slotted weights may be hung as shown in Figure 11.

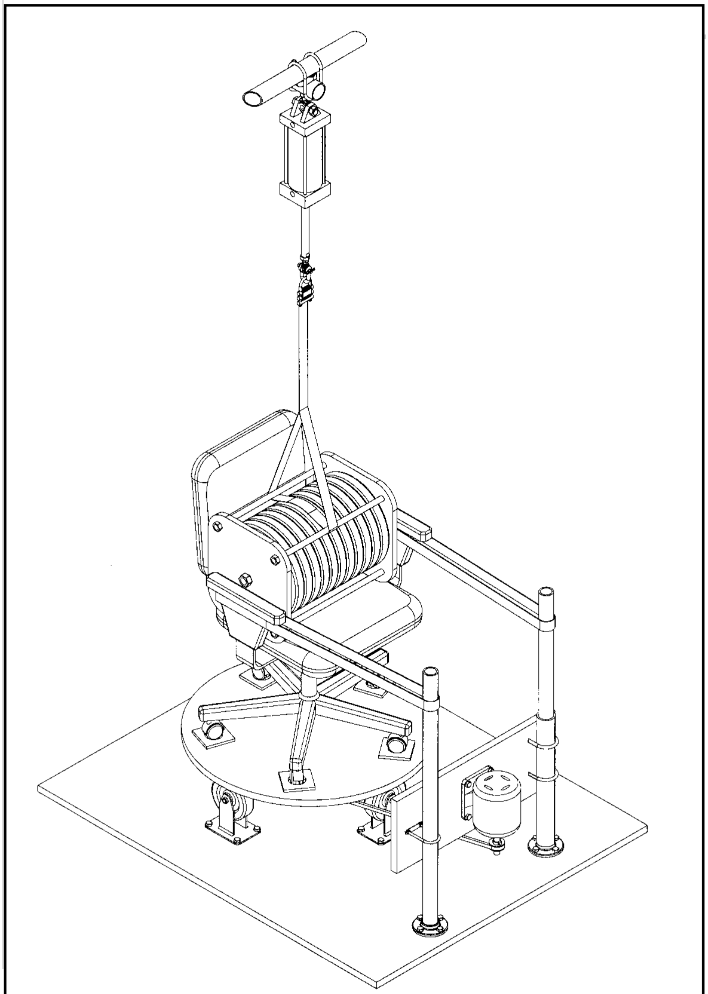

Figure 7. Set-up for cyclic vertical load test on seats, bases, and casters.

4.9.3 Procedures

The front stability test is conducted as follows:

A. The chair is placed on a level test platform with the seat height adjusted to its lowest setting.

B. The base and casters are placed in their most unstable position.

C. A downward vertical load is applied to the front center edge of the seat. The load in pounds required to just lift the rear casters off the test platform is recorded as the measure of front stability.

4.10 Back Stability Test

4.10.1 Summary of Method

The back stability test consists of applying a front to back load to the top of the backrest of a chair in a front to back direction until the chair begins to tilt backward. The front edge of the chair is loaded with 50 pounds before the test is conducted. The force required to cause the chair to tilt multiplied by the height of the point of load application on the chair back above the platform is taken as the back stability of the chair.

4.10.2 Test Set-Up

The test is carried out in the testing machine frame as shown in Figure 12. A length of strap, or chain, is looped around the chair back and the free ends allowed to droop over the front edge of the seat at the center point of the front edge of the seat. The free ends then extend vertically downward and pass through an opening cut in the platform base. An eyebolt attached to the lower end of the strap provides a construction on which slotted weights may be hung as shown in Figure 12. A similar length of strap is looped around the back of the chair and then passed over the top of the backrest to the rear of the chair as shown in Figure 12. This strap extends backward, parallel to the floor, and passes over a pulley. The free end of the strap, which then hangs in a vertical direction, is attached to an eyebolt that provides a construction on which slotted weights may be hung as shown in Figure 12.

A 1-inch diameter pipe is placed behind the base of the chair to prevent the chair from rolling backwards during the test. In practice, this causes the base to turn so that two casters bear against the pipe-stop; the casters, in turn, rotate to the inward position.

4.10.3 Procedures

The back stability test is conducted as follows:

A. The chair is placed on a level test platform at the lowest seat height setting.

B. The base and casters are placed in their most unstable position.

C. A 1-inch high obstruction is placed behind the two rearward casters.

D. The front edge of the seat is loaded with 50 pounds applied in a manner similar to that used in the front stability test.

E. A horizontal front-to-back load is applied to the top of the backrest. The force required to overturn the chair multiplied by the height from the platform to the top of the backrest is recorded as the measure of back stability.

4.11 Caster and Base Durability Test

4.11.1 Summary of Method

The objective of the test is to evaluate the durability of the chair base and casters in response to the forces and wear caused by the user moving the chair backward and forward.

4.11.2 Test Set-Up

The chair is placed on the test platform as shown in Figure 13 and Figure 14. The test vehicle consists of a movable platform mounted on 4-inch casters. The casters, in turn, run in two tracks constructed of 4-inch wide channel iron. Obstacles are mounted on the surface of the test platform in accordance with the diagram given in Figure 15.

The chair is held in place by a U-bolt that passes around the stem of the chair and is secured in turn to a metal plate that is welded to the end of a 2-inch pipe. This pipe is then attached to two vertical pipes, which are parts of the main testing machine frame, by means of scaffolding clamps. The function of these two vertical pipes is to keep the chair from moving from side to side as the test platform rolls back and forth.

The back and forth motion of the platform is provided by a crank arm system (for purposes of safety, a disk should be used—at least 30 inches in diameter) and push rod. The crank arm is attached to a gear reducer unit that in turn is driven by an electric motor. A 3/4 inch steel push rod equipped with rod ends on both ends is then attached to the crank arm and to the test platform as shown in Figure 13.

An air cylinder is attached to an overhead crossbar of the testing machine frame by means of a cylinder attachment assembly, Figure 28. This cylinder is used to lift the load off the seat when the chair is being inserted or removed from the test jig.

4.11.3 Procedures

A chair with casters is mounted on the moveable platform as shown in Figure 13. A 300-pound load is applied to the chair seat with the chair spindle fully extended. The base is attached to a mechanical device that exerts a horizontal push and pull of from 30 inches to 34 inches as illustrated in the figure. The base and casters are free to rotate and swivel. The machine operates continuously at a rate of 8 to 10 cycles per minute with a maximum speed of 50 feet per minute. One cycle consists of a forward and backward stroke of the mechanical device. Testing continues until the base or a caster suffers structural breakage, loss of serviceability, or a failure that would in any way cause personal injury to the occupant or bystanders, or, the desired acceptance level is met.

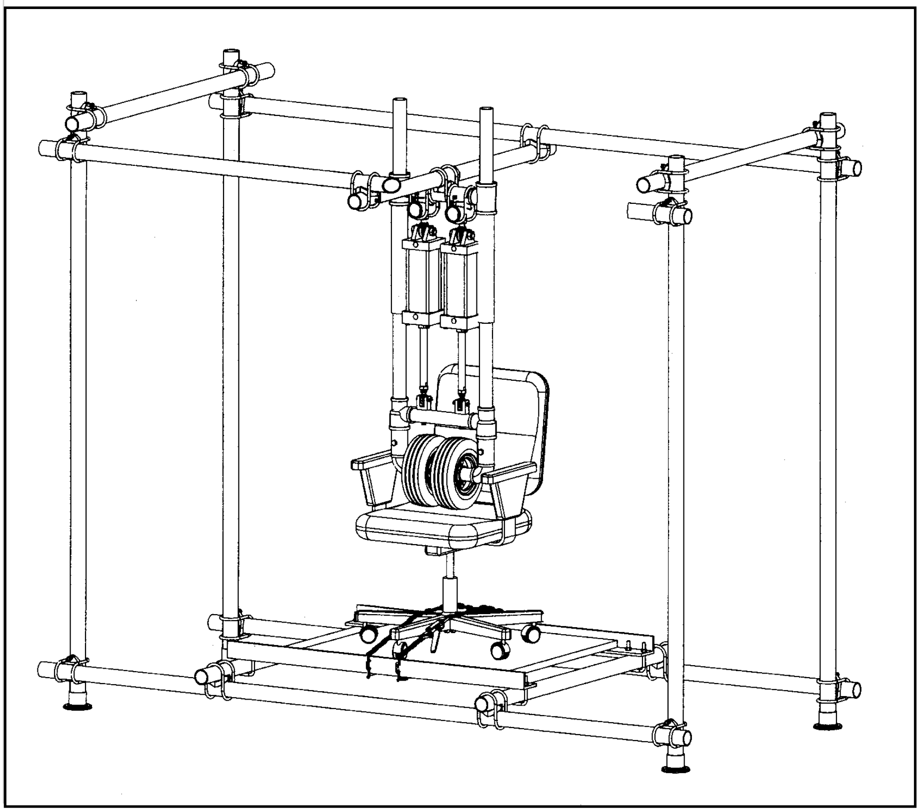

Figure 8. Test set-up for cyclic fatigue test of swivel bearings.

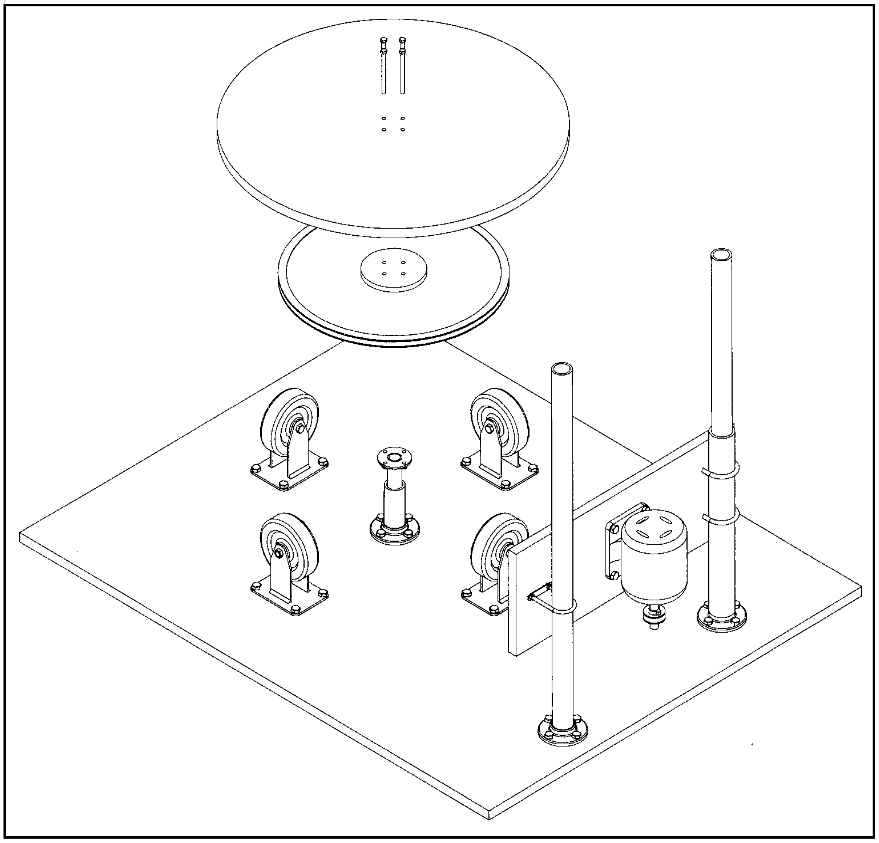

Figure 9. Exploded view of the rotating test platform.

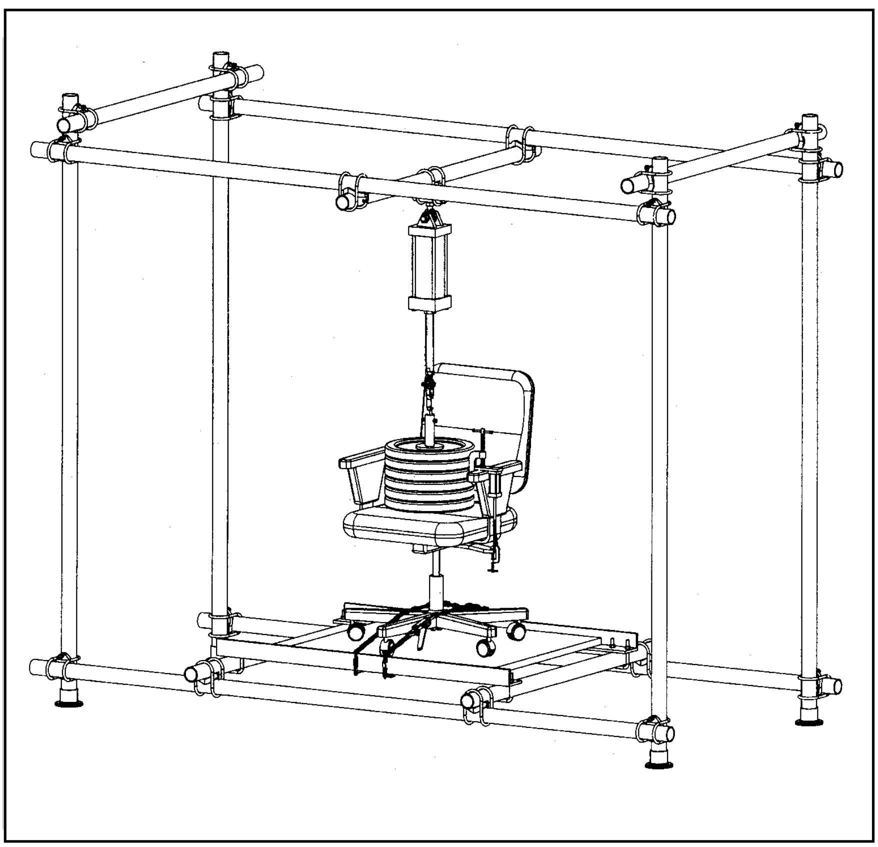

Figure 10. Cyclic pneumatic height adjustment durability test set-up.

4.12 Fabric Durability Test

The provisions of the fabric durability test lie outside the scope of structural durability tests and hence are not included in this document.

4.13 Spindle Attachment Tests

4.13.1 Summary of Method

Two distinct tests are used to evaluate the strength of the spindle attachment to the seat control mechanism. In the first test, the stem is subjected to torsional forces. In the second test, the stem is subjected to withdrawal forces.

4.13.2 Test Set-Up

In the torsional test, the control is mounted in a bench vice with the stem of the chair extending outward in a direction parallel to the floor. A torque is then applied to the stem by means of a device such as a pipe wrench. In practice, a pipe wrench can be attached in a horizontal position to the stem of the chair. The handle of the wrench can be inserted through the eye of a large eyebolt and the eyebolt positioned on the handle at a distance of 12 inches from the longitudinal axis of the stem of the chair. A large washer and nut are then threaded onto the threaded end of the eyebolt to provide a surface on which slotted weights may be placed.

In the withdrawal test, a universal testing machine is used with appropriate jigs to pull the stem free from its socket in the control mechanism.

4.13.3 Procedures

The control and spindle shall be detached from the chair and tested as follows:

Test A) Apply a torque of 100 foot-pounds to turn or displace the spindle from the control by use of a tool such as a torque-wrench.

Test B). Apply a force of 1,500 pounds to the spindle in the direction of its removal from the control at the rate of 0.100 to 0.125 inch per minute.

When a free swiveling fitting is used to attach the spindle to the control, Test A may be disregarded.

5. Acceptance Levels

The acceptance levels given below are those specified in FNEW 83-269, "Performance Tests for Intensive Use Chairs."

Test	Acceptance Level
4.1 Cyclic Back and Back Tilt Mechanism Fatigue Test	1,000,000 cycles
4.2 Cyclic Increasing Back Load Test	Complete 175 lb load level
4.3 Cyclic Pneumatic Back Tilt or Seat Inclination Adjustment Test	Not Specified
4.4 Cyclic Vertical Load Test on One Arm	Complete 250 lb load level
4.5 Cyclic Side Thrust Load Test on Arms	Complete 200 lb load level
4.6 Cyclic Vertical Load Test on Seats, Bases, and Casters	Complete 1300 lb load level
4.7 Cyclic Fatigue Test of Swivel Bearings	Max. 150 lb-in at 300 lb load on seat
4.8 Cyclic Pneumatic Height Adjustment Durability Test	125,000 cycles
4.9 Front Stability Test	Min. 125 lbs
4.10 Back Stability Test	Min. 1450 lb.-in.
4.11 Caster and Base Durability Test	36000 Cycles
4.12 Fabric Durability Test	
4.13 Spindle Attachment Tests	Spindle shall remain unmoved after completion of Test A or Test B.

6. Specific Test Equipment

6.1 Vertical Load Frame

An exploded view of the construction of a typical vertical load frame used in the vertical load test on seats (4.6) is shown in Figure 16. The load frame consists of three basic units—an internal and an external load frame and tire load head. The internal frame consists of two vertical extension shafts that are joined together at one end by two reducing tees and a crossbar to form a U-shaped frame.

The tire load head is constructed as follows. A pair of pipe flanges is bolted to the rim of each tire. The two 11 x 4 smooth tread tires are then joined to each other by means of a 1-1/2-inch diameter pipe nipple screwed into the pipe flanges. Another nipple is then screwed into the pipe flanges on the outside of each tire. Elbows are next attached to the free ends of the nipples. Finally, two short extension shafts are attached to each elbow to make the tire-head unit complete. These extension shafts are made to fit into mating 2-inch diameter extension shafts on the lower ends of the internal load frame. The load head frame and the internal load frame are then joined together by means of bolts as shown in Figure 17.

The external load frame consists of two vertical extension shaft sleeve bearings that are joined together at one end by two tees and a crossbar to form a second U-shaped frame. Diameter of the pipe used in the internal frame is 1-1/2 inch, whereas the diameter of the pipe used in the external frame is 2 inches. These frames are adjusted during construction so that the internal extension frame is free to slide up and down inside the external frame.

The center crossbar of the internal frame has two holes drilled into it so that two clevises can be attached to it. These clevises provide points of attachment for the rod ends of the cylinders.

The crossbar of the external frame is just long enough to accommodate three scaffolding clamps, Figure 18. The center scaffolding clamp is used to attach the complete load frame to the testing machine frame. Short lengths of pipe (4 inches long) are attached with scaffolding clamps on either side. These pipes are a part of the cylinder attachment assemblies, Figure 28, and serve as points of attachment for the air cylinders. The air cylinders are aligned parallel to the longitudinal axis of the load frame. As the cylinders extend and retract in operation, the internal load frame necessarily follows. The action of the air cylinders is thereby transmitted to the load frame that, in turn, transmits it in a controlled and directed manner to the seat of the chair. Length of retraction of the internal frame in an upward vertical direction is controlled by the air pressure supplied to the cylinders, the length of the cylinders, or by stop collars on the shafts of the internal frame. The extension movement is limited by the resistance provided by the seat or by the length of stroke of the cylinder. Side and front views of the vertical load head are given in Figure 19. A bill of materials for each of the seat load frames is given below.

6.1.1 Bill of Materials for Vertical Load Frame:

Internal Load Frame

2 extension shafts, 1-1/2 inch x 44 inches
2 reducing tees, 1-1/2 inch x 1-1/2 inch x 2 inches
1 crossbar 1-1/2 inch x 10 inches
2 extension shafts, 2 inches x 4 inches
2 ells, 1-1/2 inch
2 extension shafts, 1-1/2 inch x 4 inches
2 crossbars, 1-1/2 inch x 2 inches
1 center crossbar, 1-1/2 inch x 4 inches
4 pipe flanges, 1-1/2 inch
2 pneumatic tires, 4.10 - 5HNS

External Load Frame

2 extension shaft sleeve bearings, 2 inches x 16 inches, heavy wall
2 tees, 2 inches x 2 inches x 2 inches
1 crossbar, 1-1/2 inch x 5 inches
1 crossbar, 2 inches x 10 inches

6.2 Backrest Load Frames

The load frames for testing the backrests are similar to those for testing seats, but important differences do exist, Figure 20. Again, each load frame consists of two basic units—an internal and an external frame. The internal frame consists of two extension shafts constructed of 1-inch diameter pipes that are joined together at one end by a crossbar to form a U-shaped frame. The external frame consists of two extension shafts (sleeve bearings) joined together at one end by a crossbar to form a second U-shaped frame. These pipes are 1-1/4 inches in diameter, however, so that the internal frame is free to slide within it. Crossed tees, attached to the two free ends of the extension shaft sleeve bearings of the external frame act as bearings for a shaft inserted through them. These two bearings together with the 1-inch diameter pipe inserted through them form part of a hinge that allows the backrest load frame to pivot up and down and thereby follow the natural movement of the backrest as the load head pushes against it.

The other half of the hinge is formed by a tee attached to the end of the 1-1/2 inch diameter pipe that acts as a vertical load frame swivel column. This pipe, or swivel support column, in turn, fits inside of a two-inch diameter heavy wall sleeve (swivel sleeve bearing - schedule 80 pipe), Figure 21. This two-inch sleeve is firmly attached to the testing machine frame in a vertical position by means of scaffolding clamps; the 1-1/2 inch diameter pipe is free to rotate within it so that the load frame and the load head attached to it are free to swing from side to side. The 1-1/2 inch diameter pipe is prevented from sliding out of the two-inch diameter sleeve by means of a pin, which passes through the inner pipe near its upper end, Figure 22. This pin rides on the upper end of the sleeve and carries the full weight of the load frame apparatus. A shallow V-groove is cut into the top of the sleeve so that the weight of the backrest load frame acting on the pin causes the pin to index into the bottom of the groove in the same location each time the cylinder retracts. This arrangement allows the load frame and load head to follow any side to side movement of the backrest during a load cycle and then return and index in the proper starting position automatically on the unload cycle.

The head of the air cylinder is supported by means of a small chain that is looped over the hinge pin and the body of the cylinder. Ends of the chain are joined together by means of a spring that allows some movement of the cylinder and thereby avoids binding. The cylinder should be positioned in the frame so that the rod-end of the piston rod fits into the eye of the clevis without applying

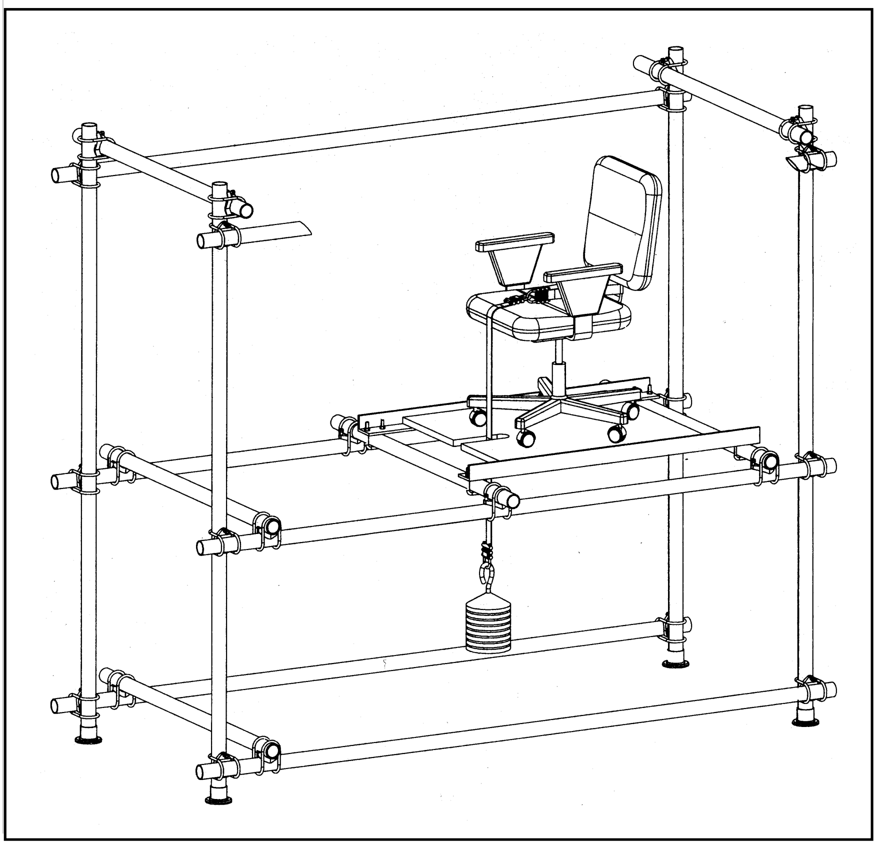

Figure 11. Front stability test set-up.

sidethrust force to the piston rod. If a clevis with a slightly oversized opening is used to attach the rod-end-bearing to the load frame, and if it is turned so that the pin is in a vertical position, it will allow the rod-end bearing to slide up and down on the pin slightly and thus relieve any accompanying side thrust forces on the piston rod as the load frame extends and retracts as it deflects under load.

The rear end of the air cylinder, which is equipped with a clevis, is attached to the external load frame by means of a male rod-end-bearing. The body of the bearing passes through the crossbar of the external load frame and is secured with a nut on the opposite side.

A 1/4-inch or 5/16-inch diameter U-bolt is attached to the crossbar of the load frame as shown in Figure 21—a slightly modified U-bolt system is shown in Figure 20. This U-bolt provides a point of attachment for the turnbuckle/chain linkage that controls the angle of the load frame with respect to the horizontal.

The complete linkage is shown in Figure 20. The rear of the external load frame should be weighted so that the total load frame is just balanced when the internal load frame is fully extended. If the backrest deflects downward as it is loaded, the load head and load frame are free to follow. When the internal load frame retracts, however, the weight at the rear of the external load frame causes the entire load frame to return to its original starting position. Normally, the weight of the air cylinder is sufficient to cause this action without the addition of external weights.

The load head is attached to the end of the load frame by means of a rod-end and bracket, Figures 21 and 22. Clearances between the bracket, the rod-end, and the end of the load frame are such that the load head itself is free to pivot both up and down and rotate from side to side predetermined amounts about the rod-end. This freedom of movement allows the load head to adjust to local changes in the shape and angle of the backrest.

6.2.1 Bill of Materials for Backrest Load Frame:

Internal Load Frame
2 Ells, 1 inch
2 extension shafts, 1 inch x 48 inches
1 crossbar, 1 inch x 6 inches

External Load Frame
2 reducing tees, 1 inch x 1-1/4 inches
1 crossbar, 1 inch x 5-1/2 inches
2 extension shaft sleeve bearings, 1-1/4 inch x 16 inches
4 tees, 1-1/4 inch
2 close nipples, 1-1/4 inch (to form crossed tees)
4 close nipples, 1-1/4 inch (for bearings in crossed tees)
1 cross pin, 1 inch x 12 inches
2 end caps, 1 inch (for cross pin)

Swivel Support Column
1 tee, 1-1/4 inch
1 close nipple, 1-1/4 inch
1 reducing coupling, 1-1/2 to 2 inch
1 swivel column, 1-1/2 inch x 20 inches
1 swivel column sleeve bearing, 2 inches x 18 inches (heavy-wall pipe)

6.2.2 Backrest Load Heads

Configuration of the backrest foundation load heads is shown in Figure 23. This load head is similar to that specified in British Standard 4875 for the testing of sofa backs (BSI, 1975). The load heads may be fabricated from solid wood. Angle-iron brackets attached to the back of the load head may be used to form a clevis. A male rod-end whose shaft is bolted to the load frame connects the load head to the load frame, Figure 20.

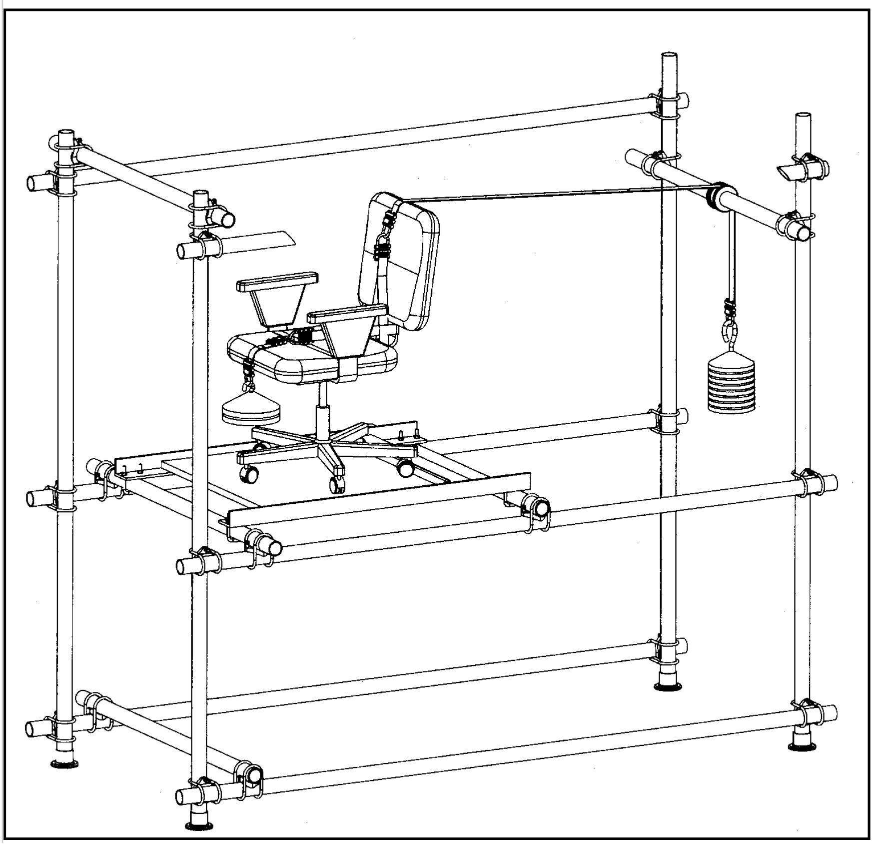

Figure 12. Back stability test set-up.

Articulation of the load head is governed by the opening width of the clevis and by the location of the hole. Some experimentation may be necessary to determine the optimum location for the specific rod-end used. In general, however, the load head should have sufficient freedom of movement to follow the deflection of the backrest without binding.

6.3 Load Calibration

A force dynamometer may be used to calibrate and periodically monitor the force exerted by the air cylinders on the furniture. One such force dynamometer and an accompanying load frame are shown in Figure 24. This dynamometer has a 1000-pound load capacity and an 8-inch diameter face that has been divided into 5-pound increments for easy reading. A frame constructed from pipe and scaffolding clamps in which the dynamometer and an air cylinder can be placed for calibration is also shown. Desired force levels are obtained by adjusting the air regulator while the air valve is operating at its normal cyclic rate. Design of the testing equipment is such that a cylinder can readily be detached from the testing machine and inserted in the calibration frame. When matched cylinders are used, however, a spare cylinder mounted in the calibration frame can be used to calibrate identical cylinders without removing them from the testing machine. An extra cylinder is required, of course, if this latter procedure is followed.

When calibrating cylinders at high pressure levels, the cylinders may cause near impact loading on the force dynamometer that may damage the interior force-indicating mechanism. Speed control valves should be used to reduce the rate of loading.

6.4 Testing Machine Frame

The external testing machine frames previously shown consist of a rectangular skeletal steel framework fabricated from pipe and scaffolding clamps. This framework provides points of attachment for the various devices that are used to apply loads to the furniture, and it also provides a means of supporting and holding the furniture in place while it is being tested. Overall size of the testing machine is not critical, but it must provide sufficient space for the chair and loading apparatus to be mounted properly as well as sufficient space for servicing the equipment. A typical testing machine framework is shown in Figure 25. Corner posts about 9-feet high are anchored to the floor.

Crossbars are attached to these posts to form the frame of the machine. All of the frame members are constructed of nominal 2-inch diameter pipe. Lightly loaded members, and in particular, columns may be constructed of schedule 40 pipe; heavily loaded crossbars, on the other hand should be constructed of schedule 80 pipe. Scaffolding clamps, Figure 26, are used to join the members together to form a rigid frame. The frame is attached to the floor by means of special floor flanges, Figure 27. These flanges are particularly useful for attaching the frame corners to anchor bolts set in concrete floors. Standard floor flanges may be used for attaching the frame corners to wooden or similar floors.

The scaffolding clamps provide considerable rigidity to the frame, and it should not be necessary to brace the frame in any way. Should this prove necessary, however, additional pipes and clamps may be used to insert diagonals in the side frames.

The frame should be given regular maintenance while testing; specifically, the setscrews in the scaffolding clamps should be regularly inspected and tightened if necessary. Scaffolding clamps

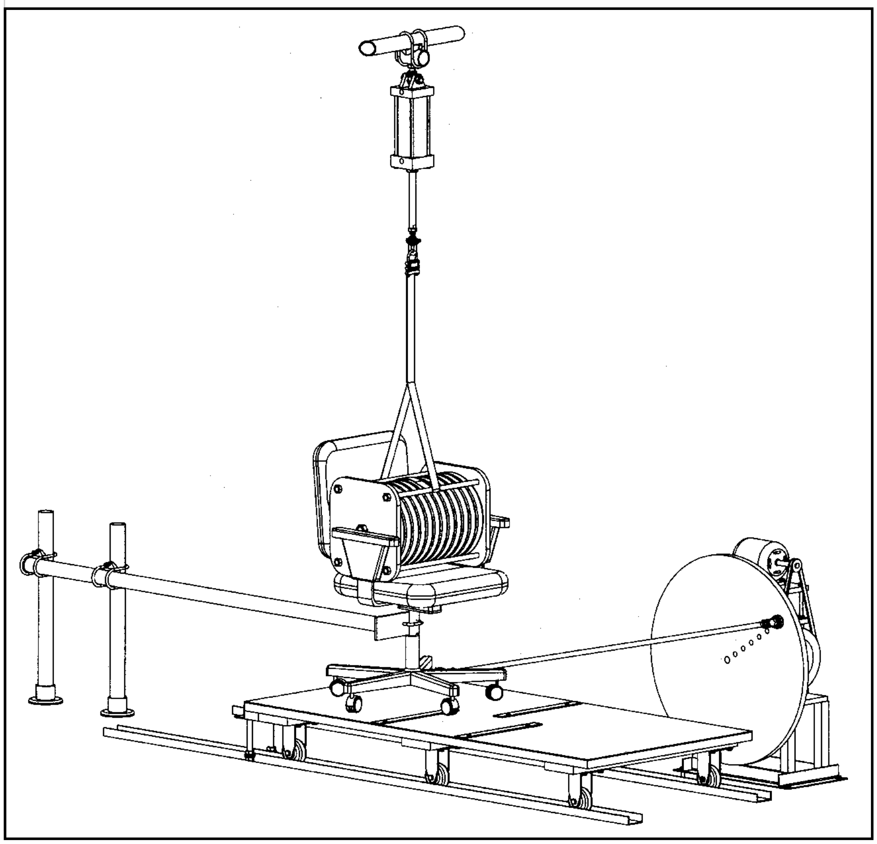

Figure 13. Caster and base durability test set-up, front perspective.

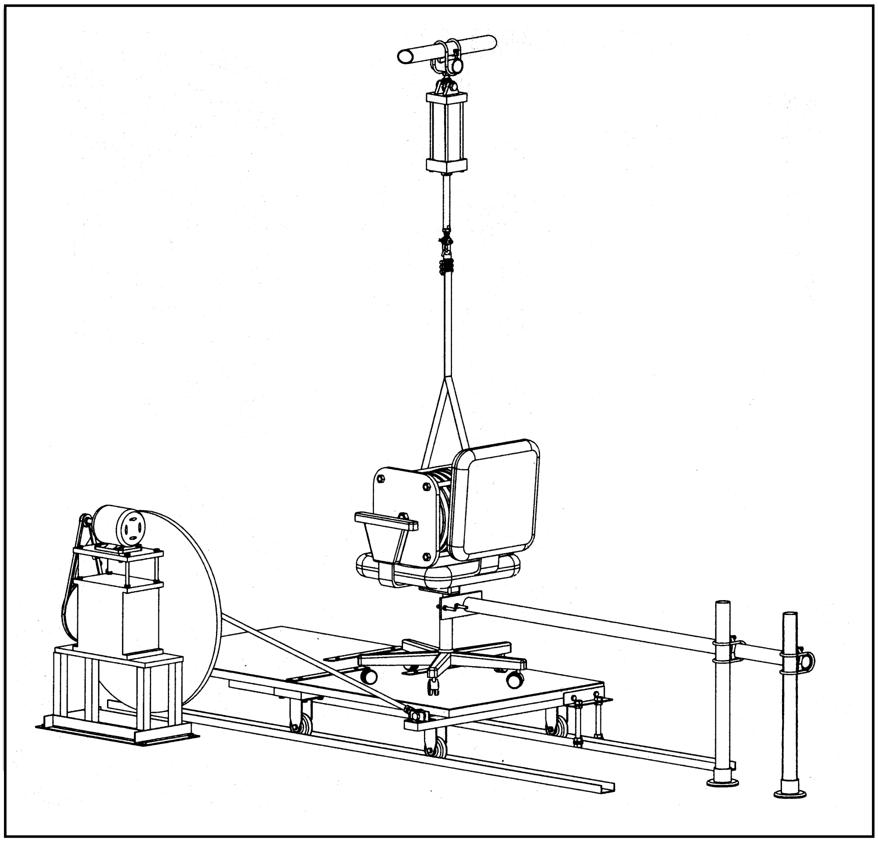

Figure 14. Caster and base durability test set-up, rear perspective.

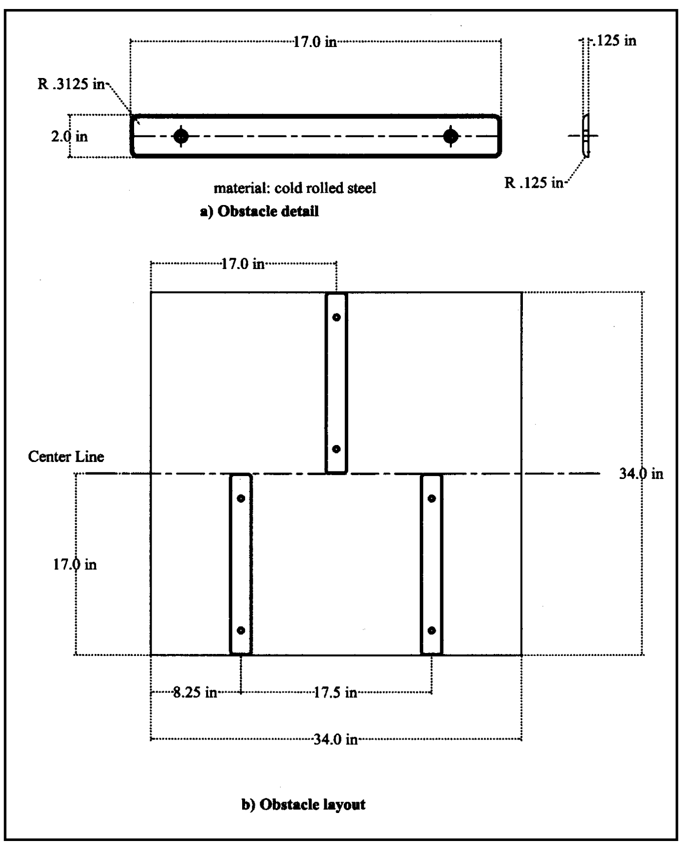

Figure 15. Obstacle layout for caster and base durability test.

may also break if they are subjected to high load levels for a great number of cycles. If this situation should occur, additional members should be added to the testing machine at critically stressed points to share the load. Safety chains hooked over the tops of the corner posts or over the top of intermediate posts should be used to ensure that a crossbar cannot fall if a clamp should loosen.

6.5 Air Cylinders

At least two air cylinders with a 4-inch bore and 12-inch stroke are needed to carry out the cyclic vertical load test on seats, bases, and casters (4.6). Presumably, these cylinders can also be used to conduct the other tests, but they may be difficult to calibrate and control at lower load levels because of the practical limits of accuracy of the air regulators at low load levels. A cylinder with a bore of 2-1/2 inches and a stroke of 18 inches, for example, is better suited for use and more compatible with the load frames developed for the back rest tests; likewise, cylinders with a stroke of 10 to 12 inches will be found more convenient for other tests. Also, a small cylinder with 1-inch bore and 6-inch stroke is needed to activate the back tilt mechanism (4.3) and seat adjustment mechanism (4.8). The most important requirement is that the cylinders must have sufficient stroke to allow the furniture to deflect fully; they must, for example, have sufficient stroke to allow the seats and the backrests to deflect fully. The quality of the air cylinders used is optional, but medium duty cylinders should give satisfactory service under laboratory conditions.

To simplify attachment of the cylinders to the load frame, the cylinders should be equipped with a clevis mount. In addition, the ends of the piston rods should be threaded internally to receive a male rod-end bearing although external female rod-end bearings can also be used with externally threaded piston rods.

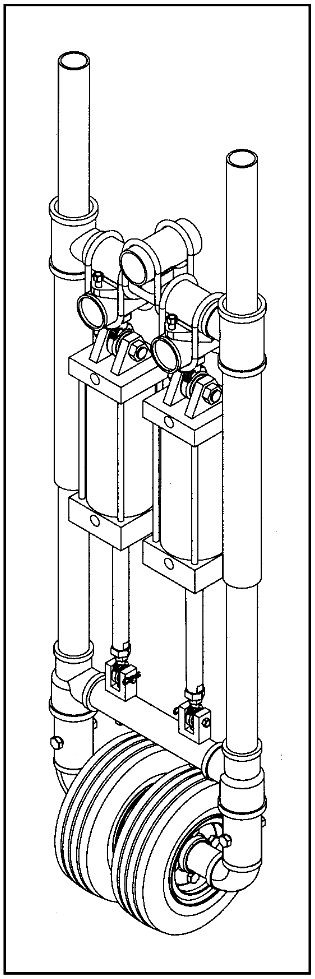

Figure 16. Vertical load frame.

6.5.1 Cylinder Attachment Assembly

The air cylinders are attached to the main frame of the testing machine by means of a male rod-end and a short length (4-inch long) of 2-inch diameter pipe, Figure 28, which will be called a cylinder attachment assembly. The 4-inch long pipe has a 1/2-inch diameter hole drilled through it crossways at mid length that receives the threaded portion of a rod-end. After the rod-end is inserted in the hole, it is held in place by external and internal nuts, Figure 28. An attachment of a cylinder to the testing machine frame is shown in Figure 29.

6.5.2 Cylinder Support Assembly

The air cylinders are supported in a horizontal position, when needed, by means of a cylinder support assembly. This assembly consists of a cylinder support frame, Figure 29, that is made of two lengths of 1-1/2-inch diameter pipes joined together by a 90 degree ell, a length of chain or a strap, and a spring. One leg of the cylinder support assembly is inserted into the top end of an upright to which a cylinder attachment assembly is connected. The chain is then looped over the horizontal arm of the cylinder support frame, around the barrel of the air cylinder, and connected to itself by means of a small spring. The strap or chain and spring should be adjusted so that no side thrust forces are applied to the shaft of the cylinder.

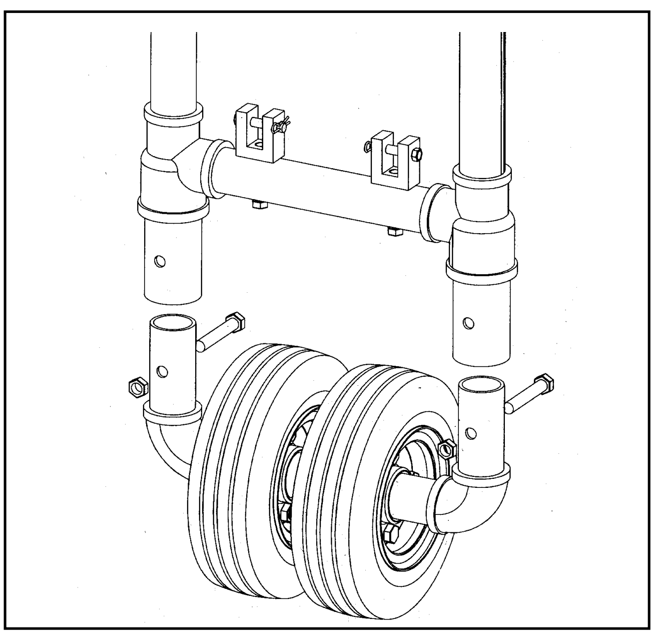

Figure 17. Connection of the load head to internal frame.

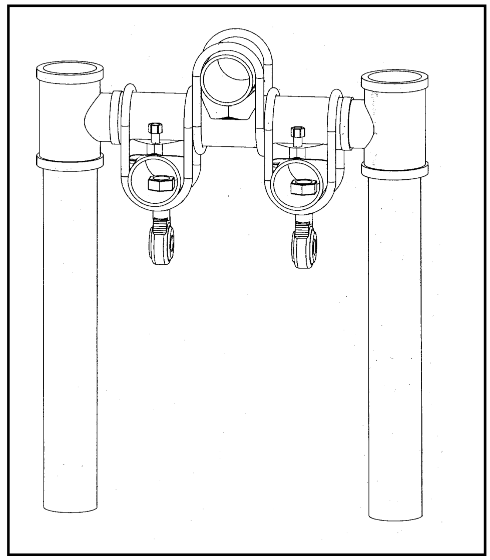

Figure 18. A view of external frame.

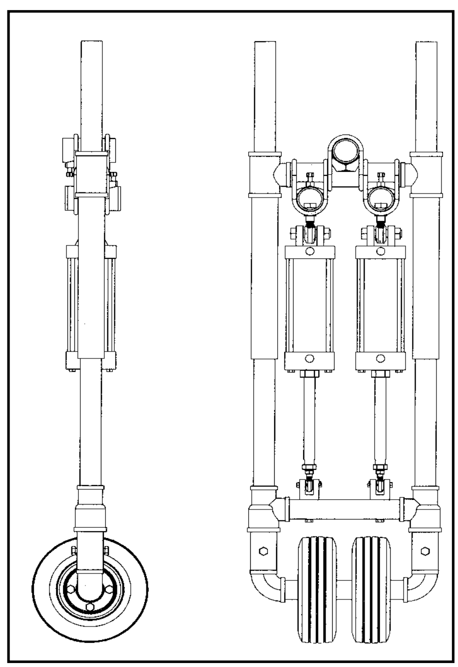

Figure 19. Side and front views of vertical load head.

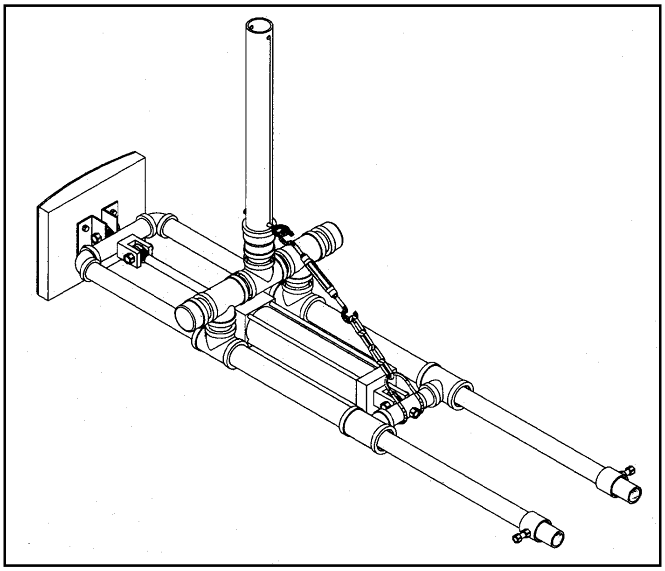

Figure 20. Overview of backrest load frame.

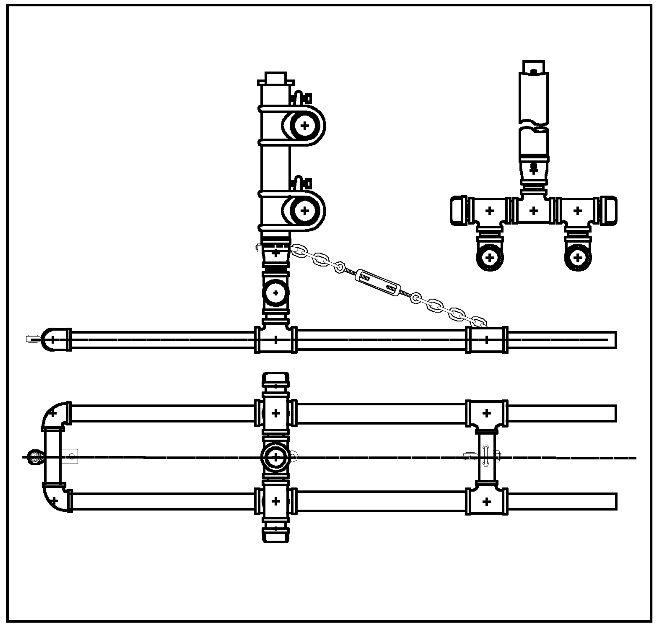

Figure 21. Working drawing of backrest load frame.

6.5.3 Load Application

For some applications, loads are applied to the furniture by means of a length of chain or a strap. The chain is looped around the part of the furniture frame that is to be tested (an arm, for example) and is then attached by means of a pivot pin to one end of a double clevis (or single clevis if the chain is large enough to permit the eye of the clevis to pass through a loop of the chain). The other end of the double clevis is then attached by means of a pivot pin to the cylinder rod-end, Figure 30. It should be noted that two conventional clevises could be used back to back instead of a double clevis.

If straps are used instead of chain, then a fixture must be used to secure the end of the strap and also to obtain the necessary length adjustment. A simple fixture of the type shown in Figures 30 and 31 may be used both to secure the end (or ends) of the strap and also to obtain the necessary adjustment for length. This fixture may be fabricated from a 5/16-inch diameter U-bolt and short lengths of 1/4 -inch diameter pipe. Larger sizes may be used if desired.

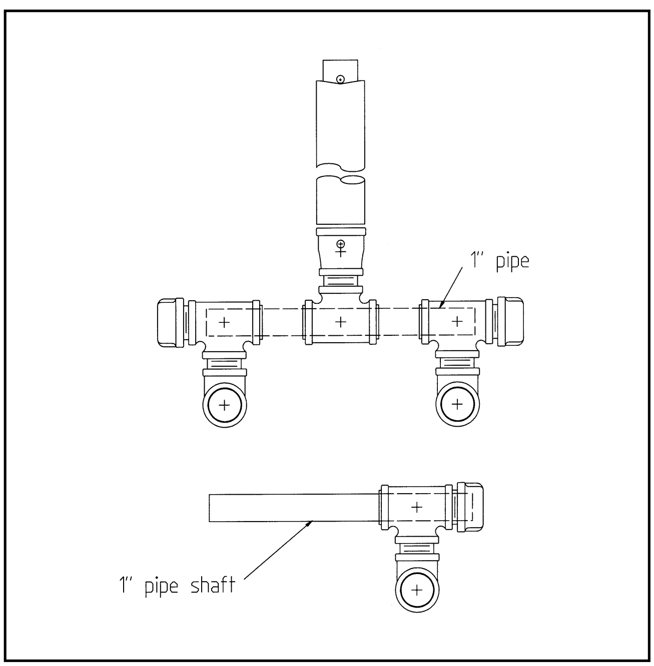

Figure 22. Exploded view of backrest frame hinge.

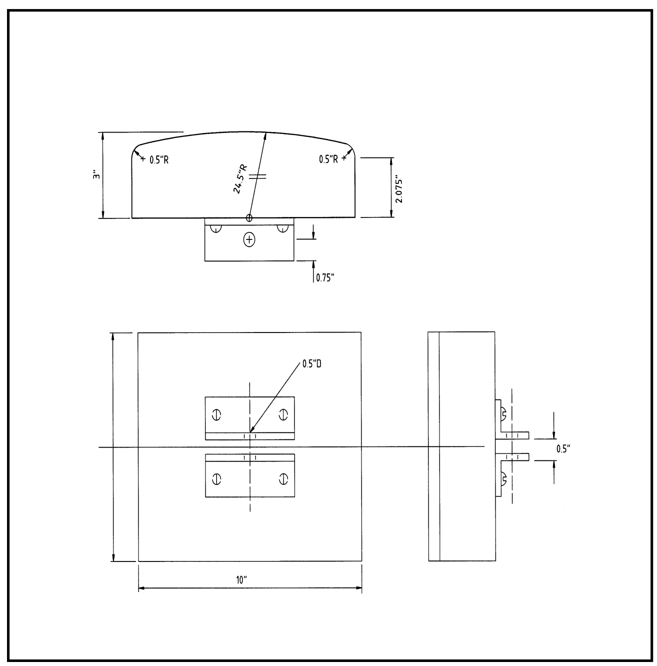

Figure 23. Configuration of backrest foundation load head.

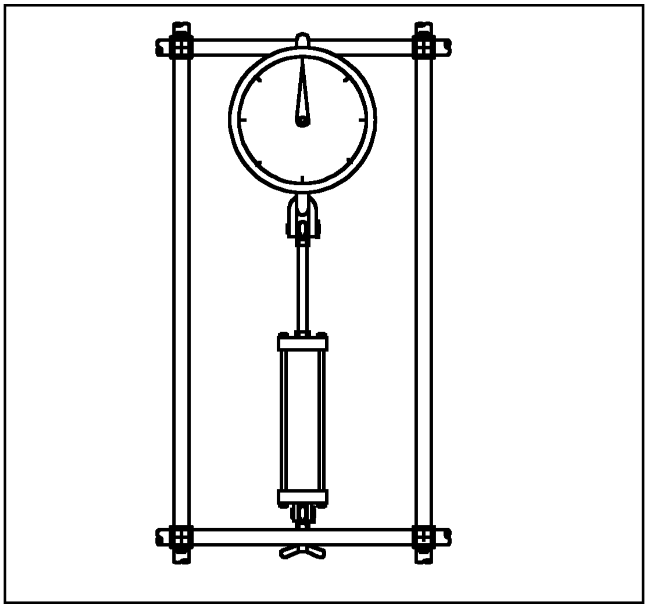

Figure 24. Force dynamometer and load frame.

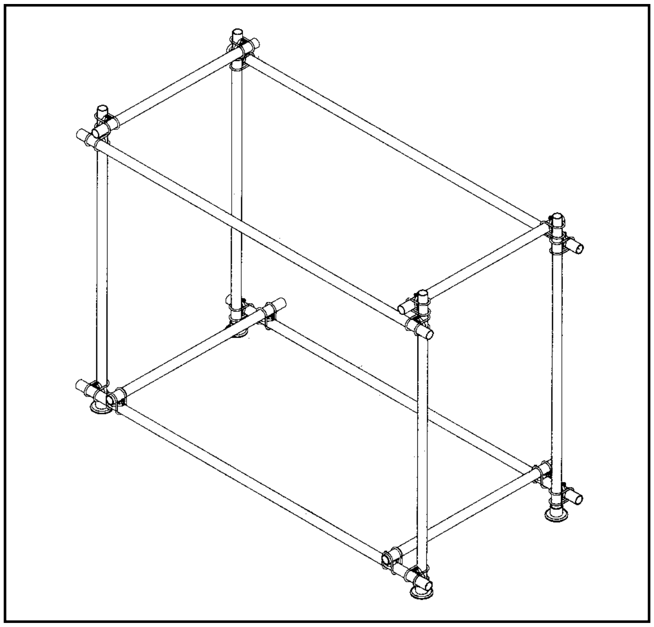

Figure 25. A typical testing machine frame.

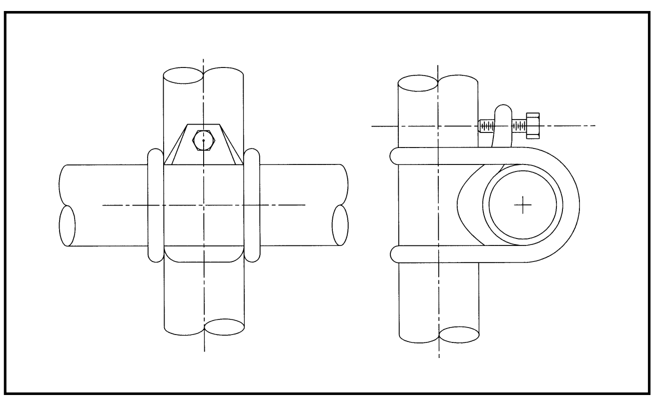

Figure 26. Scaffolding clamp used to fabricate main testing machine frame.

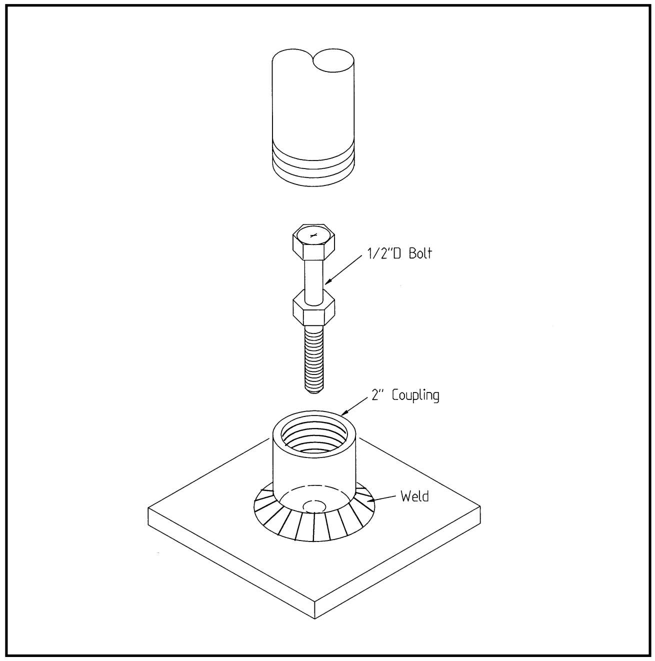

Figure 27. Details of floor flange assembly.

6.6 Air Control System

Standard 3/8-inch, three-way solenoid valves are used to control the flow of air to the cylinders. These valves control the flow of air to both sides of a cylinder, Figure 32. Pipe trees may be connected to the outlet ports of each valve so that three cylinders can be operated from each of the four valves (for the seat load test). Twenty-foot lengths of 3/8-inch ID diameter hose are used to connect the valves to the cylinders. Use of equipment of this size is mandatory to ensure that desired force levels can be developed and maintained. The main supply line should be properly sized to provide peak air demand during load cycles. Use of a 2-inch diameter feeder has been found useful. If supply lines are long, an air ballast tank should be located near the test apparatus.

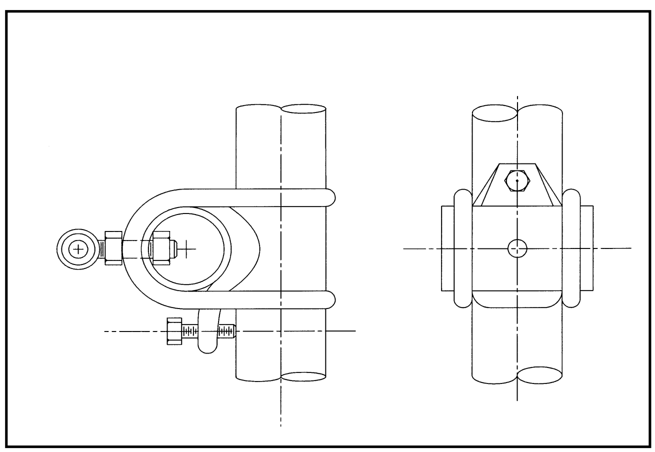

Figure 28. Details of cylinder attachment assembly.

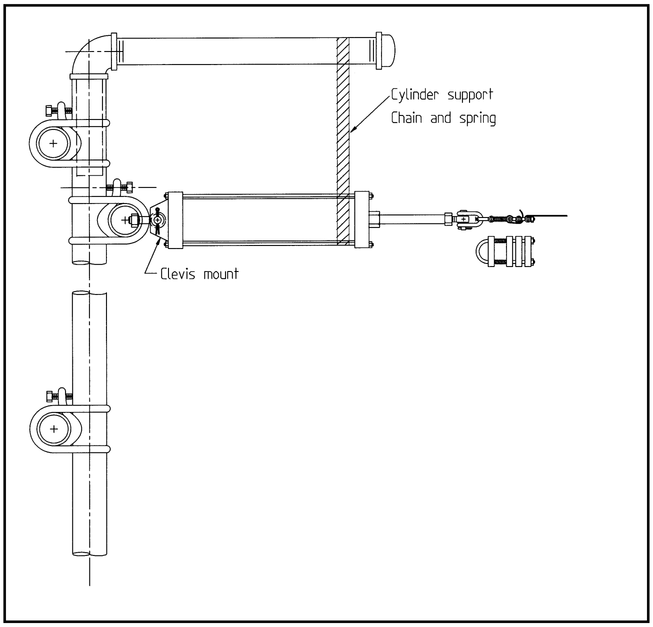

Figure 29. Cylinder attachment and support assembly.

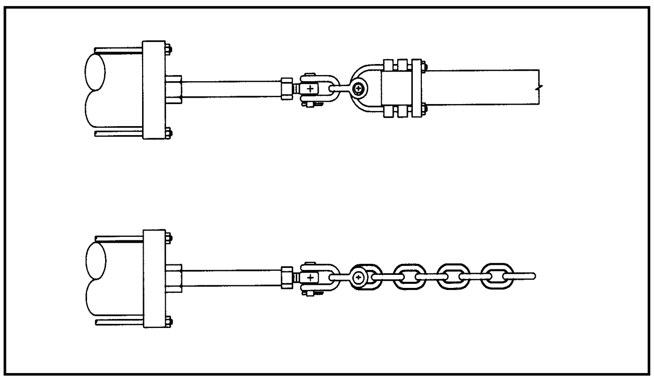

Figure 30. Loads are transferred from air cylinders to furniture by means of a strap (above) or chain (below).

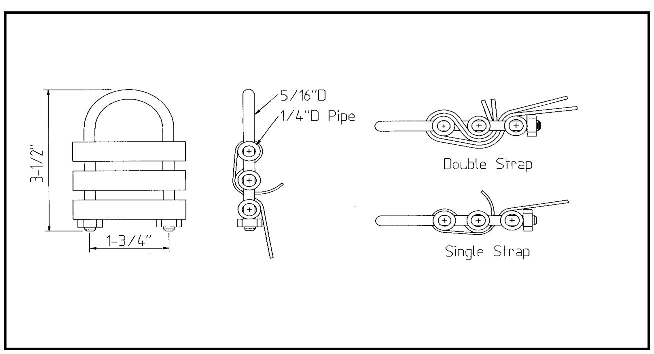

Figure 31. A simple end-connection for straps that holds the ends of the straps securely in place.

Operating pressure is controlled by standard air regulators; oilers are included in order to provide the lubrication needed by the valves and air cylinders.

6.7 Electrical Control Circuit

An example of a hard wire electrical cyclic control system that may be used to carry out the tests is shown in Figure 33. A repeat cycle timer is used to control the length of the on/off portion of each cycle along with the rate at which the test is carried out, that is, 20 cycles per minute. The cam should be adjusted to obtain 50 percent on/off cycles.

Electrically operated predetermined counters are used to count the number of cycles completed and to stop the test after a predetermined number of cycles have been completed. These counters have internal electrical switches that open when a preset number of cycles have been completed. The counters are wired into the electrical control circuit as shown in Figure 33. Although this equipment works well, it should be noted that its use is not mandatory, and many users will choose to use simple process controllers to carry out the tests. A break wire,

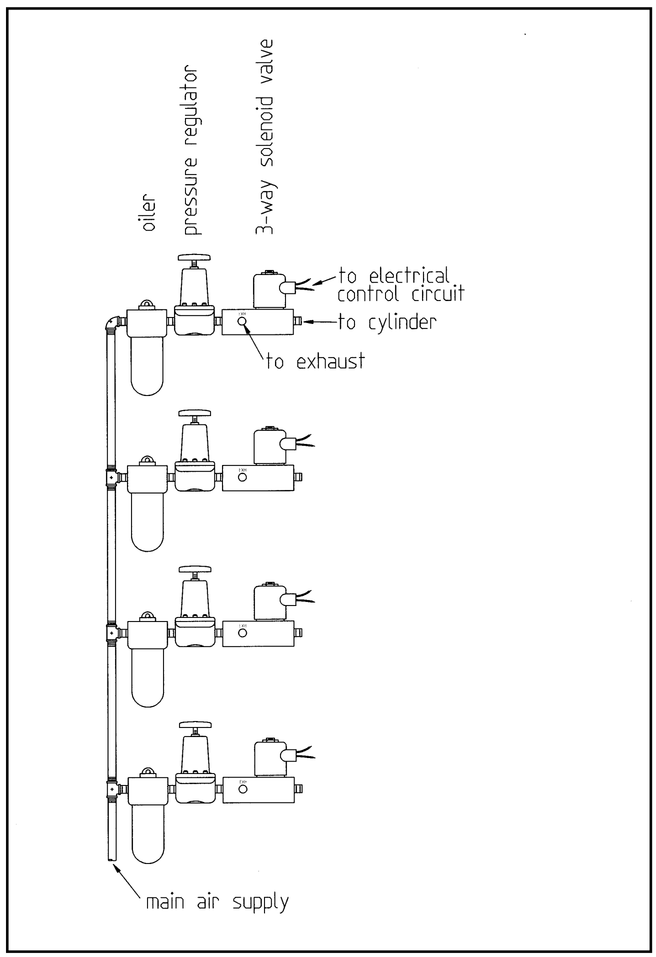

Figure 32. Example air control system.

Figure 34 may be used to stop the test when a part breaks or fails. The wire used in the test should be rubber coated instrument lead wire. One end of the wires should be attached to the "break wire" terminals shown in Figure 33. (The internal connection between these two terminal should be removed.) The wires are then passed over a main machine member (or other pipe) and a full turn taken around the pipe. The free ends are then attached to a short length of wire equipped with alligator clips that passes around the part under test as shown in Figure 34. The "tightness" or "slack" of the section of the wire between the pipe and the part under test may be easily adjusted by loosening the loop of wire around the pipe. Once the length of wire has been properly adjusted, however, the loop around the pipe will not move.

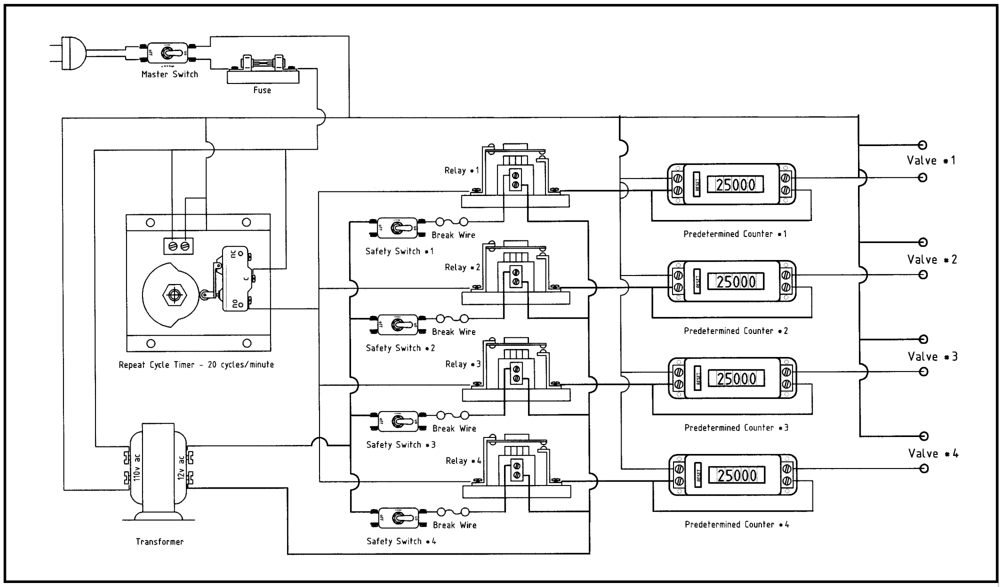

Figure 33. Example control system that may be used to control cyclic rate of loading and terminate test after predetermined number of test cycles have been completed.

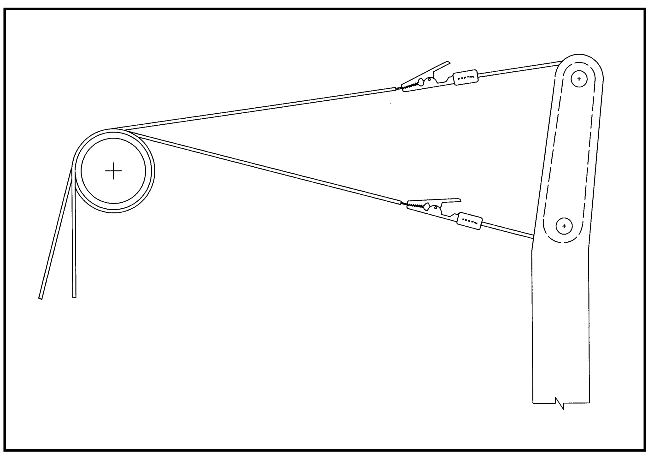

Figure 34. Break wire connection used to terminate test when part fails.

7. References

British Standards Institution. 1975. BS 4875. Strength and Stability of Domestic and Contract Furniture. London.

Eckelman, C.A. 1978a. Development of Performance Tests for Upholstered Furniture—Development of Tests and Results of Test Program. National Technical Information Service, Department of Commerce. Washington, D.C.

Eckelman, C.A. 1978b. Development of Performance Tests for Upholstered Furniture—Design of Equipment. National Technical Information Service, Department of Commerce. Washington, D.C.

Upholstered Furniture Test Method. FNAE-80-214. General Services Administration. Wash., DC.

Performance Test Method for Intensive Use Chairs. FNAE-83-269. General Services Administration. Wash., DC.

ANSI/BIFMA X5.l-l985 -General-Purpose Office Chair Tests. American National Standards Institute, 1430 Broadway, New York, NY 10018.

NEW 9/01