PRESSURE-SENSITIVE TAPE CLOSURE SYSTEMS FOR USE WITH FACTORY-MADE AIR DUCTS – STANDARDS UL 181A AND UL 181B

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Introduction

Factory-produced air ducts that are intended for use in heating, ventilating and air-conditioning systems are evaluated in accordance with the Standard UL 181, entitled “Factory Made Air Ducts and Air Connectors.” The first edition of UL 181 was published in 1961 and included requirements for Rigid Fiberglass Duct Board air duct products. The second edition of UL 181 was published in 1967 and included requirements for Flexible air ducts. From the original publication until 1991, the joints and closure products used with UL-Listed factory-made air ducts were evaluated by UL in conjunction with the investigation of the specific air ducts being certified.

In 1991, UL published the first edition of Standard UL 181A, entitled, “Closure Systems for Use With Rigid Air Ducts and Air Connectors,” which originally addressed two types of closure systems: pressure-sensitive aluminum tapes and heat-activated aluminum tapes, both for use with rigid fiberglass air ducts. UL 181A was later revised to include requirements for mastic closure systems.

In 1995, UL published the first edition of Standard UL 181B, entitled, “Closure Systems for Use With Flexible Air Ducts and Air Connectors,” which addressed pressure-sensitive tapes for use with flexible ducts. This Standard was later revised to include requirements for mastic products.

UL performs third-party certification testing and Follow-Up Service for pressure-sensitive tapes in accordance with the Standards UL 181A and UL 181B. Pressure-sensitive tape products are eligible to bear the product UL Mark after successful evaluation by UL and the initiation of ongoing conformity assessment inspections at the manufacturer’s facility. The development of these Standards, performance requirements, submittal process for evaluation and marking requirements will be addressed in the following sections. UL will also provide an overview of other categories where pressure sensitive tapes are commonly evaluated by UL and will address some frequently asked questions (FAQs).

Development of Standards UL 181A and UL 181B

UL develops and maintains safety standards using a process that includes review by all interested parties. As part of this process, UL may establish ad hoc working groups that develop the initial drafts of Standards and address the public comments. Working groups were established on an ad hoc basis for the development of UL 181A and UL 181B, covering pressure-sensitive tapes.
Pressure-sensitive tapes for use with both rigid fiberglass air ducts and flexible air ducts were originally evaluated by UL in conjunction with specific air duct constructions. The complete evaluation of these tape products to UL 181 requirements was necessary if an air duct manufacturer were to recommend that particular product for closure of the Listed air ducts in the field. The evaluation of a tape product and the continued compliance with UL’s requirements during UL factory audit was the sole responsibility of the air duct manufacturers. However, this method of evaluation and factory audit ultimately led to some difficulties since air duct manufacturers did not control the tape construction nor its continued compliance. The tape samples also were not consistently available from the air duct manufacturers during factory audits. The earlier method of evaluation also led to some difficulties with the Authorities Having Jurisdiction (AHJ) since the tape products were not always marked to allow positive identification in the field.

UL 181A, Part 1 – Pressure-Sensitive Aluminum Tapes For Use With Rigid Fiberglass Air Ducts

In response to these concerns, UL worked with the rigid duct board organization identified as the North American Insulation Manufacturers Association (NAIMA), various tape manufacturers and other interested parties in the development of UL 181A, Part 1 – Pressure-Sensitive Aluminum Tapes For Use With Rigid Fiberglass Air Ducts. NAIMA proposed requirements for pressure-sensitive aluminum tapes that were to be used with rigid duct board products. The intent was to develop requirements that would equal or exceed the evaluation criteria of UL 181 for a pressure-sensitive tape’s usage with all UL-Listed rigid fiberglass duct board air ducts.

UL 181B, Part 1 – Pressure-Sensitive Tapes

During the development of UL 181B, Part 1 – Pressure-Sensitive Tapes (for use with flexible air ducts), UL responded to AHJ concerns regarding energy conservation issues. Officials from the state of Florida participated significantly as part of their work on the Florida Energy Code; they requested that requirements be developed that detail the criteria used to evaluate a tape’s ability to perform in the field. UL responded to this expressed need of the AHJs by convening an ad hoc committee consisting of representatives of UL, AHJs, the tape industry and the flexible air duct industry. The purpose of the ad hoc committee was to conduct testing and develop requirements for pressure-sensitive tapes for use with flexible air ducts and air connectors. The purpose of this testing was to 1) evaluate the proposed UL 181B test methodology, 2) assess the proposed requirements, and 3) compare the proposed test methods with those that had previously been applied under UL 181. As with UL 181A, the objective of this initiative was to develop requirements that would equal or exceed the evaluation criteria of UL 181 for a pressure-sensitive tape’s usage with all UL-Listed flexible air ducts.

Scope of the Requirements

Since we have outlined why and how these UL Standards were developed, we will look at the scope that defines UL Listings of these pressure-sensitive tapes.

Both rigid fiberglass duct board and flexible air ducts and their closure products are intended to be installed in accordance with the Standard for the Installation of Air-Conditioning and Ventilating Systems, NFPA 90A, and the Standard for the Installation of Warm-Air Heating and Air-Conditioning Systems, NFPA 90B; and/or Model codes. Additionally, pressure-sensitive tapes are intended to be installed expressly in the manner described by the accompanying air duct installation instructions. Since air ducts are UL Listed for indoor use only (unless specified), the scope of the Listing of the pressure-sensitive tapes are also for indoor use only.
During the development of the requirements, it was defined in UL 181B that pressure-sensitive tapes for flexible air ducts be used only at the core-to-fitting attachment and at the outer moisture barrier attachment. When used at the core-to-fitting attachment, a mechanical clamp is required to be installed at the joint. The tape must be employed at this location such that it does not disrupt the connection of the mechanical clamp. When tape is used at the outer moisture barrier, mechanical clamps may or may not be employed.

Performance Requirements

Pressure-sensitive tapes are subjected to a variety of performance requirements contained in UL181A and UL 181B. To understand the rationale for the Standards’ requirements, one must first examine the performance requirements of UL 181 for air ducts. The UL 181 performance requirements that may be applicable for an air duct incorporating a joint with pressure-sensitive tape are:

1. Flame Resistance Test
2. Mold Growth and Humidity Test
3. Temperature Test
4. Static Load Test
5. Impact Test
6. Pressure Test
7. Collapse Test
8. Tension Test
9. Torsion Test
10. Leakage Test

The objective of the Standards development process for UL 181A and UL 181B was to provide evaluation criteria that equals or exceeds that of the well-recognized requirements in UL 181 for an air duct joint. These requirements would be utilized in lieu of the UL 181 evaluation such that tape products successfully evaluated could be Listed and referenced for field use.

Performance Requirements, UL 181A, Part 1 – Pressure-Sensitive Aluminum Tapes For Use With Rigid Fiberglass Air Ducts

The following is an overview of the requirements in UL 181A for pressure-sensitive aluminum tapes for use with rigid fiberglass air ducts.

Material and Construction

The material and construction requirement for these tapes are that they be constructed of aluminum or aluminum alloy foil, minimum of 21/2 inches wide covered on one side with adhesive. A release liner protects the adhesive surface and is intended to be removed at the time of tape installation. These requirements were developed based upon the typical construction and minimum size of tapes that had been successfully used with flexible air ducts.

Tensile Strength Test

Pressure-sensitive aluminum tapes for this purpose are subjected to a Tensile Strength Test in both the machine and cross-machine directions. These requirements were established based on the structural examinations in UL 181 for rigid fiberglass duct board, i.e., the Pressure Test. The requirements also correlated to the tensile strength of pressure-sensitive aluminum tapes that had been successfully utilized with Listed rigid fiberglass duct board air ducts. The test methodology was based on the ASTM D3759 test method, Tensile Strength and Elongation of Pressure-Sensitive Tapes.
Peel Adhesion Test at 180-Degree Angle

To evaluate a tape’s basic peel characteristic, tapes are subjected to a Peel Adhesion Test at a 180-degree angle. This test was developed based on correlation to the peel values of pressure-sensitive aluminum tapes that had been successfully utilized with Listed rigid fiberglass duct board air ducts. The tape’s peel adhesion to stainless steel represented the most controlled and reproducible substrate for testing. The test methodology was based on the ASTM 3330 test method, Methods of Peel Adhesion of Pressure-Sensitive Tapes at 180-Degree Angle.

Shear Adhesion Test at 180-Degree Angle

Tapes are also subjected to a rigorous Shear Adhesion evaluation. This test method was based on the ASTM 3654, Standard Test Method for Holding Power of Pressure-Sensitive Tapes. These requirements were developed based on an analysis of anticipated application conditions and a correlation to the shear performance of pressure-sensitive aluminum tapes that had been successfully utilized with Listed rigid fiberglass duct board air ducts.

Peel Adhesion Test at 20-Degree Angle

Another peel evaluation is the Peel Adhesion Test at a 20-degree angle. This test is a combination of the Peel Adhesion Test, except for the angle of the test substrate, along with a holding power examination similar to the Shear Adhesion Test.

Surface Burning Characteristics Test

The Surface Burning Characteristics Test stems directly from UL 181 and NFPA 90A. The intent of this test is to verify that the burning characteristic of the tape as applied to the duct board complies with the basic same-surface burning requirement of UL 181. This test is a full-scale fire examination where a nominal 2 foot wide by 24 foot long sample of the duct board with the tape applied is positioned in a fire chamber. An ignition source is provided at the leading edge of the sample and observations are made as to the flame propagation distance versus time. These numbers are computed to determine a flame-spread index. In addition, recordings of the visual density of the smoke developed are used to determine a smoke-developed index value. This Standard requires a flame-spread index value of not more than 25 and a smoke-developed value of not more than 50. The test method is described in UL 723, Surface Burning Characteristics of Building Materials, and is similar to ASTM E-84.

Mold Growth and Humidity Test

This examination is consistent with the examination performed on air duct materials in UL 181. The intent of this test is to determine whether a tape is resistant to mold growth when exposed to the effects of high humidity and a mold source. Mold mycelia and spores from Chaetomium Globosium are applied to the adhesive side of the specimens. The samples are then placed in a closed vessel in which an atmosphere saturated with water vapor is maintained at room temperature under dark conditions. The specimen exposure lasts for 60 days.

Temperature/Pressure Cycling Test

This test was established based on its proven value during testing by manufacturers of rigid duct board while conducting research and development on air duct joints and materials. During this test, an actual sample of a duct is formed and the joint with aluminum tape shall maintain an applied pressure of 3 inches water column during certain temperature/pressure cycles. The temperature environment conditions are 165°F, 90°F at 90 percent relative humidity, and 0°F. The pressure fluctuates between 0.1 to 3 inches water column during the various temperature exposures. At the conclusion of each cycle phase, the leakage rate shall not exceed 15.0 cubic feet per minute while the pressure is maintained at 3
inches water column. Additionally, the tape shall not rupture, as evidenced by breaks, tears, rips or other openings greater than 1/8 inch, and the tape shall remain intact to the extent that it is not displaced more than a total of 1/8 inch from both edges.

**Burning Test**

Tapes are also subjected to a Burning Test. This test is based on the Burning Test of UL 181 whereby the tape as applied to duct board is subjected to a bunsen burner flame in the horizontal, 45-degree angle and vertical orientations. Observations are made as to burning duration time, flame propagation and evidence of dropping particles that could cause a fire.

**Performance Requirements, UL 181B, Part 1 – Pressure-Sensitive Tapes**

The following is an overview of the requirements in UL 181B for pressure-sensitive tapes for use with flexible air ducts.

**Material and Construction**

The construction requirement for these tapes are that they be constructed to be a minimum of 17/8 inches wide. This minimum requirement was developed based upon the typical construction and minimum size of tapes that had been successfully utilized with flexible air ducts.

**Tensile Strength Test**

Similar to the examination as with rigid duct board, pressure-sensitive tapes for this purpose undergo a Tensile Strength Test in both the machine and cross-machine directions. During the development of the requirements, consideration was given to the tape's associated unwinding force, the Tension Test of UL 181 and correlation testing that had been conducted on tapes of typical construction. Those tapes had been successfully utilized with Listed flexible air ducts and various air duct substrates. The test methodology was based on the ASTM D3759 test method, Tensile Strength and Elongation of Pressure-Sensitive Tapes.

**Peel Adhesion Test at 180-Degree Angle**

These tapes are also subjected to a Peel Adhesion Test at a 180-degree angle. The test was developed based on correlation to the peel values of pressure-sensitive aluminum tapes that had been successfully utilized with Listed rigid fiberglass duct board air ducts. The test methodology was based on the ASTM 3330 test method, Methods of Peel Adhesion of Pressure-Sensitive Tapes at 180-Degree Angle.

In addition to testing as applied to stainless steel, it was judged that peel adhesion also needed to be evaluated with the “worst-case” substrate. Review of the previous test data revealed that testing to the tape’s own backing was appropriate. This examination would represent the second wrap of tape that is typically required by the installation instructions of flexible duct manufacturers. It would prove consistent with the testing to the tape's own backing described in the peel adhesion method published by the Pressure Sensitive Tape Council.

**Shear Adhesion Test at 180-Degree Angle**

One of the more difficult examinations in this Standard is the Shear Adhesion Test. As in UL 181A, the test covers three different application scenarios. The first is the Shear at Room Temperature; the requirements and methodology were based on the UL 181 tension test and the requirements described by the "holding power" method published by the Pressure Sensitive Tape Council (PSTC). The 24-hour holding period and slippage requirements also stem from UL 181 tension test.
Another shear examination is intended to evaluate a tape's structural performance at elevated temperatures. The 150°F exposure temperature and hanging weight of a 100-gram weight was based on the method published by PPP-T-60. In addition, the 150°F correlates to the temperature experienced by a tape during the Temperature Test of UL 181. The 24-hour holding period and slippage requirements stem from the UL 181 tension test.

Lastly, is a shear test after a 60-day exposure to an elevated temperature of 150°F. Based on a review of field performance, the need to evaluate the tape's performance after extended exposure to elevated temperatures was examined. Ultimately, there was consensus that shear adhesion after exposure to 150°F for 60 days was appropriate. The 150°F and 60-day criteria is based on the Temperature Test of UL 181. The 1-pound load was selected based on half of the room temperature shear requirement, which correlates directly to the Tension Test of UL 181 as noted previously in this discussion. Again, the 24-hour holding period and slippage requirements for shear adhesion stem from the UL 181 tension test.

**Surface Burning Characteristics Test**

This examination for pressure-sensitive tapes for use with flexible ducts is the same as described in UL 181A except rather than evaluating the combination effects of tape as applied to the duct material substrates, the test is conducted with the tape applied to inorganic reinforced cement board. It was considered that since flexible ducts do not employ longitudinal joints, but only circumferential joints, there would not be continuous flame/smoke propagation, due to the interaction of materials, when subjected to this test. Consequently, it was determined that the test be conducted on the tape material only.

**Mold Growth and Humidity Test**

This examination is the same as the mold growth examination for UL 181A except the examination is conducted with mold mycelia and spores applied to both the film side and the adhesive side of the specimens.

**Temperature Test**

The Temperature Test stems from the High Temperature Test of UL 181 and is conducted on the following generic representative core substrates in order to evaluate a tape's compatibility with these materials: aluminum foil, polyethylene, polyethylene terephthalate and chlorinated polyethylene. This 60-day test examines a tape's resistance to the effects of high temperature. This test is based on the High Temperature Test portion of UL 181 in which the internal duct temperature during the test is 265°F and the external temperature is maintained at 125°F. The test temperature in UL 181B is 212°F and is representative of the temperature experienced by a tape used at the core of an air duct.

**Submittal Process for UL Certification of Tape Products**

We have discussed why the Standards were developed, how they were developed and the requirements contained in them, now the real work begins – getting tape products UL Listed. This section will provide an overview of the UL Listing process.
Initial Step

Manufacturers contact UL to request an investigation of their product(s) to the applicable Standards. They provide a disclosure of materials and manufacturing processes so that UL can develop an evaluation program. All information relating to product submittals is considered proprietary information and held strictly confidential. Once the evaluation program is developed, UL staff communicates the evaluation program to the submitter along with the samples required.

Witnessing Production of Test Samples

The next step is for UL staff to witness production of the test samples to be submitted for test. This is necessary for the documentation of materials, processes and factory quality identification tests that will be key to the establishment of requirements in UL’s continued factory audit program called Follow-Up Services. Attention is given to all aspects of the manufacture of the products and representative sampling of production runs. The witnessed samples are identified and shipped to UL.

Testing

When UL receives the test samples, we proceed to conduct the testing. In addition to the tests required by the Standard, UL also conducts certain identification tests, such as a qualitative infrared analysis and percent solids on adhesives, whose results will be specified in the Follow-Up Services audit document.

Reporting and Publishing the Listing

When UL completes the Listing process, UL issues a report of the results and, if successful results are obtained during testing, UL develops the ongoing factory audit document called the “Follow-Up Service Procedure.” The Listing is considered published and Listing information is released for publication in the Heating, Cooling, Ventilating and Cooking Equipment Directory as well as placed on UL’s Web site: www.ul.com. The pressure-sensitive tapes are now eligible to bear the UL Mark.

Follow-Up Service

The Follow-Up Service procedure is used on an ongoing basis by the UL representatives in the local area who conducts unannounced visits to the manufacturing facility. The UL representative’s audits are a counter check that the products bearing the UL Mark are being produced in accordance with UL’s requirements and as originally tested.

Markings

All pressure-sensitive tapes Listed for use with rigid fiberglass and flexible air ducts are identified by the UL Listing Mark together with other specific marking information.

Tapes Listed under UL 181A are marked every 36 inches or fraction thereof, with the following information: the manufacturer or private labeler’s name or identifying symbol, the distinctive type or model designation, the date of manufacture (which may be in an established code), and the marking “181A–P.” Additionally, if a manufacturer produces aluminum tape at more than one factory, each roll of tape shall have a distinctive marking to identify it as the product of a particular factory.

Tapes Listed under UL 181B are marked every 6 inches or fraction thereof, with the following information: the manufacturer or private labeler’s name or identifying symbol, the distinctive type or model designation, the manufacturing location, if the manufacturer produces pressure-sensitive tape at more than one factory, and the marking “181B–FX.”
The UL Listing Mark on the product is the only method provided by UL to identify products manufactured under its Listing and Follow-Up Service. The UL Listing Mark for these products includes the UL symbol, together with the word "LISTED," control number and the appropriate product designation.

This marking arrangement as shown in the table below allows tapes and mastic products to be positively identified in the field. In addition, air duct manufacturers can reference the use of the various UL Listed 181A or 181B closure systems for use with their duct.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Part Number</th>
<th>What Product Is Covered</th>
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<td>UL 181B</td>
<td>II</td>
<td>Mastic Closure Systems For Use With Flexible Ducts</td>
<td>181B-M</td>
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Other Pressure-Sensitive Tape Products Evaluated by UL

General Use Tapes

This category covers general use tapes, which are intended to be used as building materials. Since this product type is the same as those Listed under UL 181A or UL 181B, there may be some confusion between the two categories. Products covered under this category are Classified as to their Surface Burning characteristics only. The tapes undergo the same Surface Burning characteristics evaluation discussed earlier in accordance with UL 723, "Test for Surface Burning Characteristics of Building Materials." The products are Classified as to surface burning characteristics when applied to uncoated, high density (nominal 110 pcf), 1/4 inch thick inorganic reinforced cement board with flame spread and smoke-developed values of 0 in longitudinal strips at the specific percentages of exposed area shown in the individual Classifications. The toxicity of the products of combustion and other properties have not been investigated. The Classifications are confined to the materials themselves and do not pertain to the structures in which the materials may be installed.

These products are Classified since they address a specific hazard only. Inasmuch, the UL Classified symbol on the product and Classification Marking of Underwriters Laboratories Inc. on the smallest unit container in which the product is packaged is the only method provided by UL to identify products produced under its Classification and Follow-Up Service. The UL Classification Marking
includes the UL symbol; the word “CLASSIFIED” above the UL symbol; the product identity; “AS TO SURFACE BURNING CHARACTERISTICS ONLY”; and a control number.

**Insulating Tape**

A different type of pressure-sensitive tape is the product affectionately known as “electrical tape.” These are rubber insulating tapes for insulating joints and splices in electrical conductors where an outer covering of protective material, such as friction tape, is to be applied over the insulating tape. This listing also covers thermoplastic tapes for use as the sole insulation and covering of joints and splices in electrical conductors.

These tapes are suitable for use on insulated conductors at temperatures not exceeding 80°C (176°F), and, if so designated and marked, meet the following special requirements:

- ♦ Flame Retardant - Indicates that an insulating tape complies with the requirements for flame retardancy;
- ♦ Cold Resistant - Indicates that an insulating tape may be used to insulate splices while subjected to temperatures down to -10°C; and
- ♦ Weather Resistant - Indicates that an insulating tape is suitable for exposed outdoor use.

The Standard used to investigate products in this category is UL 510, entitled, “Insulating Tape.” These products are identified by the Listing Mark on the tape or the UL symbol on the product and the Listing Mark of UL on the smallest unit container. The product name that appears on the product is: “Insulating Tape,” “Insul. Tape,” “Electrical Tape,” “Elec. Tape,” “Electrical Insulating Tape,” “Elect. Insul. Tape” or other appropriate product name.

**Frequently Asked Questions**

The following are a few frequently asked questions that UL has received with respect to pressure-sensitive tapes, and the terms of their UL Listing.

**Are Pressure-Sensitive Tapes Listed For Use With Sheet Metal Ducts?**

Pressure-sensitive tapes are not Listed for use with sheet metal ducts. As defined by the scope of both UL 181A and UL 181B, neither of these documents addresses the use of pressure-sensitive tapes for use with non-Listed sheet metal ducts. In the absence of data developed from testing sheet metal duct joint constructions with pressure-sensitive tapes, there may be performance characteristics for the sealing of sheet metal duct that are not currently addressed by Standards UL 181A or UL 181B, i.e., aging, leakage, etc.

UL has explored the topic of pressure-sensitive tapes for use with sheet metal duct with specific groups in view of code documents that reference the sealing of all ductwork systems. It is clear that the tape products under UL 181A and UL 181B satisfy this need for UL-Listed rigid fibrous glass and non-metallic flexible ducts. However, there appears to be fairly widespread uncertainty as to what certifications, if any, would be required for products used to seal sheet metal air duct.
How Can One Find Out Who Is Listed?

This information, complete and current, is just a click away. UL has launched our UL Online Certifications Directory, which is accessible through our Web site www.ul.com. Listings can be searched through company name, file number or using the category control code, ALKW. Using the category control code will display all manufacturers currently Listed in the category. In addition, Listings can also be found in UL’s Heating, Cooling, Ventilating and Cooking Equipment Directory.

Can Listed 181B-FX Tapes Be Used Without Clamps?

181B-FX products used in the field with flexible non-metallic ducts are intended to be used with a mechanical fastener (clamps) of the type that has already been evaluated to the requirements of UL 181 at the core-to-fitting attachments. Clamp usage plays a major role in the acceptable performance of a UL-Listed air duct construction. Clamp use is not only required as part of the UL Certification of air ducts but is also prevalent throughout installation standards (i.e. Air Diffusion Council). Also, the Codes require the air ducts and joints to be installed in accordance with the Listing and accompanying installation instructions. Therefore, the clamps are an integral part of the air duct system construction.

Who Requires The Use Of Listed Tapes?

One may ask how Listed tapes are regulated, understanding now the efforts that have gone into the Standards development and the manufacturer obtaining a Listed product. UL 181 requires that installation instructions of UL-Listed duct materials reference the use of Listed product on their installation instructions. Most major codes require the air ducts and joints to be installed in accordance with the Listing and accompanying installation instructions. Moreover, several major codes such as the International Residential Code, International Mechanical Code and International Energy Code have been revised to directly reference the use of Listed closure systems during the installation of air ducts.

Summary

In summary, UL values the cooperation and contributions by the Pressure Sensitive Tape Council, product users and Authorities Having Jurisdiction to develop and maintain the safety requirements for pressure-sensitive tapes.