Designation: F504 – 05 (Reapproved 2017)

Standard Test Method for Measuring the Quasi-Static Release Moments of Alpine Ski Bindings[1]

This standard is issued under the fixed designation F504; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers a procedure for the measurement of release moments of ski bindings under conditions where inertia loadings of the ski binding system are not significant.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F498 Test Method for Center Spring Constant and Spring Constant Balance of Alpine Skis

F779 Test Method for Torsion Characteristic of Alpine Skis

F944 Specification for Properties of Adult Alpine Ski Boots (Withdrawn 2004)[3]

2.2 *ISO Standard:*[4]

ISO 9838 Alpine Ski Bindings–Test Soles for Ski Binding Tests

ISO 9462 Alpine Ski Bindings–Safety Requirements and Test Methods

ISO 9465 Alpine Ski Bindings–Lateral Release under Impact Loading-Test Method

3. Terminology

3.1 The following terminology is introduced with reference to the sketch of the boot-ski system shown in Fig. 1.

3.1.1 Six points of load application to the standard test ski are required. With the adult boot sole (300 mm in length) the most forward point, located at a position 90 ± 0.5 cm from the centerline of the test shaft, shall be called the "forward point" and shall be designated as *F*. The second point, 45 ± 0.5 cm in front of the centerline of the test shaft, shall be designated the "near point," *N*. The third point, located 45 ± 0.5 cm behind the centerline of the test shaft, shall be designated "rear point," *R*. The fourth point, located 35 ± 0.5 cm in front of the center line of the test shaft, shall be designated the "near preload point," *NP*. The fifth point, located 75 ± 0.5 cm behind the centerline of the test shaft shall be designated the "far rear point," *FRP*. The sixth point, the "alternate near preload point," ANP, is located 7.5 ± 0.25 cm, in the minus *y*-direction from the point NP. For sole lengths longer than 300 mm the F and FR points are not changed from the location used for the 300 mm boot sole. For sole lengths shorter than 300 mm the N, R, ANP and NP points are not changed from the location used for the 300 mm sole. For bindings which are to be used exclusively with skis shorter than the test ski, F and FR tests shall be performed at the N and R points. If the ski is too short for the specified N and R points, N and R shall be moved closer to the *z*-axis by 10 cm each, and all tests performed using the new N and R points. The forces that are applied to the standard ski at these six designated points may now be described by simple vector notation. A laboratory-fixed axis designation shall be used with the numeral *z* denoting the vertical axis normal to the top face of the ski (in the region of the test shaft) and positive in the direction outward from the ski; the numeral *x* denoting the longitudinal axis, positive in the forward direction of the ski; and the numeral *y* denoting the lateral axis, the positive direction of which is determined by the right-hand rule. The *z*-axis is coincident with the centerline of the test shaft. The origin of the XYZ coordinate system is a point 230 mm along the axis of the test shaft from the bearing surface of the test sole for 300 mm test soles. The location is changed proportionally for soles other than 300 mm. The direction of any force applied

[1] This test method is under the jurisdiction of ASTM Committee F27 on Snow Skiing and is the direct responsibility of Subcommittee F27.10 on Binding Test Procedures.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

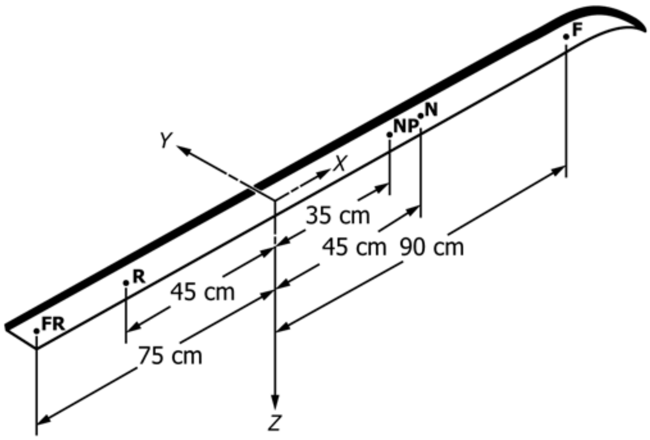


FIG. 1 Load Application

to the ski is defined by its unit vector. The magnitude of a preload force applied to the ski is defined by the M_z or M_y moment created by the force.

4. Summary of Test Method

4.1 The ski binding is mounted on a standard ski and a standard boot sole is inserted into the binding. A relatively stiff test shaft instrumented for moments is affixed to the sole and attached rigidly to the test frame. The apparatus is shown in Fig. 2.

4.2 Loads sufficient to produce binding release are applied to the binding by forcing the ski to displace relative to the frame until release occurs. The components of the moments transmitted through the binding to the test shaft are recorded. These records are interpreted to provide the static release moments of the binding.

5. Significance and Use

5.1 This test method involves simulation in the laboratory of potential injury-producing loads that can occur in skiing, without implying the frequency or the magnitude of the danger. This test method does not include the simulation of all or part of a skier, and care must be taken not to confuse the values of moments measured by the test shaft with the loads subjected to the tibia of a skier under the same conditions.

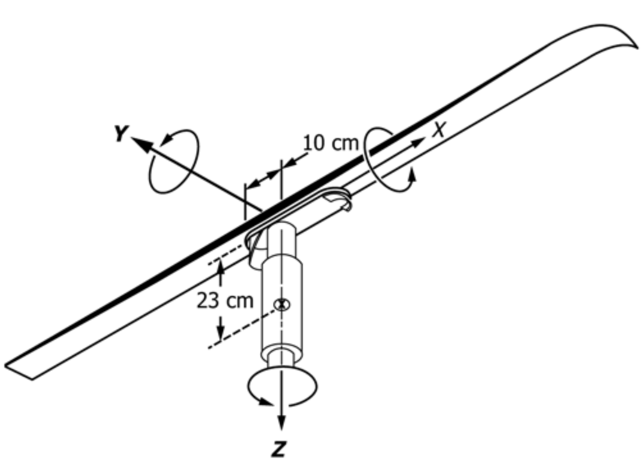


FIG. 2 Test Equipment

6. Apparatus

6.1 *Ski:*

6.1.1 *Ski*—Three test skis are defined in Table 1 of ISO 9462. The mounting platform shall be as specified in the relevant ASTM standard. The boot's ski location marker as shown on Specification F944 or ISO 9838 shall be aligned with the boot centerline marker on the ski. If there are no markers on the boot or ski the center of the boot sole shall be located 15 ± 0.5 cm behind the center of the ski's projected length unless the relevant ASTM standard applies.

6.2 *Boot*—Four test soles are defined in Table 2 of ISO 9462. The standard adult sole shall be 30 ± 0.5 cm in length and shall be adjustable, over a range of ±4 cm. It shall be constructed to meet the requirements of ISO 9838. Details concerning boot characteristics shall conform to the relevant ASTM standard. However, it shall be permissible to modify the boot if the binding manufacturer specifies that modification is necessary for proper function of the binding.

6.3 *Stiffener*—When a ski stiffener is called for (see Annex A1 and Annex A2), a channel of dimensions 75 to 80 mm wide by 35 to 40 mm high by 4 to 5 mm thick shall be used to stiffen the ski between the near and rear points. The channel shall be made of 6061 T6 aluminum, or equivalent. The bar shall be attached to the ski by bolts, screws, or clamps at *N* and *R* points and at a point half way between *N* and *R* points. The stiffener described in Fig. A1.1 meets this requirement.

6.4 *Test Frame:*

6.4.1 The test frame consists of all mechanical components that connect the boot to a stationary reference, including the boot sole attachment, the test shaft, and the supporting structure for the test shaft. The test frame shall include a boot sole attachment constructed in accordance with ISO 9838 for the standard sole.

6.4.2 The angle between the bottom of the boot sole and the test shaft shall be 90 ± 1° in the $z-x$ and $z-y$ planes; the positions of centerline of the test shaft relative to the boot shall be at a longitudinal location 20 ± 1 cm from the front of the boot sole when the 300-mm boot sole is used. For other boot sole lengths the distance shall be two thirds the distance from the front of the sole.

6.4.3 The test shaft and associated instrumentation shall be capable of measuring moments about the *x*-, *y*-, and *z*-axes as required. Further specifications for the test shaft as part of the instrumentation system are discussed in 6.6.

6.4.4 The linear compliance of all combined mechanical components of the test frame shall be no more than 4×10^{-6} m/N in either of the *x* or *y* directions, and no more than 4×10^{-7} m/N in the *z* direction for loads applied at the intersection of the test shaft and the attachment plate. The angular compliance shall be no more than 5×10^{-5} rad/N · m for rotations around the *x*, *y*, or *z*-axes.

NOTE 1—When an associated high-speed test series is established, the angular compliance shall be no more than 2.5×10^{-5} rad/N · m for rotations around the *x*-, *y*-, or *z*-axes.

6.5 *Cable:*

6.5.1 The minimum length of cable between the point of attachment to the ski and the nearest support shall be 1 m.

6.5.2 The cable shall be attached to the ski such that the resultant force transmitted through the cable passes within 1 cm of the centeroid of the cross section of the ski.

6.5.3 Preloads are applied through a pulley near the base of the load cell pedestal with an attachment swivel not more than 12 cm offset from the load cell axis. A spring with a spring constant of 65 N/cm (±10 %) and an unloaded length of at least 20 cm is attached between the preload cable and the attachment fixture. When a preload (PL) is used in a test the preload cable force will induce a moment M_y that is a specified percentage of the nominal release moment in test 2.1 (see Fig. 11).

6.5.4 Release in tests 1.1, 2.2, and 2.2 (Fig. 3, Fig. 11, and Fig. 12) is accomplished by a single cable connecting points *N* and *R* that is loaded by a traveller pulley of a design capable of applying loads at *N* and *R* that are opposite in direction and equal in magnitude to within 5 % of each other.

NOTE 2—Preloads (PL) given in are examples of M_y preload moments that may be specified.

6.6 *Instrumentation:*

6.6.1 *Measurements*—The instrumentation shall provide measurement of the peak M_z and M_y moments. The values of measured moments are referred to a point 23 ± 0.1 cm above the bearing surface of the boot sole on the *z*-axis for 300-mm sole lengths. Other length soles shall require this reference point to be shifted proportionally.

6.6.2 *Range*—Maximum moment along a single axis:

$$300\ N\cdot\text{m}\ (\text{full} - \text{scale for } M_z M_x) \quad (1)$$

$$1000\ N\cdot\text{m}\ (\text{full} - \text{scale for } M_y)$$

6.6.3 *Accuracy*—Absolute accuracy for moment measurements to errors less than ±2 % of reading for readings above 50 N·m and less than ±1 N·m for readings 50 N·m or less.

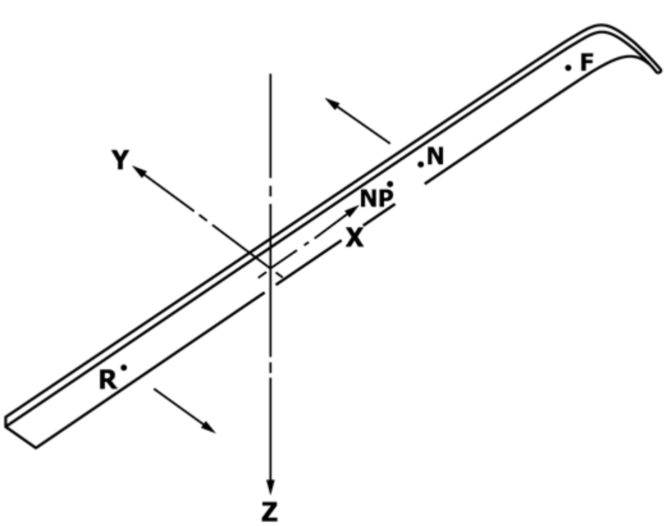


FIG. 3 Test 1.1

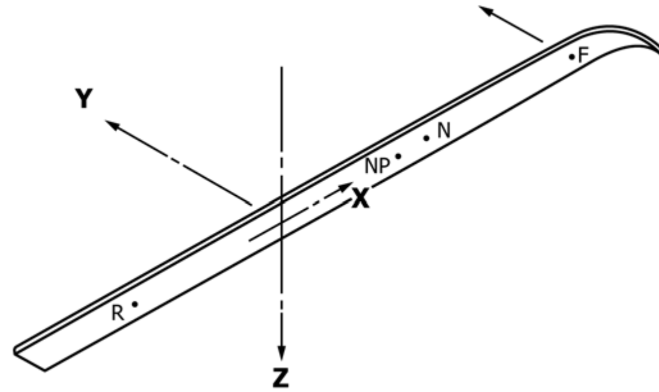


FIG. 4 Test 1.3

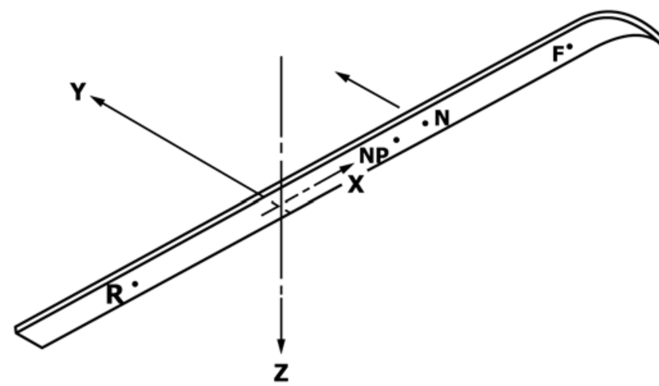


FIG. 5 Test 1.4

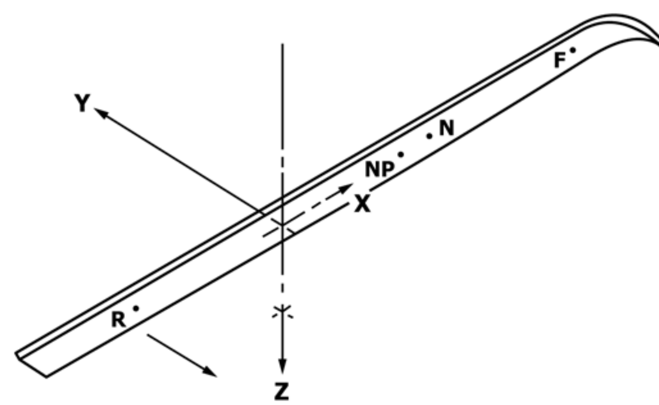


FIG. 6 Test 1.5

6.6.4 *Repeatability*—Repeated readings under standard test conditions shall be repeatable to ±1.5 % for moment readings above 50 N · m. Repeatability shall be to ±0.75 N·m for lower readings.

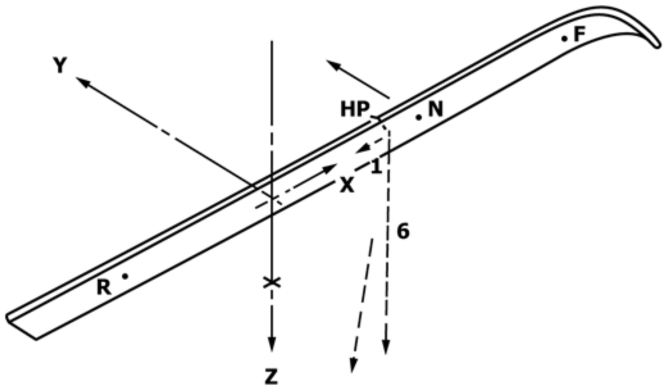
6.6.5 *Hysteresis*—The hysteresis measured at no load shall be less than 1.5-N · m moment following a cyclical load to full scale.

6.6.6 *Null Drift* shall be correctable to less than 0.75-N · m moment at 20°C.

6.6.7 *Temperature Sensitivity:*

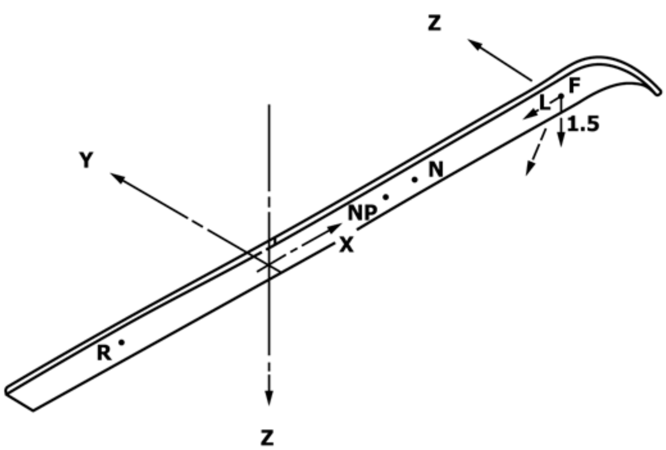
$$\text{Gain variations: correctable to } 0.2\ \%\ {}^\circ C \text{ at} \quad (2)$$

$$T_o \pm 0.5^\circ C$$



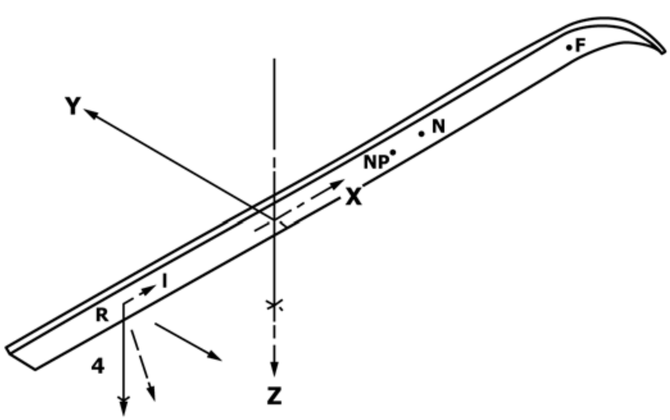
PL = .75 × [2.1]

FIG. 7 Test 1.6



PL = .50 × [2.1]

FIG. 8 Test 1.8

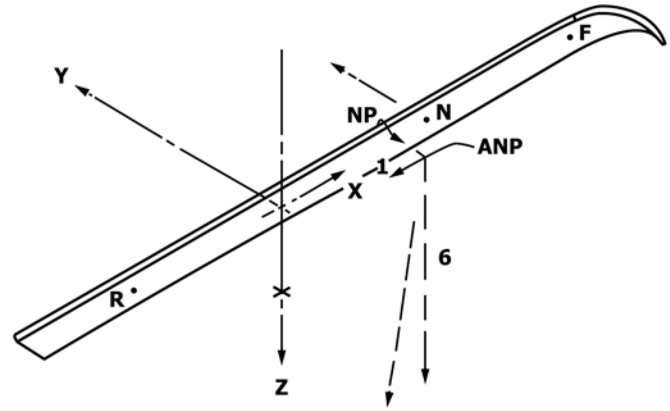


PL = .50 × [2.1]

FIG. 9 Test 1.10

$$\text{Null variations: correctable to } 0.5\ N{\cdot}\text{m}/^{\circ}C \text{ at } T_o \pm 0.5^{\circ}C \tag{3}$$

where: T_o = equilibrium environmental temperature and is in the range from −20 to +20°C.



PL = .75 × [2.1]

FIG. 10 Test 1.11

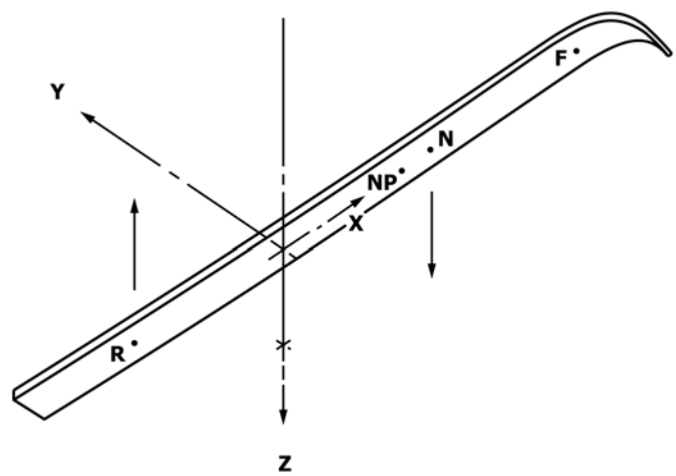


FIG. 11 Test 2.1

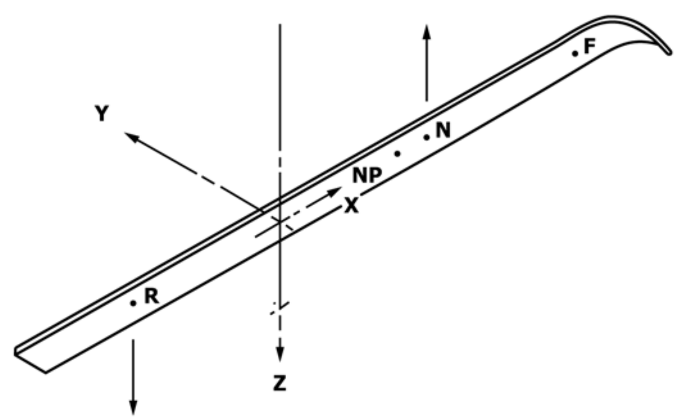


FIG. 12 Test 2.2

6.6.8 *Frequency Response*—Gain measured at full scale shall vary less than 1 dB over the bandwidth 0 to 100 Hz. Phase lag shall be less than 10° over the same bandwidth.

6.7 *Load Application:*

6.7.1 *Locations and Directions of Application*—The apparatus shall have the capability of applying the load configurations in accordance with Figs. 3-15. Tests in Category 1 have

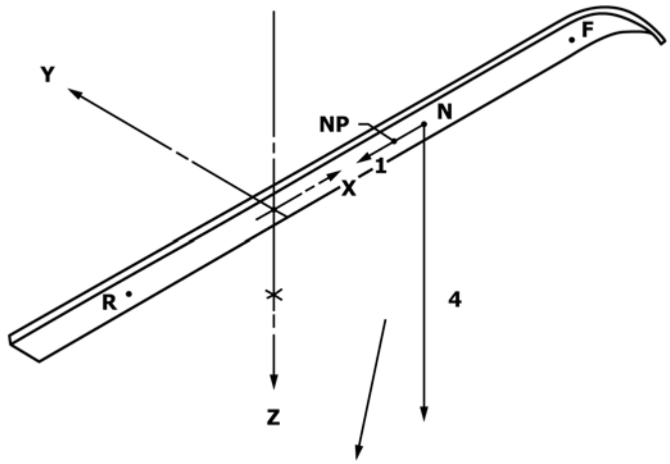


FIG. 13 Test 2.3

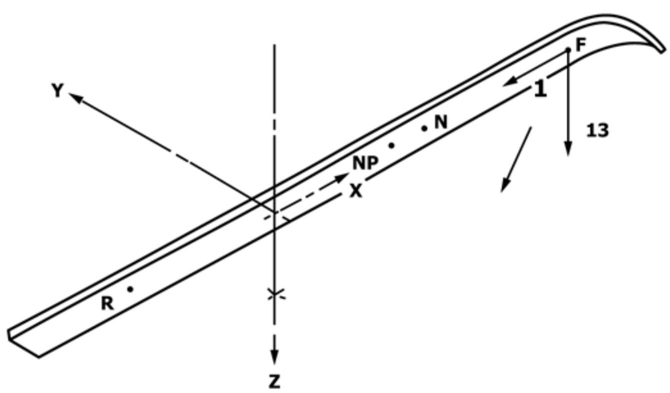


FIG. 14 Test 2.5

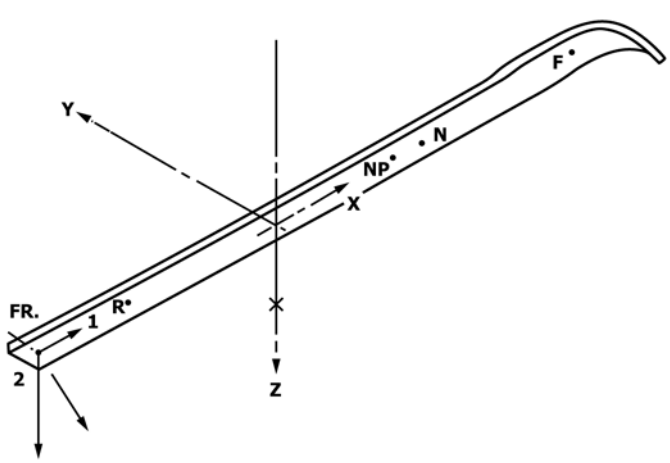


FIG. 15 Test 2.8

a significant M_z component; tests in Category 2 have a significant M_y component. Note that the unit vector is given for all loads applied through the cable system. The unit vector for a release load is shown as a solid line while the unit vector for a preload is shown as a dashed line. Preloads (*PL*) are given in terms of the nominal value of test 2.1 (see Fig. 11).

6.7.1.1 Release load and preload cables shall be adjustable to within 2° of the orientation of the unit vector specified in Figs. 3-15 as measured under a cable tension equivalent to approximately 10 % of the nominal release load in tests 1.1 or 2.1 as appropriate.

6.7.2 *Rates of Application*—The apparatus shall have the ability of applying loads such that the linear speed of the cable at the point of attachment to the ski shall be adjustable to two different rates as follows: 2 ± 0.5 cm/s and 60 ± 10 cm/s.

6.7.3 *Calibration*—The load cell is calibrated using the fixture and procedures defined in Annex A.

6.7.4 *Zeroing*—The instrumentation is zeroed without the ski attached to the test sole.

7. Test Specimen Preparation

7.1 Bindings should be mounted in accordance with the manufacturer's specifications, and boot surfaces and interfaces shall be cleaned with an appropriate cleaner, unless otherwise specified by environmental test procedures. All tests shall be performed with boot-binding contact points wet by a mist of distilled water unless otherwise specified by environmental procedures.

8. Procedure

8.1 An individual release measurement shall consist of attaching a ski-binding system to the test apparatus and applying a load configuration, as specified in 6.7.1 and 6.7.2, sufficient to cause the binding mechanism to release while simultaneously recording information sufficient to determine the two peak M_z and M_y moments. Refer to Annex A2 for step-by-step procedures.

9. Keywords

9.1 alpine ski binding; release binding; release envelope; release moment

ANNEXES

(Mandatory Information)

A1. FIXTURES

A1.1 Scope

A1.1.1 This Annex describes fixtures that may be used to adapt the device described in Test Method F504 to meet the requirements of ISO 9462 Method B.

A1.2 Fixtures and Test Configurations

A1.2.1 Use the ski stiffening fixture described in Fig. A1.1 and release loads as defined in Fig. 3 and Fig. 11 unless otherwise specified.

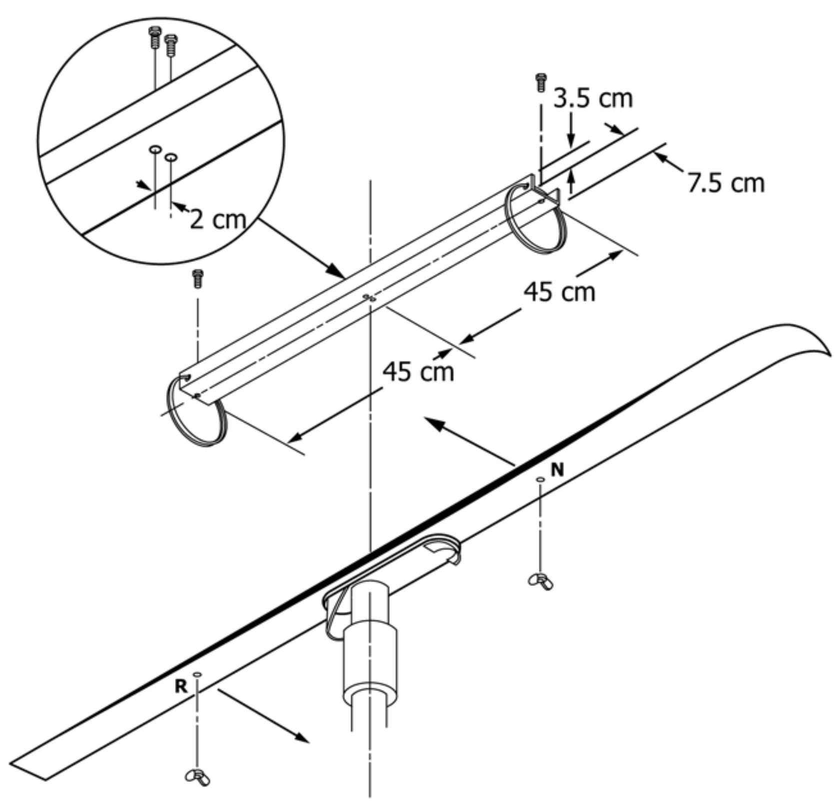


FIG. A1.1 Ski Stiffening Fixture

A1.2.2 To perform the release with ski deflection test, use the fixture described in Fig. A1.2.

A1.2.3 To perform the release with combined loading test for influence of forward lean of the body, use the load configuration defined in Fig. A1.3 to apply the preload moment M_y.

A1.2.4 To perform the release with combined loading test for influence of roll loading, use the fixture described in Fig. A1.4 to apply the preload moment M_x.

A1.2.5 To perform the release with combined loading test for influence of backward lean of the body, use the load configuration defined in Fig. A1.5 to apply the preload moment M*y* where the rear preload (RP) point is 35 cm behind the *z*-axis.

A1.2.6 To perform the release with combined loading test for influence of axial force, use the fixture described in Fig. A1.6 to apply the preload force *F*.

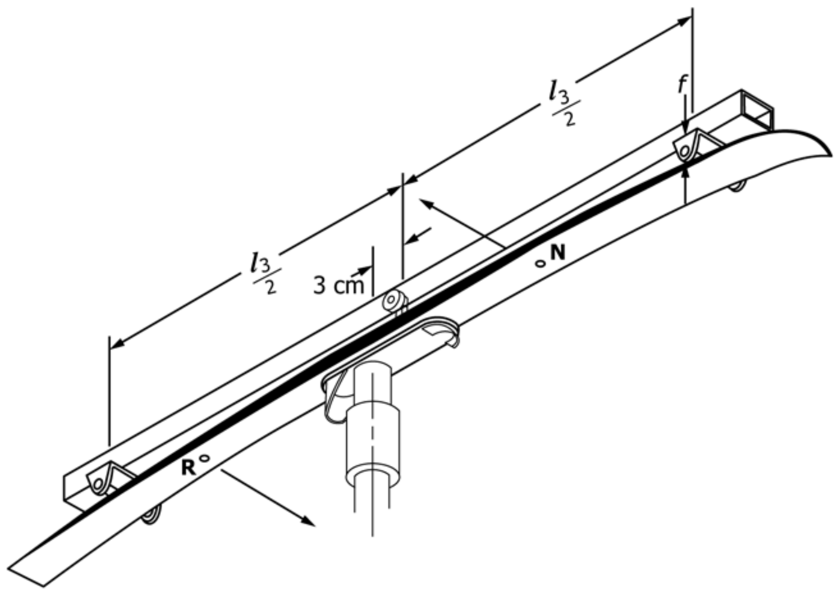


FIG. A1.2 Release with Ski Deflection Test

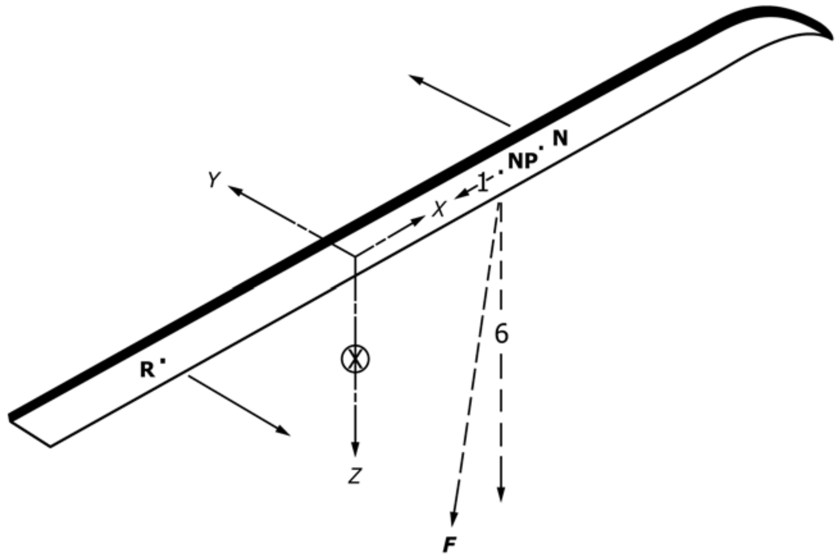


FIG. A1.3 Release with Combined Loading Test

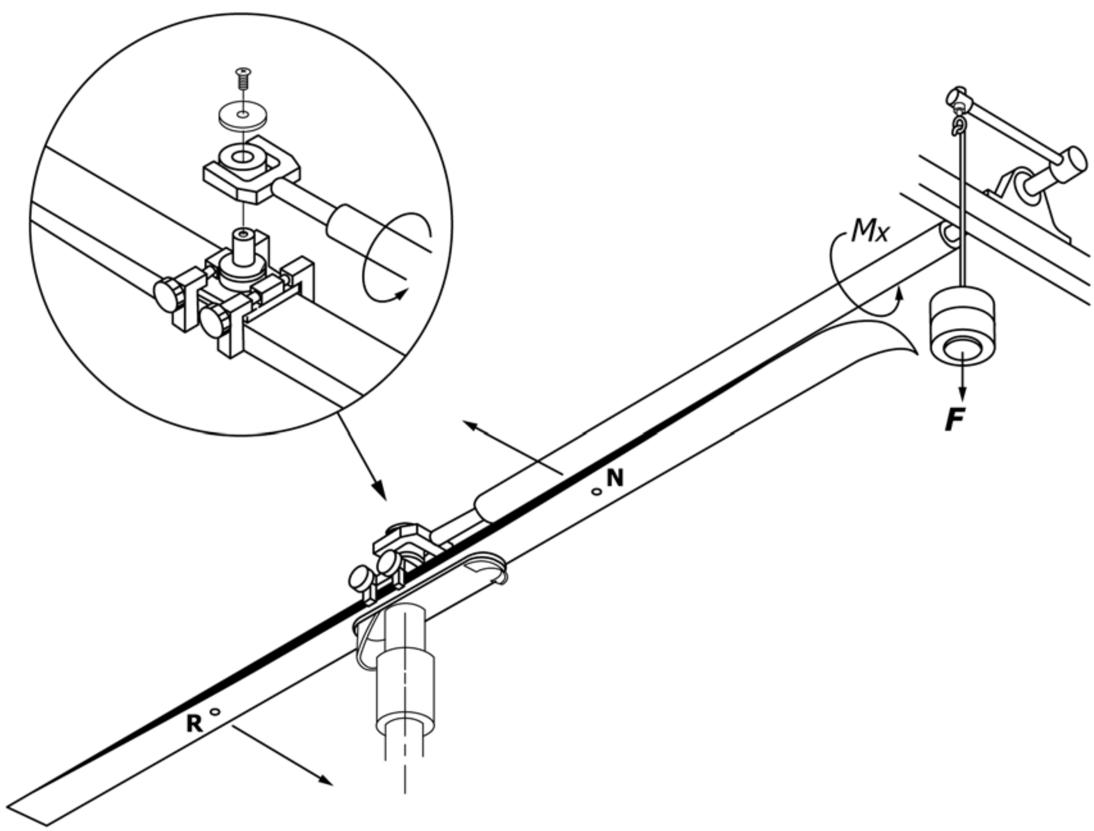


FIG. A1.4 Release with Combined Loading Test for Influence of Roll Landing

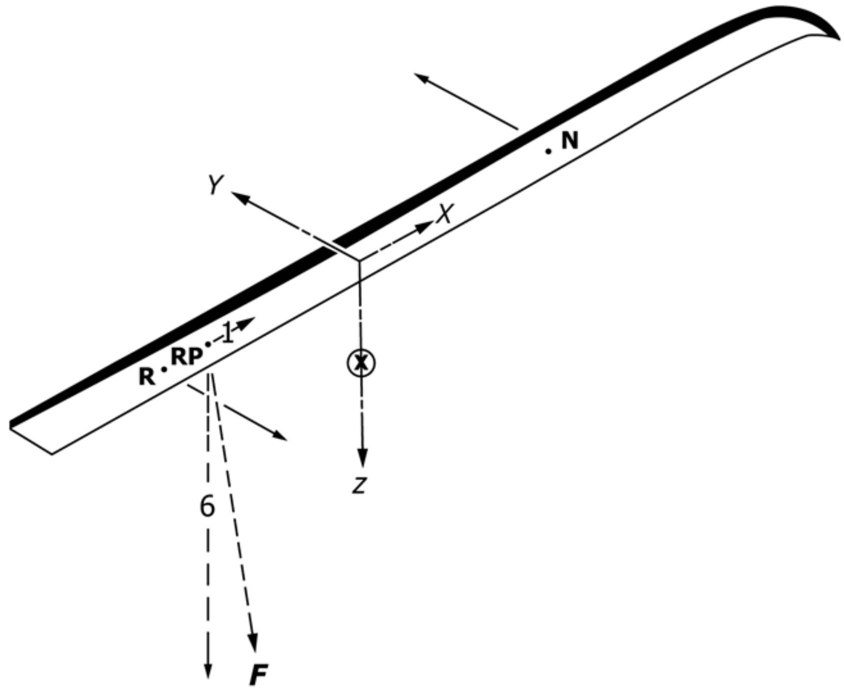


FIG. A1.5 Release with Combined Loading Test for Influence of Backward Lean of the Body

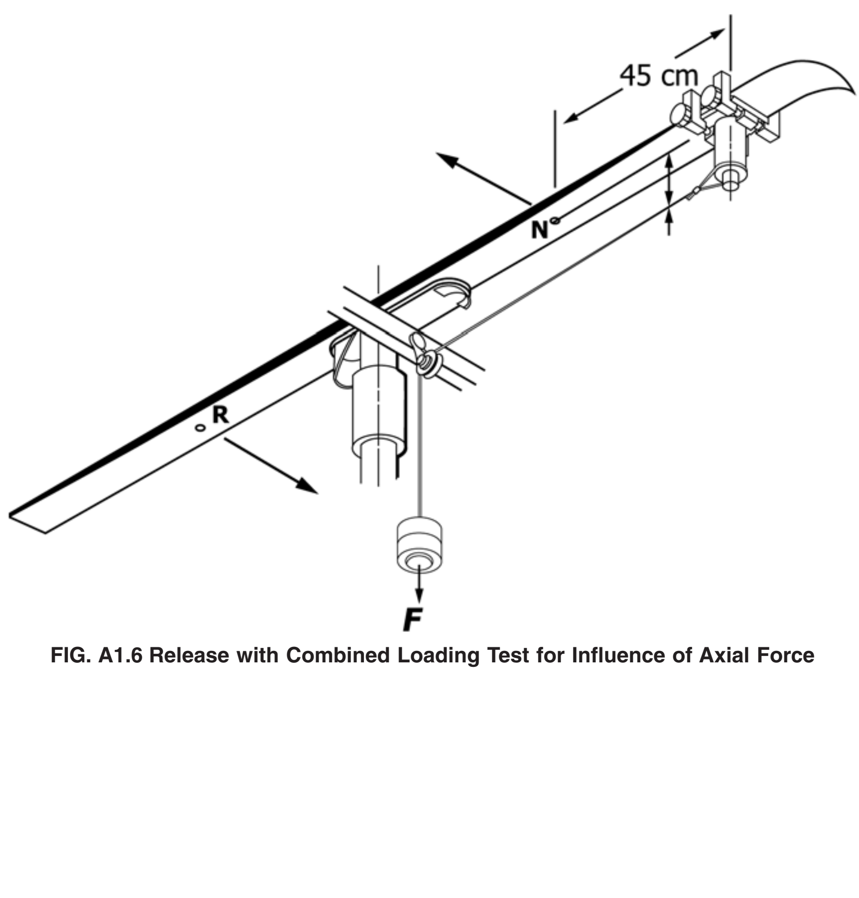


FIG. A1.6 Release with Combined Loading Test for Influence of Axial Force

A2. PROCEDURES

A2.1 Scope

A2.1.1 This example procedure defines the steps required to calibrate the load cell described in 6.6 and perform a typical test in the Test Method F504 series.

A2.2 Calibration Procedures

A2.2.1 The load cell is calibrated by means of a dead weight and a lever.

A2.2.1.1 The lever is a hollow steel tube 25 mm (±2.5 mm) square with a 3 mm (±1 mm) wall thickness and a length of at least 90 cm.

A2.2.1.2 The mass of each dead weight used in the calibration procedure shall be known to an accuracy of within 0.2 % or 50 g, whichever is greater.

A2.2.2 Calibration of the instrumentation for the moment M_y is as follows:

A2.2.2.1 With the load cell in its normal position (*z*-axis vertical), attach the lever firmly to the test sole so that it points in the *x* direction with its center in line with the *z*-axis.

A2.2.2.2 Zero the instrumentation.

A2.2.2.3 Select three weights that will produce an M_y moment within 10 % of the lowest and highest expected test results and a weight that is within 10 % of the average of the other two weights.

A2.2.2.4 One at a time apply each of the weights to the lever at a distance of 45 cm (±2 mm) in the positive *x* direction from the *z*-axis, and then repeat the procedure in the negative *x* direction.

A2.2.2.5 Record the result of each load application and any variation in the instrumentation zero following the removal of each load.

A2.2.3 Calibration of the instrumentation for the moment M_z is as follows:

A2.2.3.1 With the load cell in a position such that the *y*-axis is vertical, attach the lever firmly to the test sole so that it points in the *x* direction with its center in line with the *z*-axis.

A2.2.3.2 Zero the instrumentation.

A2.2.3.3 Select three weights that will produce an M_z moment within 10 % of the lowest and highest expected test results and a weight that is within 10 % of the average of the other two weights.

A2.2.3.4 One at a time apply each of the weights to the lever at a distance of 45 cm (±2 mm) in the positive *x* direction from the *z*-axis, and then repeat the procedure in the negative *x* direction.

A2.2.3.5 Record the result of each load application and any variation in the instrumentation zero following the removal of each load.

A2.2.4 Plot a calibration curve with the test results for positive and negative values of M_y and M_z. If the resulting plot is non-linear, conduct sufficient intermediate tests to construct a calibration curve to meet the requirements of 6.6.

A2.3 Test Procedures

A2.3.1 With no ski attached to the test sole, zero the instrumentation (see 6.7.4).

A2.3.2 If required, apply a mist of distilled water to the test sole at all contact points with the binding (see 7.1).

A2.3.3 Attach the ski to the test sole.

A2.3.4 Attach the necessary cable attachment fixtures or, if required, the ski stiffener (see 6.3). Unless otherwise specified, use the ski stiffener when performing tests 1.1, 2.1, and 2.2 (Fig. 3, Fig. 11, and Fig. 12).

A2.3.5 Attach the release cable(s) and if required the preload cable (see 6.5).

A2.3.6 Align the preload and the release cable(s), or both, according to the specified unit vector(s) (see 6.7.1).

A2.3.7 If required, apply the M_y preload at the specified percentage of the nominal value of test 2.1 (see 6.5.3 and 6.7.1).

A2.3.8 Perform the test and record the peak M_y or M_z as appropriate. If a preload was applied, record the M_y moment at the time M_z reached its peak.

A2.3.9 After complete separation of the ski from the test sole, re-check the instrumentation zero.

APPENDIX

(Nonmandatory Information)

X1. OTHER USES

X1.1 Devices constructed in compliance with Test Method F504 can be used to provide an overall description of the release/retention performance of ski bindings. However, the method described in this document is not to be construed as the only way, method, or machine by which a binding might be evaluated, nor is it to be considered "superior" to other methods or machines. The information that follows includes figures and text excerpted from ASTM STP 1440[5] and defines a test protocol and a convention for graphically representing test results that were first described in the Journal of Safety Research.[6]

NOTE X1.1—The axes in all figures below are given as 1-2-3. However, in later literature and in the current version of Test Method F504 the *X-Y-Z* convention is used, where *X* replaces 2, *Y* replaces 3, and *Z* replaces 1.

X1.1.1 Three moments and three forces fully define the loads applied by the ski to the test frame described in Test Method F504. The origin of the reference axis used in Test Method F504 is located 23 cm above the bottom of the test sole and 10 cm forward of the heel of the test sole. At this location, the load cell senses twisting and bending moments applied to what can be thought of as a simulated tibia. The location of the point of force application on the ski and the direction of that force determines the relative magnitude of the three moments and the three forces as resolved at the reference point.

X1.1.2 The protocol that follows can be a practical means by which to evaluate the overall quasi-static performance of the release/retention system. It can also be a means for investigating the effects of changes in ski length and stiffness on binding performance. However, it is important to note the following limitations of Test Method F504 and this protocol before attempting to analyze test results:

X1.1.2.1 The test method does not model the tissue or structure of the lower leg,

X1.1.2.2 The test sole does not simulate the stiffness characteristics of alpine ski boots in common use.

X1.1.2.3 Although this test protocol allows for the application of a full spectrum of load configurations, there is no assurance that configurations that are possible in the laboratory are necessarily probable in actual skiing.

X1.1.3 When using the Test Method F504 test frame as a tool to examine the effects of ski length and stiffness, the only limitations in modeling a skiing event is the requirement that the force on the ski load be normal to the surface of a the naturally flexing test ski.[6,7] A force applied to a finite ski produces a force and a couple when resolved about the reference point. Couples about the 1 *z* and 2 *y* axis are in fact the same type of load used to calibrate bindings in a ski shop that follows applicable ASTM International (or ISO) standards. However, to evaluate release/retention performance under complex loading conditions, twisting and bending moments are applied in concert or in combination with forces. These combined loading tests help to assure that the release system does not misinterpret the magnitude of the couple in the plane of release or that a mechanism within one of the system components does not malfunction.

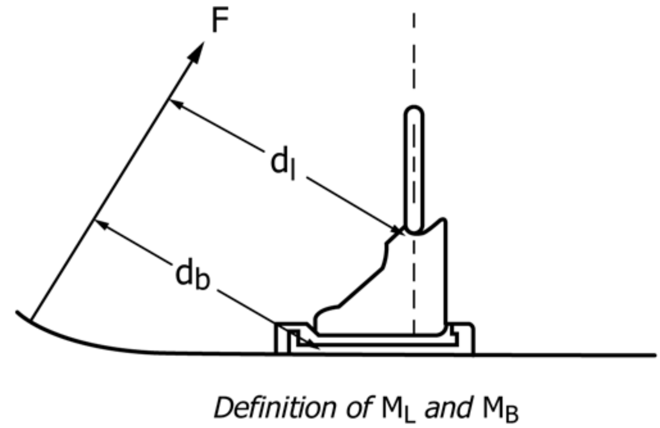


FIG. X1.1 Location of the Fulcrum Between Boot and Ski and Between Boot and Leg[6]

X1.1.4 As shown in Fig. X1.1, the moment of a force, F_s, applied to the ski and resolved about the reference point on the simulated leg is:

$$M_L = F_s \times d_l \quad \text{(X1.1)}$$

where:

M_L = moment sensed by the simulated leg and d_l is the normal distance from the force vector F_s to the reference point on the simulated leg.

X1.1.5 The moment of that same force resolved about the pivot point of the binding is:

$$M_B = F_s \times d_b \quad \text{(X1.2)}$$

where:

M_B = moment sensed by the binding and d_b is the normal distance from the force vector F_s to the pivot point of the binding.

X1.1.6 The ratio of M_L to M_B is therefore:

[5] Ettlinger, C. F., Johnson, R. J., and Shealy, J. E., "Where Do We Go From Here?" Skiing Trauma and Safety; Fourteenth Volume, ASTM STP 1440, R.J. Johnson, M. Lamont, and J.E. Shealy, Eds., ASTM International, West Conshohocken, PA, 2003.

[6] Ettlinger, C. F. and Bahniuk, E., "A Method for Testing and Analysis of Alpine Ski Bindings," Journal of Safety Research, 1980, pp. 4-12.

[7] Brown, C. A. and Ettlinger, C. F., "A Method for Improvement of Retention Characteristics in Alpine Ski Bindings," Skiing Trauma and Safety: Fifth International Symposium, ASTM STP 860, R. J. Johnson and C. D. Mote, Jr., Eds., American Society for Testing and Materials, Philadelphia, 1985, pp. 224-237.

$$M_L/M_B = d_l/d_b \quad (X1.3)$$

X1.1.7 When the force is applied near the tip or tail of a long ski, the ratio is close to 1. However, when a force is applied close to the pivot point of the release system, a disparity may arise between the moment sensed by the binding and the moment sensed by the load cell.

NOTE X1.2—The example above demonstrates the effect of a pivot point in forward lean 65 mm to the rear of the front of the test sole.

X1.1.8 In Figs. X1.2-X1.4, measurements from the Test Method F504 apparatus are plotted in what may be termed a release envelope. The magnitude of the release moment sensed by the load cell in the test shaft is plotted as a vector normal to an unflexed ski at the point through which the force that created the moment was applied. When testing adult equipment by Test Method F504 procedures using a 30 cm test sole, the far point (*F*) is 90 cm forward of the reference point, the near point (*N*) is 45 cm forward of the reference point, and the rear point (*R*) is 45 cm behind the reference point. When a test sole of a different length is used, the locations of these load points are adjusted proportionately.

X1.1.9 Results for plus and minus infinity (*I*) are created by applying a simple couple to the system by means of two equal and opposite forces. (*I*) tests are used in the Test Method F504 procedure to calibrate the binding before a test series.

X1.1.10 In general, areas of the envelope that are high relative to calibrated release moments may indicate release problems, while low areas may indicate retention problems. This method of analysis, however, does not indicate the probability of encountering specific sectors of the envelope in actual skiing and falling situations.

X1.1.11 Although most researchers[6] and ASTM Committee F27 on Snow Skiing have restricted their attention to the portions of the envelope that exclude the area between Points *N* and *R* and do not load the ski closer to the tip than Point *F*, determining the envelope over the full length of the ski, excluding only the area of the ski occupied by the test sole, may be an effective means for understanding binding performance under extreme circumstances. When using Test Method

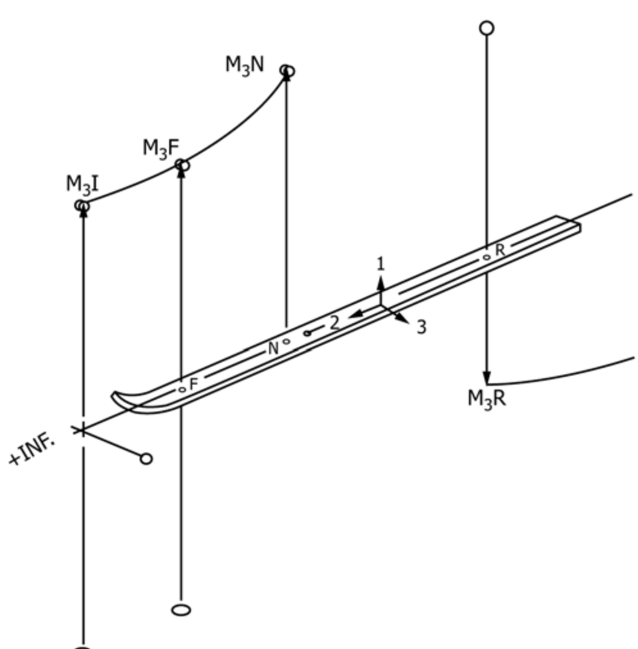


FIG. X1.2 Partial Release Envelope Showing Release Moments in Forward Lean[6]

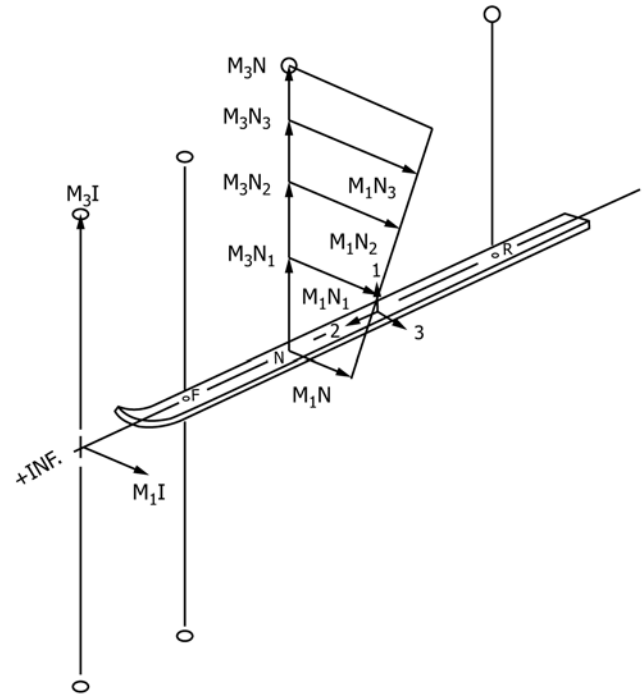


FIG. X1.3 Partial Release Envelope Showing Release Moments in Twist Under Combined Loading Using a Preload in Forward Lean[6]

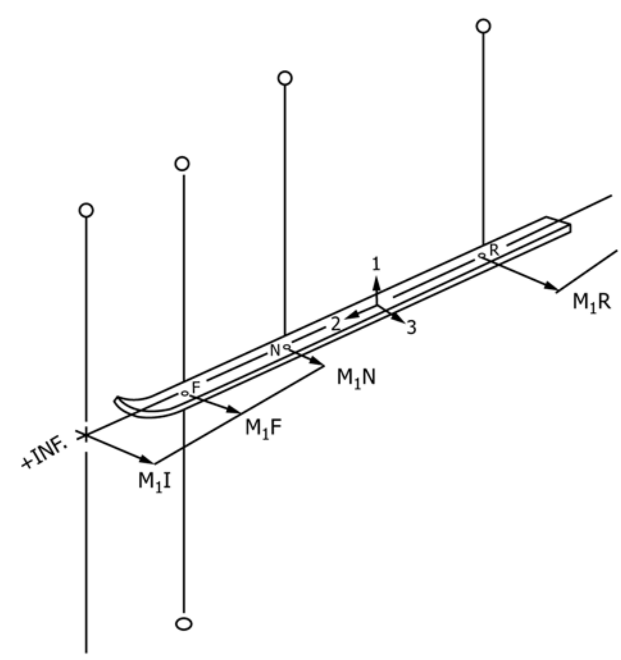


FIG. X1.4 Partial Release Envelope Showing Release Moments in Twist[6]

F504 as a tool to construct a release envelope, tests need not be restricted to specific points on a finite ski and the preload force can be varied over a wide range instead of using only a single preload configuration at each load point on the ski.

X1.1.12 For example, the moment M_3, about the reference point in Fig. X1.2, changes little from *I* to *F*, but increases significantly from *F* to *N*. Loads applied to the ski half-way between *N* and the tip of the test sole produce a much greater increase. The force on the ski at release in this case would be well in excess of 1g (gravity). In other words, such a test would simulate some of the effects of a "hard landing" by the skier following a jump.

X1.1.13 Another example of a laboratory simulation which required loading the ski at a point not specified in Test Method F504 was published in ASTM STP 860.[7] In the study it was observed that rapid deceleration of a partially weighted ski could result in release even though the skier was still in control and able to maneuver and stop on the remaining ski. The trajectory of the ski, after release, was rearward relative to the skier's direction of travel, indicating that energy had been stored in the ski and that the force vector, which stored that energy, had a significant component in the -2 direction (parallel to the long axis of the ski). The researchers subsequently reproduced these conditions on the Test Method F 504 device using a load point near the tip of the test ski and a force vector with a high component in the -2 direction

X1.1.14 Developing a release envelope is also a useful means for better understanding twist release performance. The effect of friction between boot and boot sole rest, or mechanisms that mimic friction, is shown in Fig. X1.3. In this simulation, the apparatus sequentially preloads the system by means of a force on the ski in the 1 direction and releases the system following each preload by means of a force on the ski in the 3 direction.

X1.1.15 The vertical cross section of the example plotted in Fig. X1.3 is highly trapezoidal in shape, indicating excessive friction or the presence of a mechanism that emulates friction between the horizontal bearing surfaces of the boot and binding. Results for bindings low in friction would produce a cross section that is more rectangular in shape and for bindings that actively sense the load normal to the bearing surfaces between boot and binding the cross section could appear elliptical in shape.

X1.1.16 The example in Fig. X1.4 shows a plot of a series of measurements made of the M_1 release moments resulting from forces applied along the 3 direction with no preload. The measured release moment M_1 in this case drops as the force moves toward the reference point. When the force is applied at Point *R*, the moment about the reference point M_1 is higher than the calibrated release moment (plotted at Point *I*). If a force were applied in line with the reference axis, the moment sensed by the load cell at release would be zero. However, if a force were applied at the pivot point of the binding in twist, the theoretical release moment would be infinite.

X1.1.17 The results of a full test series can be plotted as a single isometric drawing thereby creating an overall description of the performance of the test specimen. Shading can also be added to the surface of the plot to indicate the mode of release (toe or heel piece for example).

X1.1.18 In conclusion, the apparatus and methodology described in Test Method F504 and the protocols developed to determine a release envelope can be useful for better understanding and describing the release/retention characteristics of ski bindings.