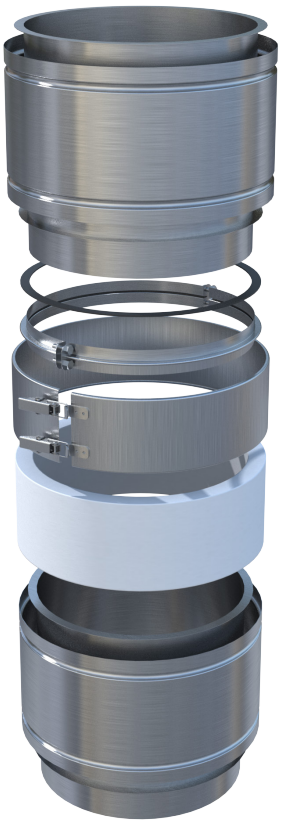
ENERVEX®
VENTING DESIGN SOLUTIONS

Technical Brief

WHY ARE SO MANY LISTED CHIMNEYS LEAKING?

The surprising truth about testing standards for chimney joint sealants (and what to do about it)



Did you know,

Metal-based Special Gas Vent is tested for **180 days** *to prove corrosion resistance.*

3 hours *of testing is what a Special Gas Vent seal must endure to show leak resistance.*

Even if a product is **listed**, *it can start leaking within a year from first use.*

Yet, Silicone and Ceramic Cement are still used in most applications.

This is changing.

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WHY IS MY CHIMNEY LEAKING?

Introduction

This may surprise you, but most chimneys on the market are leaking. Fact.

Even if your chimney is listed (UL, Intertek etc.), there's a very good chance that it is leaking not only condensation but also dangerous flue gases where people live and breathe every day. If the joint/sealant product was listed and recommended by the manufacturer, why is this happening? And what can you do to prevent it?

A leaking double-wall Special Gas Vent. Localised corrosion leading to perforation of the outer jacket.

Not All Sealants Are the Same

First, let's note that there are many different ways to seal chimneys for boilers and generator exhaust systems. The most common are Silicone, Ceramic Cement, and Viton depending on the specific application. Some have a higher initial cost than others; some have a better track record.

A leaking single-wall Special Gas Vent. The leaking condensate creates an ever-growing paste around the joint.

Because of this, many engineers just go with the chimney manufacturer's recommendation; after all, the product is listed. It was tested, met all of the standards, and is (theoretically) warranted against leakage for one year. Seems like a no-brainer.

But there's more to it than just sealants.

Let's go deeper to get the real story.

LEAKAGE AND TEST STANDARDS

Why Chimneys Leak

UL Standards establish allowable leakage rates for all chimney types.

It's just that some chimneys end up leaking more than what's acceptable after installation.

When an engineer specifies a chimney pipe with a sealant for condensing boilers, the contractor often gets called back after the one-year warranty expires for costly problems such as liquid dripping from the joints. He goes back to the manufacturer for help, but there's no more warranty coverage. Now what?

Similarly, contractors are using Ceramic Cement as specified by the stack manufacturer for sealing their generator exhaust system. The product checks out during periodic testing within the first year; but then in the second year hairline cracks appear. With the expansion and contraction caused when the generator kicks on and off, carbon monoxide (CO) starts seeping into the building. It happens more than you think, causing huge liability and financial risk to the contractor and the specifying engineer.

> *If the products are listed, how can a material pass a test and then one year later, start leaking?*

And don't under-estimate the human aspect. A sealed chimney system's weakest point is possibly the person installing.

Chimneys leak because the testing standards for condensing chimneys and pressure stacks are outdated or important factors are ignored.

In certain instances, these standards do not protect you.

Outdated Testing Standards?

There are three specific chimney standards that include leakage testing and pressure ratings - UL103 and UL2561 for Category III and UL1738 for Category II, III and IV appliances.

One issue is that the test standards concentrate on testing for positive pressure applications, while ignoring testing for negative pressure applications. Testing under negative pressure is not part of any of the standards. Yet there are examples of Category III flue collapsing into itself after just a few years of use because it was not designed to operate in a negative condition.

Further, there is a dramatic increase in the application of mechanical draft systems, making it more necessary to pay attention to the effects of negative pressure chimneys in the testing and listing process.

Finally, there are distinct differences in the testing of chimney material and the testing of the joint (or sealing) method. Some of these standards are over 20 years old, and have not kept up with real-life situations for various reasons.

Take UL1738, for example. In UL1738, the metal undergoes a 10,000-cycle corrosion test where it is exposed to a corrosive condensate mixture. So, it takes six months to simulate a real situation and prove resistance against pitting. But when testing a joint sealant such as Silicone, the sealed joint is exposed to a slight positive pressure of minimum 1.25"WC (the manufacturer can use any pressure above 1.25"WC), then to a temperature of 70°F above rated temperature for three hours. If the sealant does not crack, soften, melt or show other evidence of deterioration, it passes.

Is a three-hour test really a valid way of assessing the resiliency of the sealing method?

LEAKAGE RATE TESTING

From a corrosion standpoint, the test must prove the chimney will not experience corrosion penetration for the equivalent of 300 years of use, but there are no such requirements for the sealant. (see UL1738, 3rd Ed. Section 34)

The Reality: The sealant is clearly the weakest link for a potential leak. As time goes on, the Silicone deteriorates at a different rate from the metal, causing leaks. The silicone flapper valve found in most toilets serves as a good example.

Most sealants used are based on Silicone Rubber, which can be used for temperatures up to 500°F when exposed to air.

Problem: In most chimney applications, it is not exposed to air! In a sealed condition it softens as it deteriorates and the life is shorter than it is in air. An alternative material such as Viton is not faring any better. According to DuPont (the manufacturer), the high-temperature service limits are generally considered to be:

- 3,000 hours at 450°F (232°C)
- 1,000 hours at 500° (260°C)
- 240 hours at 550°F (288°C)

As the UL1738 temperature rating is max. 550°F, a chimney with a Viton gasket is scheduled to last only 240 hours. The failure will show as leakage.

> *How can a chimney have a temperature rating of 550°F when the sealant only lasts 240 hours at this temperature?*

There are similar flaws in the testing of sealants for pressure stack applications. We test whether the high-temperature cement will expand at the same rate as the metal, thereby reducing the risk of leakage. However, this must be proven whether the chimney is heated and cooled one time or 3,000 times – something the test standard does not require.

And don't expose Ceramic Cement to water. It's water soluble! I can't handle condensate.

The Reality: Hairline cracks WILL develop in most Ceramic Cement seals, and the chimney will not remain pressure tight. Flue gases, water and CO can and will eventually leak out.

What's in a Leakage Test?

Leakage testing is an important part of UL standards covering positive pressure chimneys.

Surprisingly, the UL103 and UL1738 standards that both cover Category III appliances have different test protocols.

In UL103 and UL2561, a chimney sample with 10-12 joints or more is exposed to 60"WC, then to 4 hours of Thermal Shock at a temperature of 1700°F and finally pressurized to 60"WC and the leakage measured. It cannot exceed 50 PPM.

In UL1738, the test sample is 8 feet long and has 3 joints. It is pressurized to 0.5"WC at ambient temperature air. The pressure must be maintained for 1 hour. Leakage cannot exceed the equivalent of 0.049 PPM.

The Reality: The two standards are clearly not in sync. The major differences in testing are the number of joints in the test setup, the pressure it is exposed to, and the pre-testing taking place before the pressure test.

If the permissible leakage rate for UL1738 was calculated per the UL103 standard, it would increase to 0.783 PPM - an almost 20-fold increase!

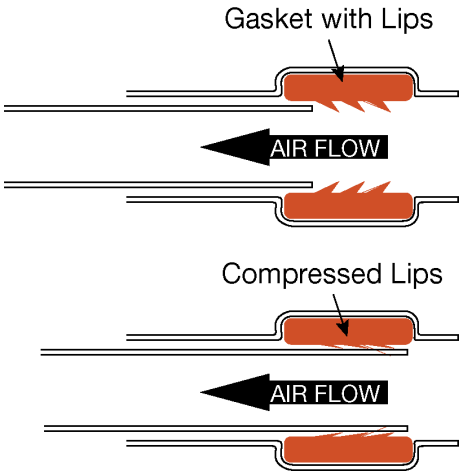
But what about leakage under negative pressure?

CLEANING? CURING?

The standards seem to assume that when a chimney can handle a certain amount of positive pressure, then it can handle negative pressure as well.

That is not always the case.

Several UL1738 listed chimneys use a seal or gasket that is directional. A compressed double-lip or triple lip directional gasket may offer protection against some positive pressure.



But when the pressure is reversed, the lips will offer less resistance. They are not designed to keep the chimney under negative pressure and can't necessarily prevent air-infiltration.

This can lead to major draft problems.

Leakage Caused by Improper Installation

It's no secret that improper installation is one of the most common causes of leakage.

Flanged chimneys are assembled with an Assembly Band (V-Band). To seal the joint, all flanges and the band itself must be properly cleaned before Silicone or Ceramic Cement is applied into the V-groove and properly cured.

Cleaned? Cured? Is this actually happening?

"Clean flanges with an appropriate organic solvent, such as acetone, MEK, or other commercial degreaser. Clean the inside V-groove of the Assembly Band.

After joining the flanges together, a layer of sealant is applied inside the V-groove of the Assembly Band prior to its installation over the joint."

> *When was the last time an installer cleaned the flanges and the V-groove before installation?*

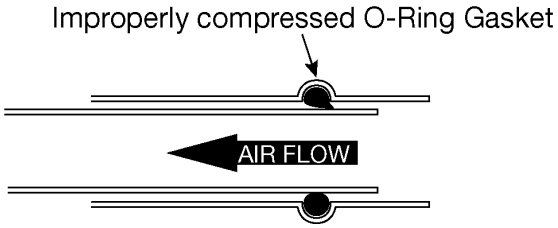
Greasy flanges and V-grooves or incorrectly applied sealant prevent the V-Band from creating a proper seal. This leads to leakage, just as not following proper curing instructions does.

And what about the sealant?

"Part No. [Ceramic Cement]: a high-temperature pre-mixed sealant for flue gas temperature up to 2000°F. [Ceramic Cement] IS WATER SOLUBLE AND SHOULD NOT BE USED WHERE EXPOSED TO WEATHER".

A joint with hairline cracks will start to leak and the leakage will only get worse as the Ceramic Cement is being "washed away".

And then there are the installation errors that remain hidden.



BE AWARE OF THE WEAKEST LINK

The Weakest Link

The pressure rating of most chimneys and special gas vents is often overstated.

According to the UL1738 standard, special gas vent joints must be able to withstand, without rupture, an internal air pressure of 2 ½ times the manufacturer's rated positive pressure, but not less than 1.25"WC. In other words, a vent with a manufacturer rating of 2"WC must be able to withstand an internal pressure of 5"WC during testing – but the rating remains 2"WC.

It is not unusual to read phrases like "Evaluated by UL and confirmed suitable for positive internal static pressures up to 8" WC", or "Confirmed for positive pressure of 6"WC". Words such as "evaluated", "confirmed", etc. do NOT have the same meaning as "rated" or "listed".

Published pressure ratings normally do not apply to Adjustable and Variable Lengths. Some of the statements appearing in installation manuals for UL103/UL2561 and UL1738 chimneys are:

"The Adjustable Length may be used when pressures do not exceed 6"WC"

"Gasket is factory installed to provide a maximum of 0.8"WC positive pressure capability"

"The Adjustable Lengths with Gaskets are limited to natural/propane gas and 400°F maximum continuous internal operating temperatures"

"The system operating pressure of 60"WC (2.08 psi) is based on the estimated capability of ceramic sealed V- Band joints."

Pay attention to the word "estimated". This all depends on the installer.

The Reality: When Adjustable or Variable Length sections are installed with a listed chimney rating of 60"WC, the actual pressure rating is substantially smaller and usually not more than 6"WC.

Some test laboratories, such as UL, now require manufacturers to add the following statement to parts shown in installation manuals that are not part of the listing:

"At present (year), Underwriters Laboratories (UL) has no Safety Standards for these devices, so although they are shown in this document and condoned by (manufacturer) and others, UL has not independently investigated this product."

> *When an Adjustable or Variable section rated at 6"WC is installed in a 60"WC listed chimney, the chimney pressure rating is 6"WC.*

In conclusion, there is no specific Safety Standard for Adjustable and Variable Lengths. These parts must be tested as regular stack sections.

Most engineers have not been made aware that Adjustable and Variable Length sections ARE NOT LISTED.

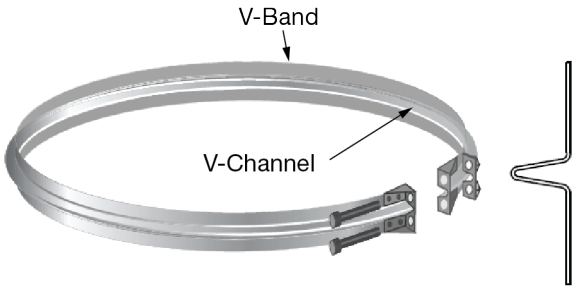
The "weakest link" determines adaptability.

IT'S ALL ABOUT THE JOINT

Joint Design Flaws

Most chimneys designed for UL103/UL2561 applications use a flange joint secured with a V-Band. Some UL1738 special gas vents use a similar joint.

This illustration shows a typical V-Band



At low temperatures, as can be seen in illustration below, the V-Channel of the V-Band is offering point contact with the edge of the flange and clamping it tight. It's noticeable that only the edge of the flange is in point contact with the V-Channel. When the V-Band is pulled tight, it forms a wedge into the V-Channel. This action instantly stresses the V-Channel by the function of the wedge, while prohibiting the expansion of the joint.

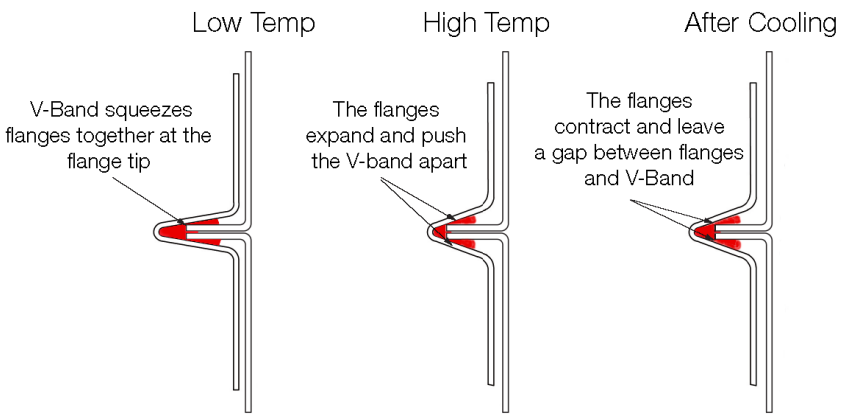
When the joint is subjected to high temperatures, both lateral expansion of the flange and radial/hoop expansion of the flanged inner liner, forces the flange edge into the V-Channel. This forces the V-Channel to open by the expansion of the flange against the profile, effectively acting as a wedge.

On cooling, the deformed V-Channel retains its shape while both the flange and inner liner contract back to its original position. The deformation of the V-Channel remains permanent and does not recover, loosening the mechanical clamp, resulting in loss of pressure integrity.

In trials undertaken during testing, the existing traditional V-Band design loosened to such a degree that the tightness of the joint was compromised, resulting in the leakage and pressure integrity reducing significantly, to the point where it could possibly fail the leakage requirements of UL103, if re-tested.

Under examination the V-Channel opened up by approximately 0.04" to 0.1" (1-2mm).

The Reality: The V-Band design can cause hairline cracking and thus possible leakage.



JOINT LEAKAGES

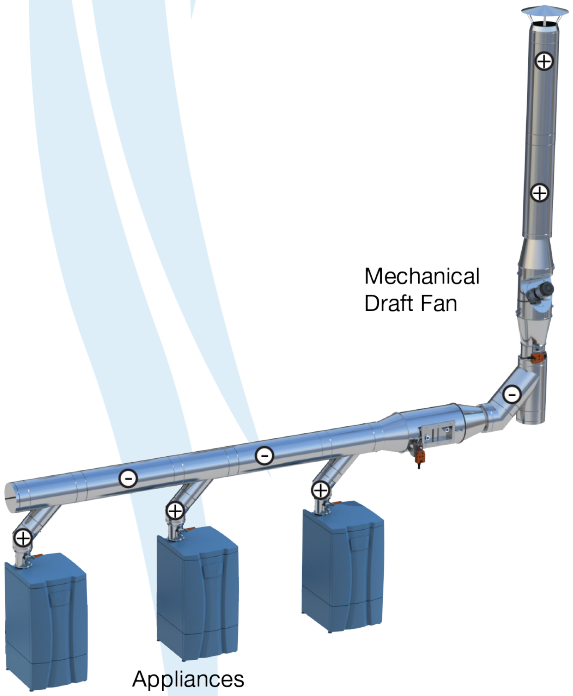
Mechanical Draft Leakage

An increasing number of Category III and IV appliances use mechanical draft systems.

Category IV boilers must comply with ANSI 21.13. When they are used in commonly vented (cascade) systems, proper draft must be demonstrated under all load conditions in order to obtain a high-efficiency rating.

Depending on the type of mechanical draft fan used, both positive and negative pressures will be present. The appliance connector will always be positive, while the common vent will be neutral or negative.

Conversely, lengthier flue runs will necessarily result in higher fan suction (negative) pressures to offset the flue pressure losses.



It is not unusual to have a draft fan capable of handling up to 6"WC of pressure, so it is important that the chimney system can handle that.

It is of utmost importance to consider draft fan capacity when selecting a proper venting system - not just the duty point, but the maximum fan capacity.

During certain operating conditions and during blocked flue conditions, substantial internal positive pressure can develop and cause potential leakage, unless the venting system is rated for such pressure.

At the same time substantial negative pressure can be created upstream from the draft fan. It can be so strong that outside air is pulled into the chimney through the seal.

Mechanical draft leakage is common, when the chimney seals are double-lipped or triple-lipped directional, so they don't seal against negative pressure.

Mechanical draft leakage is also more likely in chimneys assembled with V-Bands, where the V-bands' expansion and contraction cause hairline cracks in the Ceramic Cement seal.

CUTTING-EDGE JOINT TECHNOLOGY

A Cure for Leakage

Not many materials have proven to stand the test of time, except for graphite. Some of the main properties of graphite are:

- Soft and flexible
- Long-term stability
- Very suitable for high temperatures
- No ageing
- Nearly impermeable to gases and liquids
- Inert
- Excellent resistance to thermal shock

Adding a thin stainless steel foil between two thin layers of graphite makes the chimney seal even more impressive. A 0.08" thick gasket can operate in temperatures from -328°F to +1832°F and in positive pressures up to 2,000 psi!

By design, graphite gaskets provides the best protection against both gas and liquid leakage. They are designed for extremely high temperatures and pressures, and are immune to breakdown by acidic condensate. Graphite gaskets have a long, proven track record engine gaskets and other gaskets used in high-pressure/high-temperature applications.

In February of 2014, ENERVEX partnered with Underwriters' Laboratories to officially test the leakage rate of graphite gaskets used in the EPS PowerStack against those of UL-Listed, and commonly used, Silicone and Ceramic Cement sealants.

The graphite gaskets had already been field tested for several years before submitting it to UL - with excellent results.

Prior to the testing it was ensured that the joints were made perfectly when it came to the Silicone sealant and the Ceramic Cement and secured with a standard

A typical test setup for leakage testing under UL103 and UL 2561 Standards.

V-Band. The curing was done under perfect conditions, where the curing requirements were strictly followed. This is not necessarily what happens in real-life installations.

After the Silicone and Ceramic Cement tests, the same chimney type with 1/2" flanges and self-centering male/female joints was prepared for the graphite gasket testing.

The results speak for themselves!

CUTTING-EDGE JOINT TECHNOLOGY

The graphite gasket reduced the leakage rate by 86 percent in cold conditions and 82 percent during 60"WC positive pressure after 1400°F conditions compared to Ceramic Cement.

UL 2561: Sec 19	Graphite	Cement
TEST	Leakage Rate (ppm)	
At Ambient Temperature	0.481	3.536
After 1400°F Temperature	3.895	21.391

When compared to Silicone the graphite gasket reduced the leakage rate by 67 percent at 5"WC at 550°F.

UL 1738/ULC-S636	Graphite	Silicone
TEST	Leakage Rate PPM	
At 70°F Temperature	0.0122	0.0367

Graphite is clearly vastly superior over Silicone and Ceramic Cement.

But the above results can't be contributed to the graphite gasket only. Equally important is the joint assembly.

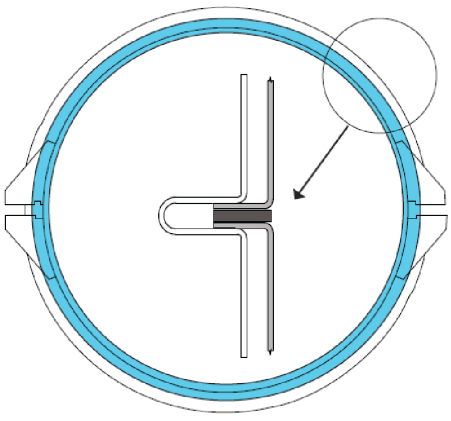
The graphite gasket is bonded to the 1/2" flange on the male end protecting it from damage and eliminating the need for a sealant. The state-of-the-art U-Band compresses the graphite gasket by putting tension on the sides of the flange rather than the edges like a V-Band, perfectly sealing the joint.

The illustration below shows the thermal expansion of the flanged inner liner of the chimney product from ambient to hot conditions.

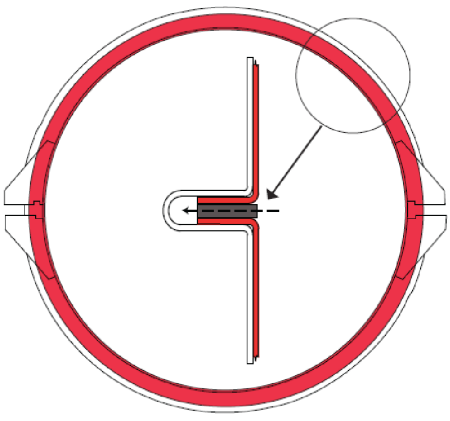
The expansion is taken up within the U-Channel without any deformation occurring either to the flange or the U-Band. When the heat is removed, the flanged inner liner contracts within the U-Channel back to its ambient condition.

Although the design of the U-Channel profile is critical, equally important is the allowance for maximum expansion within the floating clamp arrangement to allow all expansion to be taken up by the U-Band without exerting any additional forces on the U-Band, flange or gasket.

Ambient

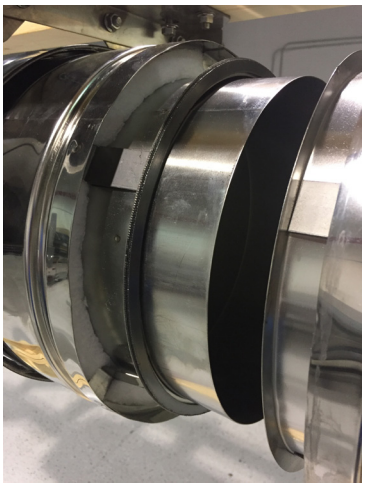


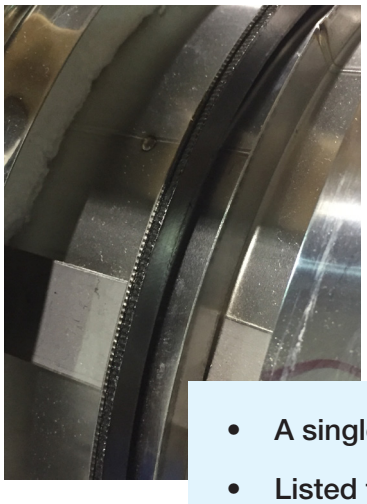
High Temperature

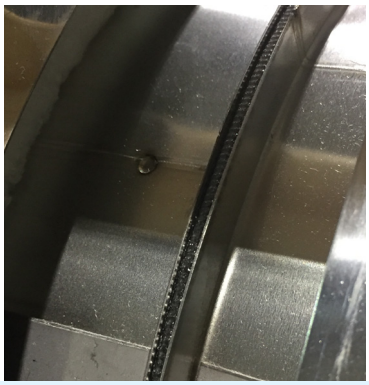


ENERVEX®
VENTING DESIGN SOLUTIONS

THE CASE FOR A STATE-OF-THE-ART CHIMNEY SYSTEM







ENERVEX PowerStack is a "state-of-the-art" chimney system with a cutting-edge joint design (Patent Pending).

PowerStack is the industry's only TRUE positive and negative pressure chimney system, where all components, including Adjustable Lengths, are tested and UL-listed to 60"WC of pressure and 1400°F.

It carries a UL and ULC listing for virtually all chimney applications. All accessories such as Balancing Baffles, Automatic Dampers, Over-Draft Dampers, Mechanical Draft Fans, etc. are UL listed to 1400°F for condensing and non-condensing applications.

The PowerStack offers the engineer and contractors maximum protection against performance and liability problems associated with condensate and flue gas leakage.

Powerstack is the industry's only COMPLETE UL-listed chimney system

- A single chimney for all applications
- Listed to UL103, UL1738, UL1777, UL1978, UL2561, ULC S635, ULC S636, ULC S662, ULC/ORD C959
- Insignificant leakage
- No messy sealants
- No cleaning prior to installation
- Zero curing
- No hairline cracking
- Resistant to extremely high pressures and temperatures
- Immune to breakdown by acidic condensate
- 60"WC pressure rating for ALL PARTS and ALL chimney applications - condensing and non-condensing
- Substantially faster and more accurate installation
- Lower installed cost
- 5-Year Leakage Warranty and Performance Guarantee

A UL103 or UL1738 listing is no guarantee for a leakage-free chimney. The specifyer must specify a desired joint assembly method along with temperature and pressure ratings.

"We notice exhaust gas smell every time we test fire the emergency generators. This occurs on several installations. We assume this is due to installer errors"

Engineer at Atlanta engineering firm

"Most 5-year old installations that we visit are leaking condensate."

President, chimney installer

"When an adjustable or variable section rated at 6"WC of pressure is installed in a UL-listed 60"WC chimney, the chimney pressure rating is 6"WC - and not 60"WC!"

Industry Expert

ENERVEX combines quality components, superior technology and experienced personnel to deliver a system that is economical, environmentally sustainable, aesthetically pleasing and reliable. In addition, our custom engineering and space saving design ensure that the project meets code requirements, as well as the high standards of today's builders.

FOR MORE INFORMATION. JUST CALL US.

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