Slopes, Skis, and Standards

Having Fun Skiing Safely, Responsibly, and Sustainably

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Theme: Standards for a World at Work and Play

I live for mornings like this. The sun is just coming up, and my friends and I are already on the lift line, ready for our first run. It snowed last night, and we can't wait to be the first ones to carve down the slope, leaving snaking trails of parallel ski tracks in the deep, fresh powder. We're on a ski trip, and even though it is cold and this all seems crazy, the mountain beckons. It challenges me with its jutting rocks, its crags, its pines and crevasses. My skis and poles are all that I have to resist the force of gravity, which persistently attempts to trip me up, rendering my practiced form into a tumbling cloud of powder and flailing arms. But I am prepared to battle the cold, the obstacles, and the gravity. I am trained, equipped, and pumped. I am also standards-aware, and know that I can count on a myriad of professionals and manufacturers who have gone before me, establishing procedures and quality controls. They have my back, protecting me from danger, and allowing me to safely explore the limits of my own abilities. We reach the top of the mountain, and my friends and I have the biggest grins as we turn downwards and gain speed. I hunker into my boots, adjust my goggles, and off we go!



Figure 1– A Perfect Skiing Morning!

The Chair Lift

The lift ride up is fast and smooth. It's not just a ride to the top: it's my chance to enjoy the scenery, to rest my aching knees, to bond with my friends. I try not to look down when I am up on the chair lift with just a restraining bar to hold onto and a pipe to rest my skis on. There are very few transportation vehicles in which you are so exposed but feel so safe. I imagine most people don't think about the fact that their lives are hanging from a single

piece of standardized wire rope[1], 6,000 feet long, running at 25 MPH, in a chair suspended by the rope and attached with a "grip." It is comforting to know that the standards-writers have my safety in mind, and are very specific about how the wire rope[2] should be selected for this application: "This specification covers stranded steel wire ropes of various grades and constructions manufactured from uncoated or metallic coated wire and cord products manufactured from metallic coated wire. Dimensional characteristics include the diameter and lay length of the rope. Mechanical property requirements include: rope breaking force, spinning loss factor, and stretch; and wire torsions, tensile strength, tensile grade, and level. Cores of stranded ropes shall normally either be of steel or fiber composition. All wire ropes shall be lubricated and impregnated in the manufacturing process. Wire finish may be final-galvanized rope or drawn-galvanized (zinc coated) rope. Rope workmanship and finish; testing and compliance; acceptance tests; and packaging and identification are also detailed."



Figure 2– Chair Lift at Asessippi Ski Area & Resort

The wire rope cable extends from giant pulleys at the bottom and top of the mountain, and thousands of small pulleys support the cable on towers on the way up the mountain. I admire the engineering involved when I am on lift lines, particularly the giant concrete counterweights used to maintain constant cable tension. Standards writers have thought about how the cable should be tested to ensure it can withstand such incredible tension:[3] "This test method

[1] DIN 17223-1:1964-03 Round Spring Steel Wire, Quality Specifications; Patented Drawn Spring Wire Made of Unalloyed Steels
[2] ASTM A1023 / A1023M - 09e1 Standard Specification for Stranded Carbon Steel Wire Ropes for General Purposes
[3] ASTM A931 - 08(2013) Standard Test Method for Tension Testing of Wire Ropes and Strand

covers the tension testing of wire ropes and strand at room temperature, specifically to determine the measured breaking force, yield strength, elongation, and modulus of elasticity. Methods described in this standard are not intended for other purposes." I admire the engineering at the top of the lift too, but only for a split second as I concentrate on unloading and not hitting the emergency lift shut-off bar, ready to engage me if I were to get stuck on the chair. That has never happened to me, but I have seen people trip this failsafe device. Usually no one gets hurt, but they sure are embarrassed to stop the entire chair lift full of people staring at them!

It is not enough, though, to consider just the components of a system when evaluating its safety and overall integrity. In order to establish parameters for the overall performance of lift systems, the National Ski Areas Association (NSAA) has become an ANSI Accredited Standards Developer (ASD) and written "a system of principles, specifications, and performance objectives, which will reflect the current state of the art of passenger ropeway design, operation and maintenance, and which will be acceptable for adoption by government agencies and others. It is recognized that certain dangers and risks are inherent in the riding, operation, construction, and maintenance of machines of this type. These objectives are intended to result in passenger ropeways that are designed, constructed, operated, and maintained in a manner that minimizes danger and exposure to risk to its passengers, operators, and maintenance personnel, and will encourage improvements in productivity, efficiency, development and progress consistent with these objectives. Such a system with these stated objectives will constitute a safety standard."[4] I ponder how a network of inter-related, internationally adopted standards can create a framework of parameters that guide designers to the myriad decisions they must make when creating such a complex machine as a ski lift. I am also impressed that no matter where I go, the same standard informs me, through signage defined in its Annex, of the rules surrounding the lifts' usage. But now I had better concentrate on catching up to my friends, and looking out for moguls, rocks, and trees!

[4] ANSI B77.1-2011 Passenger Ropeways - Aerial Tramways, Aerial Lifts, Surface Lifts, Tows and Conveyors Safety Requirements



Figure 3– Safety Signage from the *Passenger Ropeways* Standard

Equipment

One of the great things about skiing is the variety of equipment and style involved. Yes, this is not an inexpensive sport, and to be well-equipped and looking good can cost you thousands of dollars. There are many decisions to be made: how much performance you require from the equipment, how fashionable you wish to appear, how comfortable you expect to be, and whether you need the latest model of everything. Each year you inevitably break something or wear it out, or you tire of it and want to try something new, or like any clothes, sometimes you just outgrow it. Skiing is equipment-intensive, and you are always seeking out ways to enhance your experience with combinations of gear. Besides, it's fun to shop for all the cool stuff, and you never know where you will find a bargain, something safer, or something that can solve a problem – like cold fingers!

One of a skier's primary concerns is that his or her body is protected from the cold and injury. To that end, an ASTM committee[5] was founded to create a suite of standards that cover skiing safety issues. According to the ASTM, "The scope of the committee shall be standardization of specifications, test methods, practices, and terminology for: 1) Sports equipment utilized for the purpose of snow skiing to help reduce the potential risk of injury and the promotion of knowledge as it relates to standards for sports equipment utilized for the purpose of snow skiing, 2) Freestyle jumping features located in designated terrain parks at ski areas expressly constructed for recreational, non-competitive jumping to help reduce the potential risk of injury and the promotion of knowledge as

[5] ASTM Committee F27 on Snow Skiing

it relates to standards for freestyle jumping features utilized for the purposes of snow skiing, and 3) The work of this Committee will be coordinated with other ASTM committees and other organizations having mutual interest." Having some familiarity with standards, I know that coordination with other entities is one of the most difficult and important ones. There are so many considerations when writing standards, and the volunteers must have had a great deal of passion for the sport and a familiarity with affiliated technologies and associations. Besides, the best standards build on other standards, do not duplicate them, and harmonize with their terminology.

Figure 4– Logo of ASTM International

The ASTM Committee 27 covers a variety of equipment and administrative/procedural issues that affect those who work across the skiing industry, and their customers who play on their slopes:

F27.10 Binding Test Procedures

F27.30 Skis and Boots

F27.40 Ancillary Equipment

F27.50 Shop Procedures (Retail and Rental)

F27.60 Statistics

F27.65 Research and New Projects

F27.83 International Standards

F27.85 Snowboarding

F27.90 Executive

Each of the sections is a standard unto itself that allows enthusiasts to have similar experiences at each slope they visit. The standard enables professionals to perform services similar to one another, and for everyone to enjoy the

sport with safety in mind. The standards are updated frequently, keeping up with trends and developments. Newer subsets of the sport such as snowboarding and freestyle are very well represented. I have not tried either one of those as I am fairly certain it would not go well for me! They sure do look fun though, and they present different risks from traditional skiing that the standards cover in detail.

One of the most important subsets of the ASTM 27 standard deals with the performance verification of ski bindings. These sophisticated components hold the ski boot onto the ski. They are designed to be easy to get into and out of, but their most important function is to protect the skier from extreme forces that could twist a knee, hip, ankle- or break a leg. Under certain circumstances, the force in the lateral direction at the front or rear of the boot, or an upwards motion at the toe will cause the binding to "release." At that point the skier is usually falling, and relies on the binding release to get the ski out of the way quickly, before a joint or limb is injured. A standard from Germany provides a uniform way of representing the parameters involved in adjusting the binding to account for a skier's height, weight, boot length, and skiing ability.[6] This standard is so prevalent in skiing that many people refer to it as the "DIN Setting." This may be the only knowledge of the extensive reach of DIN standards that they may ever have.

Skier Weight	25-65 lbs.	30-100 lbs.	50-165 lbs.	65-200 lbs.	65-240 lbs.	65-250 lbs.	130-285 lbs.	130-200 lbs.+	150-200 lbs.+
Ability Level	Beginner - Intermediate	Beginner - Intermediate	Beginner - Intermediate	Beginner - Intermediate	Beginner - Advanced	Intermediate - Expert	Intermediate - Expert	Intermediate - Expert	Expert - Pro
Brief Description	Lightweight children	Junior skiers	Heavier beginning or beginning to advanced junior skiers	Intermediate junior skiers or lightweight beginning adult skiers.	Beginning skiers or lightweight intermediate to advanced adult skiers.	Intermediate skiers who are heavier or lighter weight expert adult skiers	Heavier or more aggressive intermediate to expert adult skiers.	Heavier skiers, very aggressive advanced and expert adult skiers.	Aggressive expert big mountain skiers and racers.
DIN	.5 to 2.5	.75 to 4.5	2 to 7	3 to 10	3 to 11	3 to 12	6 to 14	6 to 16	8 to 18

Figure 5– DIN 7881 Release Force Settings Chart

[6] DIN 7881 Winter Sports Equipment - Release bindings for alpine downhill skiing -Adjustment scale for release values.



Figure 6– Ski boot held in place on a ski by binding system

Ski helmets are another critical protective device for skiers. Several standards developer organizations- ASTM,[7] CEN,[8] and SNELL,[9] have produced guidelines for the testing of helmets, and each is acknowledged by manufacturers and sought after by helmet purchasers. These safety standards certification organizations' reputations are recognized as the preeminent voices in protective gear quality. Ski and snowboard helmets go through a rigorous testing process to be developed and approved for these safety standards and certifications. For example, ASTM requires helmets "to undergo a hot, cold and wet dynamic strength retention test. The ambient helmet is subjected to a positional stability (roll-off) test. Anvils are used for impact tests, specifications as follows: flat anvil, hemispherical anvil and edge anvil. Helmets with a design that meets these standards, passing required tests, will help reduce the risk of some injuries to the head at slower speeds, whereas at higher speeds the protection is limited. The purpose of these tests is to provide a reliable and repeatable evaluation of various types of protective helmets. The use of these methods is intended to reduce the likelihood of serious injury and death which may result from impacts to the head sustained by individuals. Ski and snowboard helmets are tested under specified environmental conditions for the limiting of head acceleration in an impact, strength and stability of the retention system, padded liner, and its attachment to the outer shell." The CEN standard includes testing of "helmet construction including field of vision, shock absorbing properties, resistance penetration and retention system properties." I think that the

[7] ASTM F2040 - 11 Standard Specification for Helmets Used for Recreational Snow Sports
[8] DIN EN 1077:2007 Helmets for alpine skiers and snowboarders
[9] SNELL RS-98 1998 Standard for Protective Headgear for Recreational Skiing and Snowboarding

engineers are protecting my cranium in every way they could think of! And incidentally, if my helmet should come into contact with a hard or penetrating object and is damaged, it is to be thrown away, as those protective qualities of the helmet are compromised.

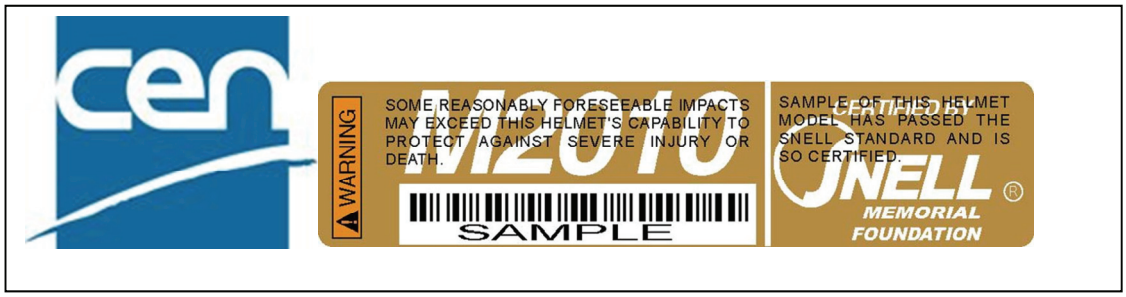


Figure 7– CEN logo and SNELL helmet certification label

It is comforting to know that the helmet I wear has a safety certification label on it, but how do I know that I can trust it? How do I know that there is verification that the certifier is valid? An important standard in the area of conformity assessment[10] is followed by testing laboratories, which are audited by impartial verifiers. As a result of all of this confidence and attention to ski and snowboard helmets, and because of the publicity of skiing head injuries, a lot more people now wear helmets. According to a 2012 study,[11] "67 percent of skiers and snowboarders now wear helmets while enjoying the slopes at U.S. ski areas, up 10 percent from the 2010/11 season. Helmet usage among those interviewed nationwide has increased 171 percent since the 2002/03 season, when only 25 percent of skiers and snowboarders were wearing a helmet at the time of being interviewed. More importantly, nearly 80 percent of children aged 17 and younger now wear helmets on the slopes." I am glad that so many people recognize how important helmets can be. I am also glad that I bought a certified helmet and I wear it every time I ski now, finding it to be just as warm and comfortable as a hat, and providing me with important protection.

[10] ISO/IEC 17025:2005 General Requirements for the Competence of Testing and Calibration Laboratories

[11] 2012 NSAA (National Ski Areas Association) National Demographic Study



Figure 8: Helmet Impact Testing at Snell Memorial Foundation Laboratories

Ski Resorts

A skier is completely reliant on the integrity of the ski resort they are enjoying. The skier also has many expectations when trying out a new mountain. Many ski slope operators have joined the NSAA, the trade association dedicated to sharing and promoting best practices. The NSAA members are dedicated to providing consistent, quality, and safe experiences for their patrons. According to their website, "the National Ski Areas Association is the trade association for ski area owners and operators. It represents 325 alpine resorts that account for more than 90 percent of the skier/snowboarder visits nationwide. Additionally, it has 472 supplier members who provide equipment, goods and services to the mountain resort industry. NSAA analyzes and distributes ski industry statistics; produces annual conferences and tradeshows; produces a bimonthly industry publication and is active in state and federal government affairs. The association also provides educational programs and employee training materials on industry issues including OSHA, ADA and NEPA regulations and compliance; environmental laws and regulations; state regulatory requirements; aerial tramway safety; and resort operations and guest services." All of these attributes are

important to me today, as I encounter equipment, conditions, and the professionals who support my enjoyable skiing experience.

Trail Markers

One important role of the NSAA is to establish uniform standards for trail markers. These markers are prominently located at the top of each trail, or "piste" in Europe. Lifts and trails are also marked on the map of the ski resort, and posted on signs on the mountain. The colored symbols next to the trails are the keys to understanding the nature of the slopes. Their shape and color indicate the difficulty of the trail.



Green Circle: Easier
Blue Square: More Difficult
Black Diamond: Most Difficult
Double-Black Diamond: Most Difficult, use extra caution
Orange Oval: Freestyle Terrain

Figure 9: Downhill Ski Trail Markers

The same trail symbols are used at every resort in the US and Canada, but they vary from resort to resort. The trail ratings are consistent within each resort, however. So all the "Greens" at a particular ski area will be about the same difficulty, as will the "Blues" and the "Blacks." In Europe, pistes are classified by a similar color-coded system. The actual color system differs in parts for each country - in all European countries blue (easy), red (intermediate) and black (expert) are used. Shapes are not always used - sometimes all ratings are circles as being defined in the basic rules of the German Skiing Association (Deutscher Skiverband, or DSV.) The three basic color codes of the DSV have been integrated into the national standards in Germany[12] and in Austria.[13] Today I do not have to worry about the difference between United States, Canadian, and European trail markers, but I hope that next year I will have an opportunity to visit the Alps, and will have to understand all of this!

[12] DIN 32912 Graphische Symbole und Schilder zur Information der Skifahrer auf Skipisten
[13] ONORM S4610 Seilbahnen und Schlepplifte - Grundlegende Schilder für Fahrgäste

I do think that there is opportunity here for the international skiing community to harmonize all of these trail markers across the world. I realize that there are different standards in different parts of the world, and all of these would have to be considered. In addition, it would be helpful to all skiers if the markers actually represented an absolute difficulty level, no matter which resort they skied at, such as a number from 1-20. I have confronted trails at resorts that were marked according to my ability- or so I thought- only to find that they were beyond my capabilities – even terrifying! If a more granular, graduated system is necessary for this to happen, I know many people who would welcome that. There are people I know who were relative beginners, thinking they were on a manageable, blue square trail, finding themselves over their heads. That bad experience turned them off from skiing for the rest of their lives, unnecessarily.

Sustainable Slopes

It is truly a privilege to have the financial means and time to be able to enjoy downhill skiing. The ski industry is enormous, and is located in some of the most remote, pristine natural locations on earth. It is important to me, as it is for many others, to treat this privilege as responsibly and sustainably as I can, as millions of people have a significant impact on the environment. In order to provide guidelines and a framework for environmental consideration, the NSAA has instituted a comprehensive plan, or "charter."[14] "In total, more than 190 resorts have endorsed the Environmental Charter over the past twelve years, representing over 75 percent of the ski resorts nationally by skier visits. Upon endorsing the Charter, these resorts have identified an environmental contact person, assessed their policies and operations against the Environmental Principles in the Charter, and have taken steps toward improved environmental performance. The Environmental Charter promotes sound environmental stewardship and, more importantly, offers a comprehensive set of 21 Environmental Principles that enable ski area operators to make sustainable use of natural resources. The Principles are the key to the Environmental Charter and address the following topics:

1. Planning, Design, and Construction
2. Water Use for Snowmaking
3. Water Use in Facilities
4. Water Use for Landscaping and Summer Activities
5. Water Quality Management
6. Wastewater Management
7. Energy Use for Facilities

[14] NSAA Sustainable Slopes 2012 Annual Report

8. Energy Use for Snowmaking
9. Energy Use for Lifts
10. Energy Use for Vehicle Fleets
11. Waste Reduction
12. Product Re-use
13. Recycling
14. Potentially Hazardous Wastes
15. Fish and Wildlife Management
16. Forest and Vegetative Management
17. Wetlands and Riparian Areas
18. Air Quality
19. Visual Quality
20. Transportation
21. Education and Outreach"



Figure 10: NSAA Sustainable Slopes logo

Ski Patrol

Thank goodness for the thousands of avid skiers who perform a valuable service to their fellow enthusiasts- the ski patrol. One part traffic cop, one part human ambulance, and one part caring individual, they are vigilant in their scan of the slopes, looking for dangerous conditions and skiers in trouble. Their credential is based on the "Certified Program" of the National Ski Patrol (NSP) in the United States. According to the NSP website,[15] "this enables patrollers to build upon experiences gained while patrolling and through other NSP programs. The program consists of six core modules:

- Area operations and risk management
- Avalanche management
- Emergency care
- Lift evacuation and rope knowledge
- Skiing /snowboarding
- Toboggan handling

This program requires independent training and advance research in order to complete the modules and receive certification. The certified candidate should possess extensive knowledge of patrol and area operations, as well as physical dexterity and skills in leadership, instruction, problem management, and decision-making. More

[15] https://www.nsp.org

importantly, the individual must have an aptitude for team building and experience in planning programs to facilitate the success of the program and area operations." Hopefully I will not need their services today, but their constant presence on the slopes ensures me that they are prepared to help if I do!

Training and Education

I would not be able to consider skiing a black diamond slope today if I had not had the excellent training from my ski instructors. When I started taking lessons in High School I had no idea that my instructors were so versed in standards and procedures, and had such considerable training and certifications. The organization responsible for their professionalism is the Professional Ski Instructors of America (PSIA). According to their website,[16] the PSIA "was incorporated in 1961 out of a need to unify the various teaching and skiing organizations that previously existed in the United States. The goal was to create a consistent experience for guests, regardless of where they were travelling and at what area they skied. The popularity and success of snowboarding gave rise to the American Association of Snowboard Instructors (AASI), which was formed in 1997. Nine regional divisions of PSIA-AASI support their local members through education, certification, and PSIA-AASI membership services. In addition, PSIA-AASI represents the United States to the rest of the world through the International Ski Instructors Association (ISIA).



Figure 11: Ski School with a certified instructor

In an effort to create educational consistency across the country, PSIA published *The Official American Ski Technique* in 1964. Technique and tactics promoted by PSIA evolved into the *American Teaching Method* (ATM)

[16] http://www.thesnowpros.org

and is currently called the *American Teaching System* (ATS), which also incorporates the *Snowboard Teaching System* (STS). The two primary components of ATS are education and certification. PSIA-AASI develops national certification standards[17] that the divisions then use to create examinations to validate instructor skills."

Skier's Responsibility Code

Ultimately, no matter how all of my preparations, training, and equipment choices have led me to this moment at the top of the mountain, the rest is up to my decisions and personal responsibility today. Not only am I responsible for skiing safely to get myself down the hill, but my actions may affect many others on the slope. According to the National Ski Patrol,[18] "Skiing and snowboarding can be enjoyed in many ways. At areas, you may see people using alpine skis, snowboards, telemark skis, cross country skis, and other specialized equipment, such as that used by the disabled. Regardless of how you decide to enjoy the slopes, always show courtesy to others and be aware that there are elements of risk in skiing that common sense and personal awareness can help reduce. Observe the code listed below, and share with other skiers and riders the responsibility for a great skiing experience.

- Always stay in control, and be able to stop or avoid other people or objects.
- People ahead of you have the right of way. It is your responsibility to avoid them.
- You must not stop where you obstruct a trail, or are not visible from above.
- Whenever starting downhill or merging into a trail, look uphill and yield to others.
- Always use devices to help prevent runaway equipment.
- Observe all posted signs and warnings. Keep off closed trails and out of closed areas."

Thankfully, enough manufacturers, resort owners, and other skiers involved in standards and certifications associations have put guidelines in place to protect me, and to help my sport be sustainable for generations to come to enjoy. The ski industry now endorses a network of safeguards that include standards, conformity assessment, professional certifications, guidelines, and education. These are the basis for an integrated approach to a $2.2 Billion industry[19] that works very well and continues to grow. Millions of people a year enjoy this sport without

[17] http://www.thesnowpros.org/BeaSkiorSnowboardInstructor/PSIAAASINationalStandards.aspx
[18] http://www.nsp.org/slopesafety/respcode.aspx
[19] Pell Research: Ski Resorts: Market Size, Industry Analysis & Financial Ratios, 2009

understanding how sophisticated and professional it really is. I realize it though and appreciate its elegance. Now can I just stop thinking about all of this technical stuff and enjoy this perfect snowy morning!? Race you to the bottom!