Guidelines for in-plant handling of aluminum plate, flat sheet and coil

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The Aluminum Association
Incorporated

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NOTICE

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SECOND EDITION, January 2006

The 2006, second edition has been revised through the support of the Technology Committee of the Sheet and Plate Division.

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The Aluminum Association, based in Arlington, VA, with offices in Detroit, MI, represents U.S.- and foreign-based primary producers of aluminum, aluminum recyclers and producers of semi-fabricated products as well as suppliers to the industry. Member companies operate almost 200 plants in North America and many conduct business worldwide.

The Aluminum Association

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Contents

1. Introduction

Aluminum flat sheet, plate and coil can be efficiently handled either manually or with most equipment. This brochure describes procedures and methods that have been used successfully. The suggestions and precautions outlined for handling aluminum to minimize surface damage and in-plant scrap can be equally beneficial for handling other metal products.

The information in this document is intended to provide a summary of best practices for the handling of aluminum flat sheet, plate and coil in order to avoid staining, scratching and other physical markings. The suggested handling practices are not intended to modify the comprehensive safety procedures that should be in effect at each individual facility. As with all plant equipment, it is critical that operators ensure that any activity is in accordance with the manufacturer's rated capacity of that equipment and that appropriate safety procedures are strictly followed.

2. Safety

Safe Practices For Handling Aluminum Sheet and Plate

Due to its many unique properties, special precautions must be taken when handling wrought aluminum products.

Even when it is in its molten state, aluminum, unlike steel, does not change color. Before touching any aluminum surface you should verify if the surface is cool enough to touch. This can be done by placing your hand near, but not on, the aluminum surface.

Aluminum wrought products can, and often do, have sharp edges. These edges can cut through the skin very easily. It is highly recommended that cut resistant gloves and wrist sleeves be worn when handling aluminum products. Other personal protection equipment (PPE) should include meta-tarsal safety shoes, hard hats, and safety glasses.

Care must be given to suspended loads. Never walk or drive under nor place any body parts under a suspended load. Be aware of the vertical drop zone. This is the area which may be impacted should something fall from a suspended load.

Other safety rules that should be adhered to are:

- Finger rings should not be worn on the shop floor.
- Neckwear should not be worn on the shop floor.
- Long hair should be tucked under the hard hat.
- Dangling jewelry should not be worn on the shop floor.
- See section 10 for references for Federal Regulations for personal protective equipment (PPE).

Because work areas often require moving coils or skids from place to place, it is always important to be aware of mobile equipment traffic. Fork trucks always have the right-of-way, and pedestrians should keep clear of their path. If a traffic lane must be crossed, make sure to look both ways and make eye contact with the fork truck operator before proceeding.

NOTE: The information provided is not purported to address all of the safety concerns which may be associated with the handling of aluminum plate, sheet and coil, or to warrant that the precautions described are guaranteed to prevent injury, but is intended to assist the user in avoiding potential safety hazards. It is the responsibility of the user of this document to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

3. Packaging

Aluminum products are packaged to prevent damage to the metal during transit, transfer and storage. It is important that the size, weight and configuration of the shipped material are within the limits of your handling system. Material suppliers can furnish material packed in a customary method which offers maximum protection. Should handling equipment limitations dictate different skid configurations, it is recommended that the material supplier be contacted. When surface quality is critical, aluminum flat sheets and plate are additionally interleaved with special paper, foam sheets or other materials to protect the surfaces against abrasion. Even though some interleaving papers contain an additive to inhibit water staining, the normal precautions during transit, handling, and storage should be followed. It is very important that the coil or sheet metal package is securely attached to the skid to eliminate any possibility of movement which can tear or otherwise compromise the integrity of the packaging during shipping. Use of desiccants is not recommended due to rapid overload conditions that can occur during long routes and the very large quantity of moisture that can accumulate on cold surfaces.

In addition to the external packaging, the use of fiber or metal cores may also be helpful in preventing damage and minimizing scrap on certain coil products. The benefits of the cores must be offset against the added cost which could include disposal or return of the cores. These issues should be addressed with your material supplier.

4. Material Receiving Inspection

Inspection of incoming material for physical damage and wetness is a vital part of the receiving process. This should be done, if possible, while the material is still on the vehicle or as it is being unloaded. If any physical or water damage is discovered on the skids, packaging, or the metal, it should be noted on the receiving papers. The purchasing or quality control department should be informed immediately. Additional information about incoming material inspection can be found in the Aluminum Association publication *Guidelines for Minimizing Water Staining of Aluminum,* which can be ordered from The Aluminum Association Bookstore at www.aluminum.org.

5. Storage

Proper storage of aluminum is vital to preventing damage to the metal. Damage to material in storage is primarily caused by condensation, by the storage systems that are in use, or by poor handling practices. Care must be taken to avoid in-house traffic damage as well. Terminology for and examples of damage can be found in The Aluminum Association publication *Visual Quality Characteristics of Aluminum Sheet and Plate*, which can be downloaded or purchased from the Association Bookstore at www.aluminum.org.

A. Water Stain

In the presence of moisture, and under certain conditions, aluminum will stain. Aluminum and other metals can stain when water is trapped between wraps, sheets or other mating surfaces. If there is no air flow to remove the water, contact between the water and the metal can cause a reaction between the two, which could result in water stain. Under extreme conditions the staining (corrosion) can occur after as little as one hour of contact. Sources of water include rain, snow, water leaks and condensation. Water vapor will condense on the surface of a metal if the temperature of the metal drops below the dew point of the surrounding air. Examples of waterstain on a coil and on sheet are shown in Figures 1 A & B.

When metal is received, it should be inspected for wetness. If found wet, note this on all copies of the receiving papers and inform the purchasing or quality control department immediately. If the metal feels cold, notify your supervisor and temporarily store the metal in a cool indoor area away from cold drafts to allow it to warm slowly (If this is not done, and the metal is stored in a heated warehouse immediately, condensation may occur and later result in water stain.) Once the metal warms to ambient temperature (in about 24 hours), move it to the warehouse.

When metal is moved between storage areas, check the temperature of the metal and the temperature of the area to which the metal will be taken. If the temperature of the new storage area is warmer by 20°F (10°C*) or more, move only enough metal for immediate use and notify your supervisor. Leave the remainder of the metal where it is until required for use.

**Metric values are given as approximations for convenience only.*

Figure 1A - Water Stain on Coil

Figure 1B - Water Stain on Sheet

The following steps need to be taken, whenever possible, to prevent moisture from condensing on the metal in storage:

- Store metal in heated warehouses;
- Allow wrapping materials to remain intact (repair if torn) until the aluminum is used;
- Store away from outside doors where the metal could be subjected to rapid temperature fluctuations;
- Store away from high humidity areas (such as paint or anodizing lines) where the dew point is usually high.

The Aluminum Association publication, *Guidelines for Minimizing Water Staining of Aluminum* provides precautionary measures to prevent stained material.

B. Flat Sheet and Plate Storage

Various types of storage racks are being used today, and circumstances may warrant these racks being secured permanently into the building structure. But an ever-changing product-mix demanded by industry has stimulated development of simple, rugged, self-supporting racking systems that can be erected, modified, or moved quickly and easily. Several manufacturers offer systems of this type. The next two figures present typical examples.

The cantilever rack shown in Figure 2 is self-supporting and easily erected from standard components. Arms of various lengths and capacities are interchangeable. They can be moved up or down by one employee to accommodate changing storage requirements. The type of rack shown in Figure 3 is also easily disassembled and moved.

Figure 2 - Typical type of cantilever rack

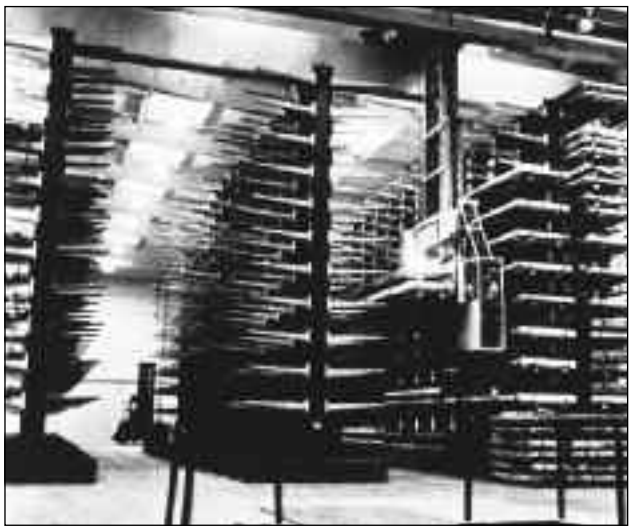


Figure 3 - Typical type of storage rack

C. Coil Storage

Since coils concentrate many pounds of metal in a compact, stable package, storage may or may not be a critical problem. Original skidded coil packages can usually be stacked three or four high. But this is not always the most satisfactory answer for locations where coils are frequently removed and returned to the storage area. Storage of partially used coils can create their own problems. Coils should be tightly rebanded, or if tape is used, new tape should be used to secure the outer wrap to the coil as old tape can release itself. Figure 4 gives an example of loose wraps, which can cause scratches when processing the coil (as discussed in section 9B). An example of the "tension" scratches that occurs when the loose wraps are tightened during subsequent processing is shown in Figure 5. An example of the "oscillation" scratching that can occur when coils with loose wraps are transported is shown in Figure 6. Storage of skidded coils under the cantilever arms of flat product storage units solves the problem of full floor-space utilization, providing direct accessibility to individual coils.

Figure 4 - Loose Wraps on a Coil

If coils are stored "eye-horizontal" and on the floor, they should at the very least be placed on some debris-free padding between the coil and the floor as is shown in Figure 7A. Additionally, all coils need to be secured (braces, chucks, or chains) in a manner that prevents rolling. The wedge shape of the padding device shown in Figure 7B can serve this purpose.

Figure 5 - Example of a Tension Scratch

Figure 6 - Example of Oscillation Scratches

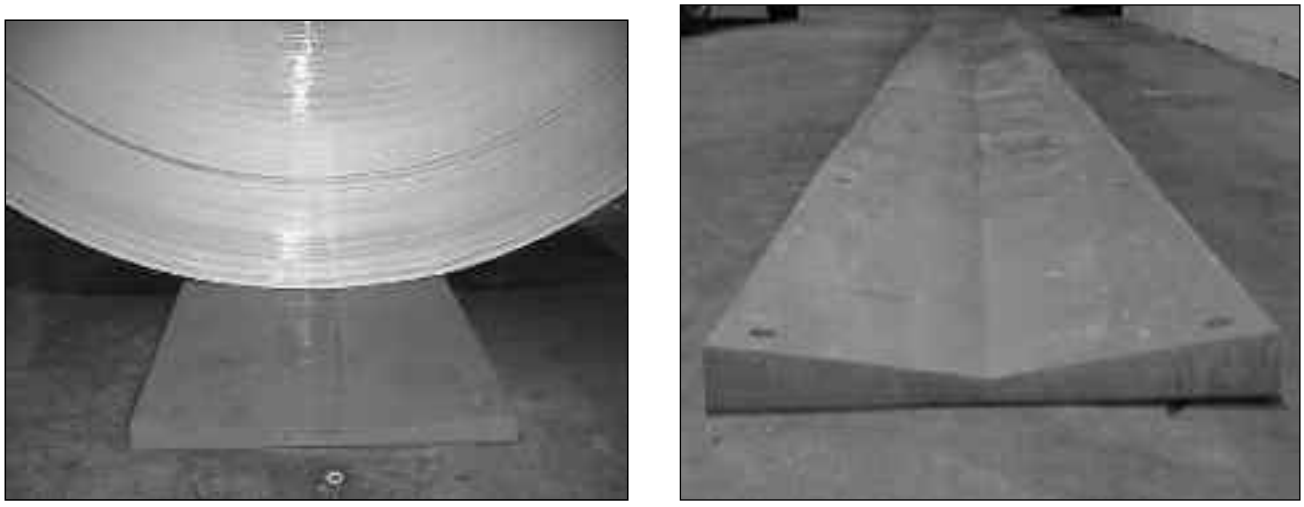


Figure 7 - (A) Storage of Coil on Protective Padding (B) Example of Wedge-shaped Protective Padding

While stacking coils directly upon each other in a pyramid type configuration is not recommended, if this is done then care should be taken to avoid damaging the outer wraps and / or collapsing the inside diameter (ID) of the coils. Additional bracing may be necessary to prevent movement of the coils in the stack.

When skidded, eye-vertical coils are stacked upon other coils, it is important that there is proper edge protection and a smooth coil side wall with no oscillation. The height of the stacking will depend upon a number of issues such as floor loading, handling equipment limitations and safety considerations. Many of these same issues will apply to eye-horizontal coil stacking.

Several manufacturers provide storage rack systems rugged enough for individual storage of coils in the vertical or horizontal position. The type of rack selected will depend upon individual requirements and types of handling equipment available. Storage systems planning should allow for expansion. It should take into account the trend toward larger coils as well as variation in coil sizes.

6. Handling

A. Coil Products

Fork trucks: Most coil stock is shipped with the ID or arbor in the vertical position. (“eye to the sky”). The fork truck is the most common method of unloading and transporting skidded material. When handling coils with a fork truck, care must be taken to avoid striking the material or the skid with sufficient force to cause either direct fork damage or side wall damage through the movement of coil against coil or coil against skid. In addition, as shown in Figure 8, the vertical portion of the fork should be padded to prevent damage to the coil.

The skid weight must be uniformly distributed on the forks when lifting the skid. Normally, this is not a problem if the skid is properly designed and the forks are of sufficient length. Care must be taken to ensure that the forks are not so long as to strike the coil behind the one being lifted. A common type of side wall damage occurs when the weight of the skid is supported by the point of the fork causing it to break the skid decking and/or penetrate the package. This usually occurs when the skid is much larger than the length of the forks, causing an imbalance. Care should also be taken to ensure that, when properly loaded, the coil does not exceed the rated capacity of the fork truck due to extending the load center beyond that for the stated truck capacity. For example, a 15,000 pound (6820 kg) coil measuring 48" wide x 68" OD (120 x 170 cm) can be picked up safely “eye to the side” with a truck which is rated for 15,000 pounds (6820 kg) at a 24" (60 cm) load center. However if the same coil is down ended onto a skid “eye to the sky” the load center has moved out to at least 34" (85 cm) which has the effect of reducing the safe lifting capacity of the truck to only 10,588 pounds (4810 kg). A

Figure 8 - Padding on Forklift to Protect Coils

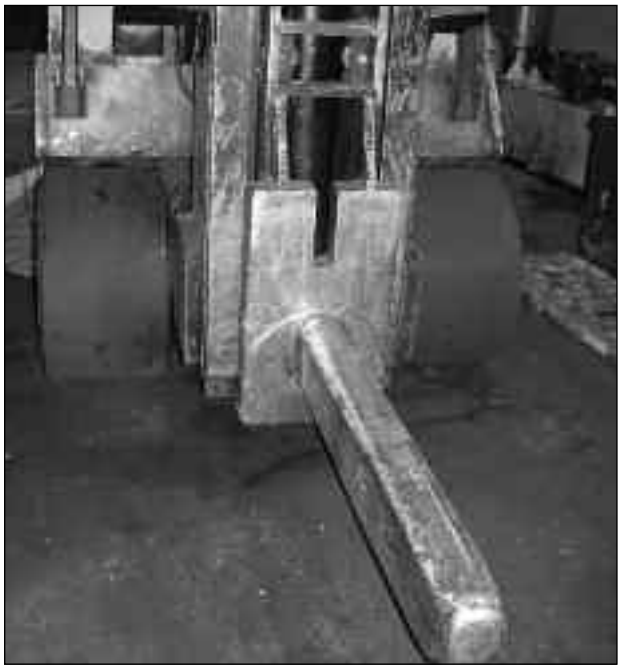


Figure 9 - Fork Truck with Curved Lifting Arm

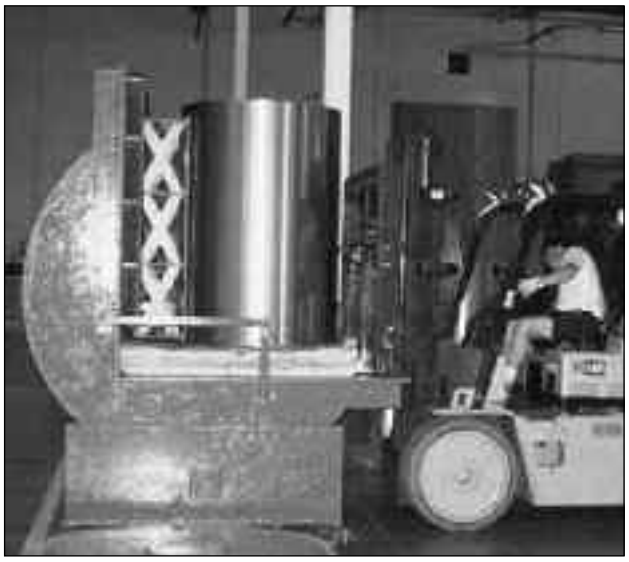


Figure 10A - Loading Coil on Upender

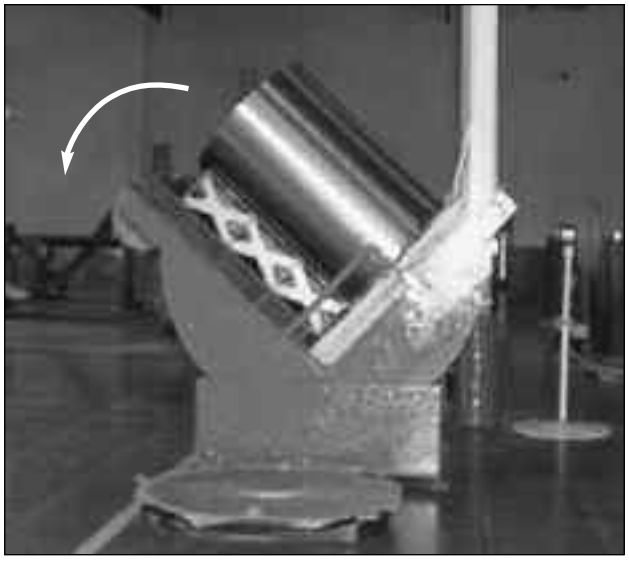


Figure 10B - Upender Changing Coil from "Eye Vertical" to "Eye Horizontal"

movement out of the load center of only 6" (15 cm) to 30" (75 cm) has the effect of reducing the capacity of a 15,000 pound (6820 kg) rated truck to only 12,000 pounds (5455 kg).

Intermediate handling of coil products consists of moving stock from storage, unpacking and preparing the material for loading on equipment. Removing stock from storage usually involves the same procedures used during unloading. Once the coil has been turned to a horizontal ID position (see "Upenders") and unskidded, it can be handled by fork truck. Several precautions should be taken: (1) There should be a fixture that provides a rounded upper surface matching the curvature of the inside diameter of the coil which can be picked up by the fork truck prior to lifting the coil (a typical example is given in Figure 9); (2) The vertical portion of the fork should also be padded to prevent damage to the inside circumference of the coil; (3) Care must also be taken when lowering coils so that the inside diameter does not collapse. (A severe blow can cause this type damage.) Coils should be lowered slowly onto a protected area by the fork truck. In preparing the material for further processing, however, additional equipment is sometimes required.

Figure 11 - Overhead Crane w/Vertical Coil Grab

• **Upenders:** Nearly all coil stock is shipped in a vertical ID position. It is necessary, therefore, to upend coils to the horizontal ID position before loading on equipment mandrels. Various types of upenders, such as that shown in Figure 10, are available. They allow for fast, safe unskidding and turning of coils.

• **Vertical Coil Grabs:** When coils must be handled with the ID vertical, vertical coil grabs (Figure 11) are the preferred method. Vertical coil grabs are used in conjunction with a crane. The portion of the grab that comes into contact with the coil edges should be padded to prevent damage.

• **"C" Hooks and Horizontal Coil Grabs:** Using a "C" hook with a crane, shown in Figure 12, is similar to handling

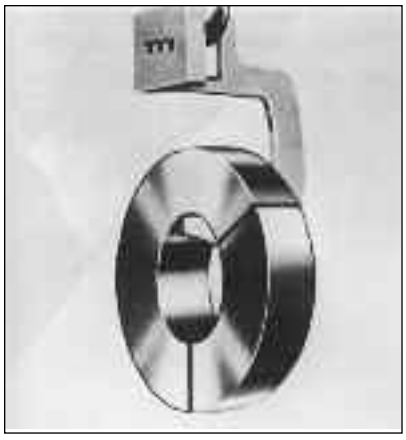


Figure 12 - Overhead Crane w/ Coil on a "C" Hook

horizontal ID material with a fork. The coil, however, must be properly centered on the hook to maintain a horizontal ID If the load is not properly centered, it will tilt and when returning it to the floor one edge will support the entire weight of the coil causing edge damage to the outside diameter. Padding should be placed wherever the metal can come in contact with the hook (see Figure 13).

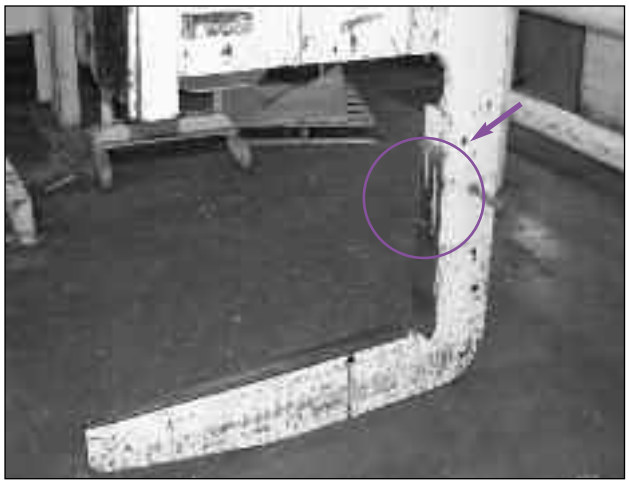


Figure 13 - C-Hook w/Padding to Protect Coils

• **Horizontal Coil:** Horizontal coil grabs used with a crane, Figure 14, are usually best for handling material in the horizontal ID position; however, the grabs should be padded to prevent edge damage.

• **Vacuum Lifts** Vacuum lifts are another method of moving coils (see Figure 15), but they require a very smooth coil sidewall.

If automated coil movers are used, such as is shown in Figure 16, attention must be given to the protective padding that is used on the coil cradle to ensure that no damage or debris is present.

Automated coil movers (also called automatic guided vehicles or AGVs), Figure 16, have no human operator and are programmed to transport coils between work stations. Attention must be given to to the protective padding that is used on the coil cradle to ensure that no damage or debris is present. Collision avoidance systems are typically employed in AGV design, but since they may begin moving without warning, pedestrians should keep a safe distance away and take care not to place themselves between the AGV and immovable objects.

B. Flat Sheet and Plate Products

• **Fork Trucks:** The same comments regarding coil stock handling apply to flat sheet and plate. Handling long skidded material with short forks will present problems. While neither method is recommended, the practice of pushing or pulling long skids is common when overhead equipment is unavailable. Of these two methods, pushing the skid with the fork truck is less likely to cause metal damage. Damage to the skid and possibly the metal is the common result of pushing large skids with a fork truck.

• **Slings:** Slings, as shown in Figure 17, are a common method for handling flat sheet and plate. They can either be steel cable or nylon belts. Since slings wrap the load, edge damage can result if the material is not

Figure 14 - Crane w/Horizontal Coil Grabs

Figure 15 - Moving Coils with a Vacuum Lift

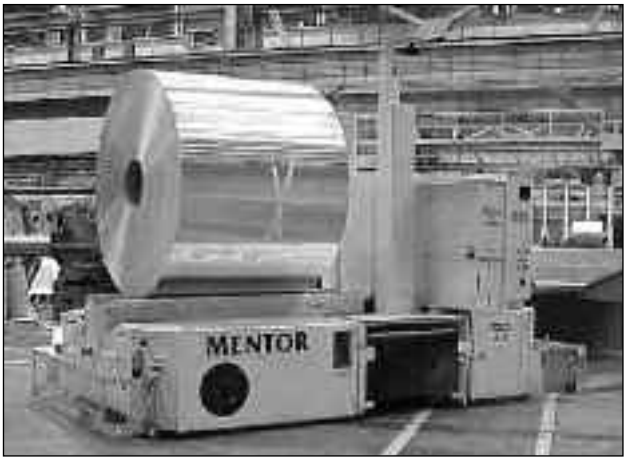


Figure 16 - Automated Coil Mover

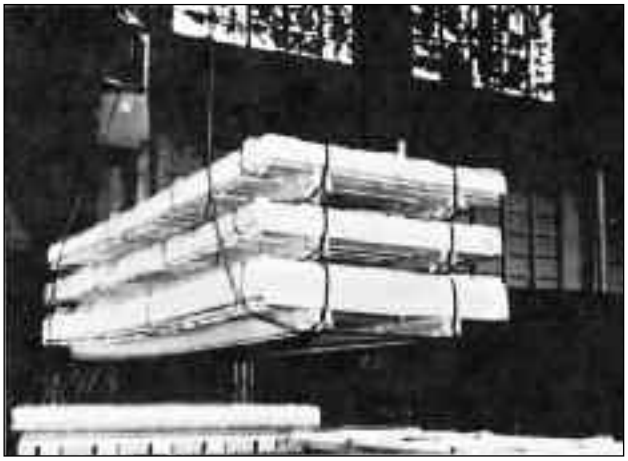


Figure 17 - Slings for Handling Skidded Sheet and Plate

sufficiently protected from the cable. Nylon belts have an advantage over cable in that they distribute the load over a greater area, thereby reducing the chance for damage. They are also less prone to slip.

• **Grabs:** Grabs, Figure 18, are the preferred method for handling flat sheet and plate with a crane although care must be taken to avoid gouging the sides of the sheet. In general, they offer excellent support and minimize the chance for damage.

Figure 18 - Grabs for Handling Plate and Flat Sheet

7. Turning Flat Sheet

This operation sounds so simple that many people overlook its importance. In spite of new equipment in use or in development, size limitations, problems of location, and the need to inspect both sides of the material still make hand turning a widely used method of transferring sheet and light plate from one skid or stack to another. (See Figure 19)

Bright finished sheet as well as mill finished sheet will mark easily if dragged across another sheet. The scratches at the far edge of bottom sheet in Figure 20 were caused when the top edge was dragged over it. If operators are careless, the top sheet will also slip down and scratch its lower surface on the edge of the bottom sheet.

Figure 19 - Manual Turning of Flat Sheet

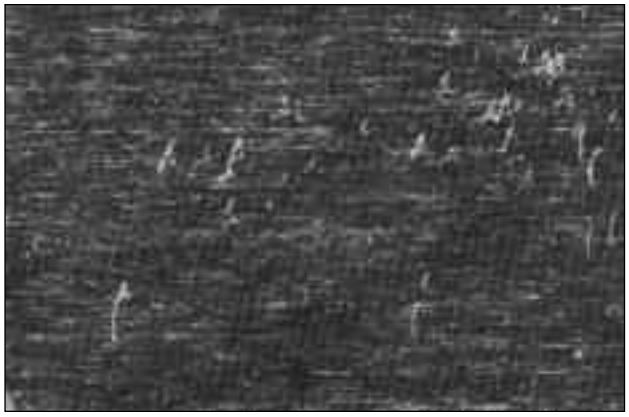


Figure 20 - Scratches on Bottom Surface of Sheet Due to Improper Handling

Figure 21 - Kinked Sheet

Sheet must be picked up cleanly and swung into position. A swishing sound as the sheet is picked up or lowered almost certainly means a marked surface. The solution is perfect timing with the operators lifting in unison. Some service centers and plants keep a skid with a few samples of various sheet types and sizes to allow new operators to practice before attempting to turn valuable metal. Another danger is kinking, as shown in Figure 21. Pull must always be straight back, especially on thinner sheet.

Clean gloves should be worn to prevent finger prints or smudging of the sheet as well as for operator safety. The salt from perspiration may etch fingerprints into the metal. In hot weather, it is sometimes necessary to prevent perspiration dripping from the operators onto the metal.

Working height should be no higher than a comfortable level and no less than 24 inches (60 cm) (Figure 22.) Distance between sheet stacks should be from 4 to 12 inches (10 to 30 cm). More may put an operator off balance; less can cause skinned knuckles and insufficient room for metal to swing clear.

Insert Figure 22 - Proper Table Working Height

A. Guidelines for Turning Sheet by Hand

- The current pallet and the new one should be located no more than a few steps from each other. The pallets should be aligned so operators do not have to walk forward/backward while turning the sheets.
- The pallet height should allow proper lifting postures for the sheet weight. This may mean elevating/lowering one or both of the pallets as the operation progresses.
- The corner closest to the new pallet will be the bottom hand when the sheet turns and the operator should hold the corner of the sheet.
- The bottom hand simultaneously pulls on the sheet edge to keep it straight and guides the sheet corner to its new location.
- Operators need to lift in unison to prevent sliding/scratching of the sheet.
- The operators should each move their bottom hand to the corner of the new stack and then begin turning the sheet. The bottom hand remains stationary, providing constant tension on the sheet.
- As the sheet is swung into place, the operators coordinate their upper hands to ensure the sheet remains straight.
- Practice on some spare/scrap sheets before trying on critical items.

B. Guidelines for the Mechanized Turning of Flat Sheet and Light Gauge Plate

Turning flat sheet by hand as described in section 7A has a number of limitations. These include the sheer size and weight of the sheet product, current emphasis on safety of the employees, and inadvertent scrap due to surface damage caused by inattention or lack of expertise of the operators.

Figure 23 -Vacuum Cup Sheet Inverter Placed on Top of Product.

Figure 24 - Sheet Being Lifted and Turned Over for Inspection on a Separate Inspection Platform.

To assist final inspection and stencilling of flat sheet products and occasionally light gauge plate, vacuum cup systems were developed and now are being routinely used by aluminium mills and are also being adopted by distribution. The technique and equipment design are quite simple. A series of neoprene cups, arranged in a rectangular array with each cup connected via a rubber hose to an ejector pump and attached to a sturdy frame, is lowered over the sheet or plate until the vacuum cups are resting on the surface. At that point the pump is activated which evacuates air from the space enclosed by the outer perimeter of each individual cup. This creates sufficient force so that very large sections weighing hundreds of pounds can be readily lifted and transferred to another inspection section platform as shown in Figures 23, 24 and 25.

Figure 25 - Sheet Rotation-Nearing Completion

The technique allows very rapid sorting, inspection and, if necessary, stencilling of the sheet. Safety concerns associated with the manual lifting of large and awkward sizes are eliminated and surface damage described in section 7A is virtually eliminated.

Guidelines for safe and efficient operation.

- Ensure that vacuum system is rated for the sheet and plate sizes to be lifted. Either increased cup spacing or a larger diameter cups arranged in a pattern, which provides full coverage of the sheet, can adjust this.
- Ensure that cups are properly maintained i.e. edges are sharp and free of nicks and gaps providing solid seal and ensuring lift. It is also important to ensure that edges are flexible. Edges, which as a result of oil and or high temperature have become hard and brittle, will not provide proper seal thus resulting in product release in mid motion.
- Ensure that cups and the frame are clean and free of debris and oil which could be transferred to the product being processed

Figure 26 - Moving (A) Flat Sheet and (B) Plate with Vacuum Lifts

8. Other Techniques for Handling Sheet and Plate

Frequently, a few sheets must be moved without turning. It sounds easy, but there is a great danger of the sheets making rub marks against each other, especially if they are not interleaved or oiled. Operators positioned on opposing ends of the sheet must obtain firm holds on both edges of the sheet.

Both operators must pull back and lift at the same time so that the sheet will swing clear without dragging in any direction. The sheet must then be lowered gently in the same way so that it settles into position. Interleaving is highly desirable in this operation because of the difficulty of positioning the sheet without rubbing. Operators should ensure that their pull is straight back to avoid kinking metal with their hands.

Where equipment is used to "pick" and transfer a part of a stack of sheet or plate, the equipment should be inspected continually to make sure that padded rollers or other parts that come in contact with metal are kept free from dust, slivers, oil or moisture which might scratch or mark metal surfaces. If a plate must be lifted with mechanical grabs, it may be necessary to tape padding to equipment at the point of contact.

Vacuum type lifts, as shown in Figure 26, can provide a satisfactory means of moving sheet and plate. Plate must be guided carefully by hand to prevent swing and rub against the plate below. Caution: Stand clear and always allow room to move back quickly in case the vacuum should fail.

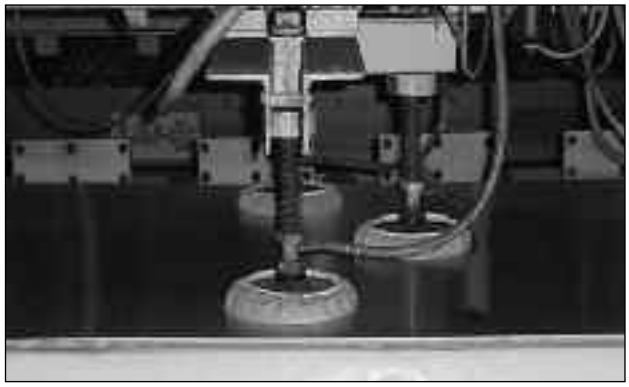
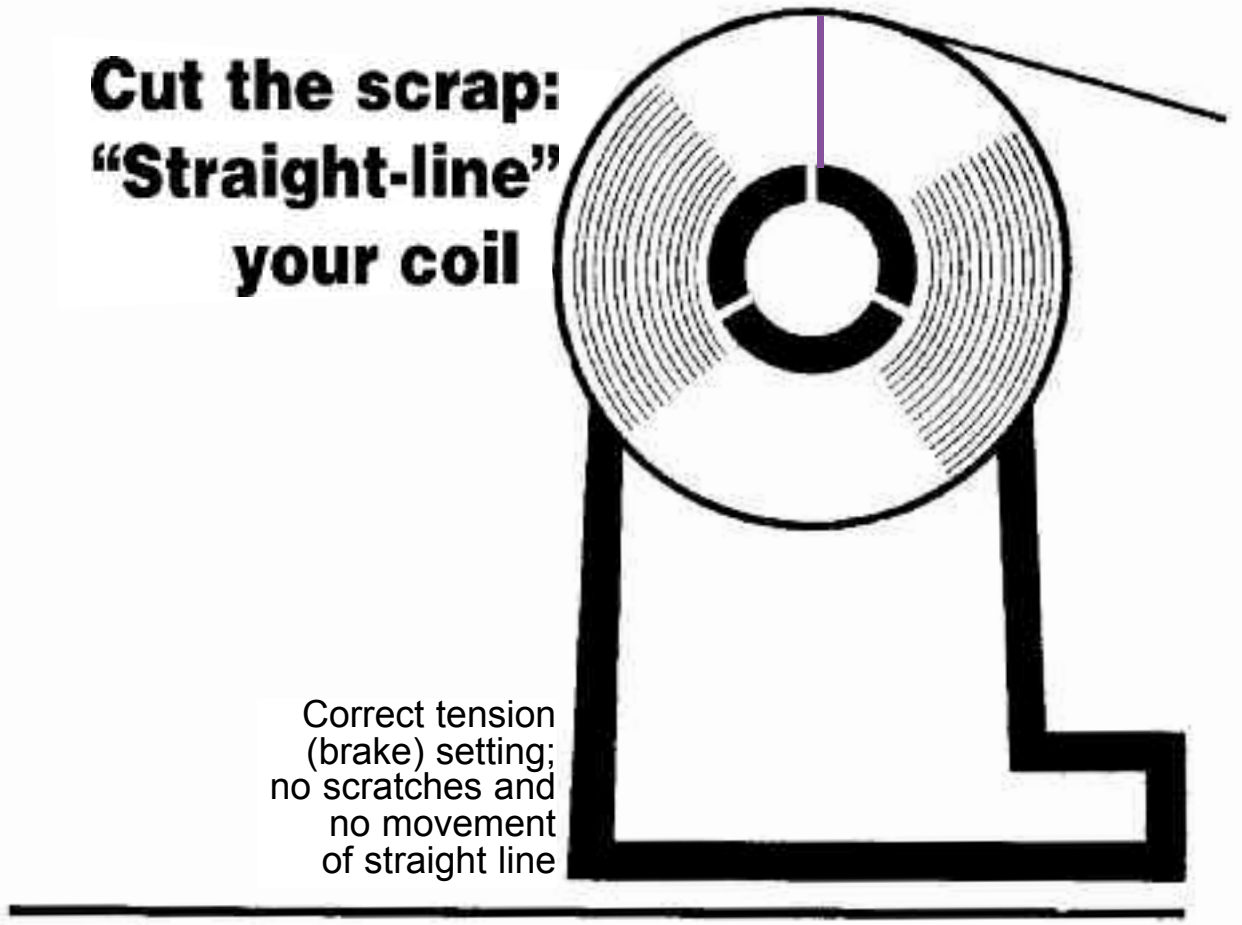


Figure 27 - Protective Coverings on Vacuum Cups

Clad, bright finish, and other critical surfaces may be stained by oil and chemicals in the rubber vacuum cups, or marked by direct contact of the rubber. A sheet of interleaving paper placed over the plate and / or polyethylene covers over the cups (See Figure 27) will usually eliminate these problems.

Protective covers can be purchased, or ordinary polyethylene can be taped in place over the vacuum cup, and a hole punched near the center to allow air to come through. Porosity of the interleaving paper allows suction to pick up the plate. However, some lifting power is lost, so extreme caution must be used not to lift or move the plate too rapidly, and to "stay out from under" in case of slippage.



Slip scratches from improper unwind back tension

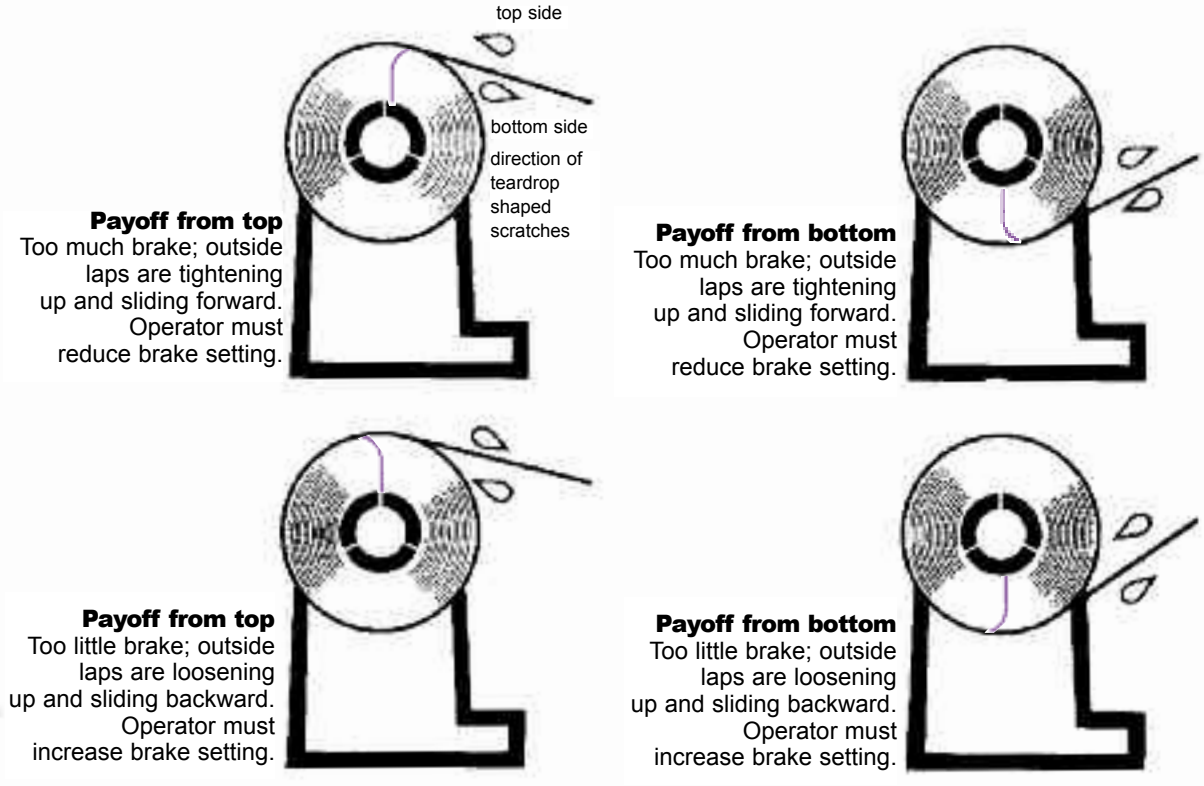


Figure 28

9. Processing

Aluminum coils and flat sheet can be processed using the same equipment as is used for other metals. However, to minimize surface damage and in-plant scrap during handling and processing there are precautions that should be taken. It is important, and in some cases mandatory, that the material identification is maintained throughout the processing steps to ensure traceability.

A. Equipment Cleanliness

Equipment cleanliness is a key factor in avoiding damage to aluminum sheet during processing. Cleanliness is especially important when process equipment is changed from other metal production to aluminum production. All parts of the process equipment (e.g., rolls and guides) that will contact the aluminum must be completely free of metal fines and particles. If not removed, these fines and particles can scar the aluminum surface. It is best to thoroughly clean all contact surfaces prior to processing aluminum and wipe down the contact surfaces periodically during operation.

All fixed surfaces that could contact the aluminum sheet should be covered with tape, or similar material, to prevent bottom side drag scratches. Conveyor belts should be cloth or rubber coated. Steel contact surfaces, such as guides, shear beds, etc., should be covered with nylon or a comparable material. It is recommended that the rolls in the line, except the work rolls, be covered with neoprene or an equivalent material. Steel rolls may be used if they are in good condition. The use of rubber or felt pads on the "V"-shaped portion of the coil car greatly reduces pressure and contact marks within the coil. All of these contact surfaces should be inspected to ensure debris does not imbed in them, creating an opportunity for surface damage.

B. Operating Practices

• **Sawing:** When sawing plate be sure to remove saw chips and cutting coolant-lubricant from the top and bottom surface before stacking the sawn plate on any surface. When sawing a number of plates simultaneously, it is important to separate the stack as soon as practical to allow for removal of saw chips that might have been entrapped. Coolant-lubricant must also be removed to prevent staining.

• **Uncoiling:** When uncoiling sheet, the unwind back tension or brake pressure should be less than the coil pressure or tension supplied by the mill if known. This can be determined and set by making a straight line mark on the edge of the coil from the OD to the ID. Observations then need to be made to ensure that the line stays straight. Should this line start to bend or develop an arc, it will be necessary to adjust the brake pressure or back tension. Neglect in following this procedure can result in creation of slip or tension scratches (See Figure 5.) The possible situations which could occur with a straight line marked coil are illustrated in Figure 28 To avoid slip scratches, follow the recommendations noted in Figure 28 for your particular situation. If unsure that the scratches are a result of incorrect brake pressure, check to see if the scratches are mirror image. If the scratches are mirror image, as shown in Figure 29, the distance from the nip to both scratches will be the same. Tight ID's should be maintained on the unwind, and the operator should ensure that if cores are used, core slippage does not occur. Forward rotation of the unwind as it is expanded in open ID's will tighten the inner wraps and minimize coil slippage.

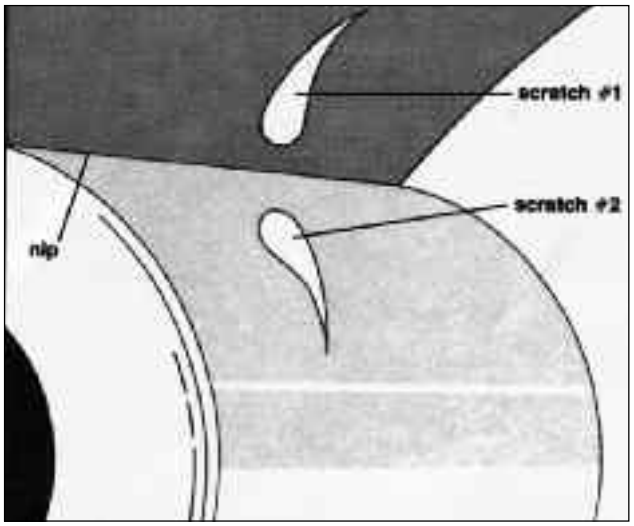


Figure 29 - Mirror Imaging of Scratches

• **Sheeting:** When cutting to length, the conveyor table speed should equal leveler speed to prevent the conveyor belt from scratching the bottom surface of the sheet. When slitting, it is essential that each cut have the same amount of rewind tension.

Stacking sheet at the end of a cut-to-length line requires attention to avoid scratching the metal. Air stackers are very effective in controlling the problem. Whether using an air box, mechanical arm, or manual stacking of the cut sheets, it is important to make sure there is no movement between the cut sheet and the one below it once contact between the two is made. The use of interleaving paper, strippable PVC, or oiling should be considered if the metal being stacked is soft and/or dry or for critical (appearance) surfaces. This will also minimize slip scratches and traffic abrasions.

10 References

Available from The Aluminum Association at www.aluminum.org .

- *Guidelines for Minimizing Water Staining of Aluminum*
- *Visual Quality Characteristics of Aluminum Sheet & Plate*

Code of Federal Regulations (CFR) — Occupational Safety & Health Standards
www.gpoaccess.gov/cfr/retrieve.html

- CFR 1910.132 PPE: General Requirements
- CFR 1910.133 PPE: Eye and Face Protection
- 29 CFR 1910.134 PPE: Respiratory Protection
- 29 CFR 1910.138 PPE: Hand Protection

Appendix 1: Suppliers of Safety Equipment & Apparel

Burlington Raeford
804 Green Valley Rd.
Greensboro, NC 27408
336-379-4864
www.burlington-raeford.com

Cintas Corporation
6800 Cintas Blvd.
PO Box 625737
Cincinnati, OH 45262-5737
(513) 459-1200
info@cintas.com
www.cintas.com

Cleyn & Tinker Inc.
5490 Thimens Blvd.
Suite 200
Ville St. Laurent, Quebec H4R 2K9
Canada
www.cleyn.com

Dupont Protective Apparel
1-800-931-3456
personalprotection@usa.dupont.com
www.dupontprotectiveapprl.com

Protective Apparel Team
140 Courtland Ave.
P.O.Box 4854
Syracuse, NY 13221
1-866-723-3212
1-866-964-3212 - Fax
sales@protectiveapparelteam.com
www.protectiveapparelteam.com

Silver Needle
6068 S. Sheridan
Tulsa, OK 74145
(918) 493-1136
(918) 493-1933 - Fax
www.thesilverneedle.com

Steel Grip, Inc.
700 Garfield St.
Danville, IL 61832
(800) 223-1595
(800) 270-0517 - Fax
www.steelgripinc.com

NOTE: The list in this appendix is included only as a convenience. No attempt has been made by The Aluminum Association to evaluate the effectiveness of the products, nor does listing here constitute an endorsement. The lists are not to be considered all-inclusive but do represent all such suppliers known to the Association at the time of publication of this document. Some of the companies listed have additional United States sales offices or outlets where the products can be purchased. Other suppliers will be added as they become known to us and will be included in republication of this document. The responsibility for the selection, determination of suitability, and proper use of the products is left to the user.

Appendix 2: Additional References for Aluminum

For additional information, the reader is referred to the following publications; published by The Aluminum Association, Inc., Arlington, VA:

- *Aluminum Standards and Data – U.S. and Metric editions*
- *Aluminum Design Manual*
- *Standards for Aluminum Sand and Permanent Mold Castings*
- *Welding Aluminum: Theory and Practice*
- *Aluminum Brazing Handbook*
- *Aluminum Soldering Handbook*
- *Forming and Machining Aluminum*
- *Guidelines for the Use of Aluminum with Food and Chemicals*
- *Aluminum Electrical Conductor Handbook*
- *International Alloy Designations and Chemical Composition Limits for Wrought Aluminum and Wrought Aluminum Alloys (Teal Sheets)*
- *Designations and Chemical Composition Limits for Aluminum Alloys in the Form of Castings and Ingot (Pink Sheets)*
- *Tempers For Aluminum And Aluminum Alloy Products (Yellow Sheets)*
- *Tempers For Aluminum And Aluminum Alloy Products — Metric (Tan Sheets)*
- *ANSI H35.1 – American National Standard Alloy and Temper Designation Systems for Aluminum*

Published Jointly by The Aluminum Association, Inc., Arlington, VA and TMS, Warrendale, PA

- *Aluminum: Technology, Applications, and Environment Sixth Edition,* Dietrich G. Altenpohl

Published by ASM International, Materials Park, Ohio

- *Aluminum: Properties and Physical Metallurgy*
- *Aluminum and Aluminum Alloys*
- *The Surface Treatment and Finishing of Aluminum and its Alloys — Metals Handbook Series*
- *Handbook of Corrosion Data*

Aluminum Casting Technology — Published by the American Foundrymen‘s Society

The Corrosion of Light Metals by H.P. Goddard, et al. Published by John Wiley and Sons, Inc., New York, NY

Handbook of Aluminum Bonding Technology and Data by J. Dean Manford Published by Marcel Dekker, Inc., New York, NY

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