Utilicor™
TECHNOLOGIES INC.

Utilibond™

Permanent Pavement Bonding Compound

Reference Manual

Version 2.0

The cutting edge in keyhole technologies™

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Utilibond™ is the only specially formulated and engineered bonding compound designed to be used to permanently reinstate pavement cores in asphalt and concrete roads, sidewalks and other paved surfaces that has been mandated by DOT's for use in some jurisdictions.

Utilibond™ is a multi-component, super-plasticized, cementitious compound specifically engineered and designed for bonding concrete and asphalt cores back into the road or sidewalk.

Unlike typical "grouts" which are moderate strength fillers used for filling cavities, voids and cracks that have little or no bonding ability, **Utilibond™** contains special additives designed to enhance the bonding performance of Portland cement-based materials.

This unique blend of components results in high cohesive strength, through high density and low water absorption, and improves the mechanical performance, workability, adhesion and resistance to harsh environmental exposures of the product such as freeze-thaw scaling.

A ready-to-use (just add water), fast-setting, high-strength waterproof bonding agent, **Utilibond™** is non-toxic and comes in two colors (**Aged Asphalt and Natural Concrete**) and has full strength gain in just 30 minutes at 70°F.

FEATURES:

- **Specially Designed for Keyhole Core Reinstatements**
- **Super Strong Bond Strength: 50,000 lbs.**
- **Exceeds AASHTO H-25 and ASTM 928 Standards**
- **Gains full Strength in Just 30 Minutes**
- **Creates a Waterproof Joint**
- **Excellent Freeze-Thaw Resistance**
- **Field-Proven 20 years – ZERO Failures**
- **2 years Shelf Life**

DOT Approved and Tested by:

- **US Army Corps of Engineers**
- **National Research Council of Canada**
- **Dept. Engineering, University of Illinois Urbana Champaign**
- **AASHTO Approved Testing Laboratory**

Colors: Aged Asphalt (UB-AA), with a black lid, is designed to more closely match the color of an asphalt surfaced roadway, and Natural Concrete (UB-NC), with a white lid, is designed to closely match concrete surfaced roadways and sidewalks.

Sizes: Utilibond™ is packaged in an air-tight plastic pail that weighs 44 lb. (20 kg) and contains two plastic lined bags of the Utilibond™ powder — a "Twin Pack" — each weighing 22 lb (10 kg) that can be mixed separately or together to give the worker the flexibility to use just the right amount of Utilibond™ according to the depth and diameter of core being reinstated.

Shipping: Utilibond™ comes packaged in skid lots of 48 pails. Smaller quantities are available as required. Utilibond™ can be purchased through one of Utilicor's authorized distributors, or directly from Utilicor.

Storage: Utilibond™ has a shelf life of at least 2 years from the date of manufacture. Utilibond™ should be stored out of direct sunlight, like under tarpaulin, as ultraviolet rays can deteriorate the plastic pails. Storage can be either inside or outside. Freezing temperatures do not affect Utilibond™.

UTILICOR TECHNOLOGIES INC. is the exclusive manufacturer and distributor of the field-proven, keyhole pavement coring and reinstatement system, used by more than 30 major gas utilities and dozens of contractors in the United States, Canada, the United Kingdom, France and Australia.

The Utilicor process combines a purpose-built, field-proven Truck - Trailer - Skid Steer mounted coring units, with ***Utilibond***™ , it's proprietary core bonding compound, which has been specifically developed for the permanent reinstatement of cored pavement coupons in all types of paved roads and sidewalks.

Utilicor Technologies Inc. is also the world leader in providing the equipment necessary for the proper implementation of the keyhole coring and reinstatement process for natural gas and other utilities and their contractors, and has successfully helped these companies launch and maintain a cost effective keyhole program to address all their small hole needs.

With more than 500,000 reinstated cores in both roadways and sidewalks over the past 20 years, Utilicor is helping the utility industry increase their internal efficiencies, achieve a greater return on their investments, reduce the impact of utility construction practices on the travelling public, and at the same time, is helping utility companies and their contractors worldwide become greener and cleaner while performing necessary utility repairs to their buried underground infrastructure.

The Utilicor coring and reinstatement process has been tested and approved by the National Research Council of Canada, the United States Army Corps of Engineers, and by AASHTO approved laboratories, as well as the materials testing facilities of the Department of Engineering of the University of Illinois.

Utilibond™, our proprietary bonding compound, is an integral part of that reinstatement process and has fast become the industry standard. Independent testing has shown that it creates a bond that is stronger than the original pavement and is capable of supporting the combined weight of five transit buses - more than 50,000 lb. after just 30 minutes at 70°F.

Surgeons have recognized for years that, when it comes to making holes -- smaller is better. Keyhole or Laparoscopic surgery is less intrusive and causes less trauma and tissue damage to the patient, which means a shorter recovery period. The smaller incision also heals faster and leaves a smaller scar. It also costs less because it consumes fewer resources and has less impact on the patient during recovery. The same holds true for cutting holes in roads to access, repair or view buried infrastructure.

With annual pavement excavation and restoration costs of more than $2 billion annually, gas system operators are turning to keyhole methods as a way to reduce overall maintenance costs. Keyhole methods can cut excavation, repair and restoration costs in half. With keyhole techniques, maintenance activities are done through small pavement openings called "keyholes", which add up to significant cost savings, reduced public inconvenience, and a better, longer-lasting repair.

Keyhole technology is a cost-saving alternative to common repair methods, that usually require large "open" excavations and the removal and disposal of large quantities of pavement debris or spoils.

Conventional excavation practices that account for over 80% of the total costs of the work, also involve several large pieces of equipment (backhoes, dump trucks, pavement breakers) that generate more than TWELVE times the amount of CO_2 and other Green House Gases as compared to keyhole methods which are significantly more environmentally friendly.

The process itself is really quite simple. A purpose-built piece of coring equipment precisely cuts a circular core, typically 18-inches in diameter, through the roadway or sidewalk. That core is removed and put aside for future reinstatement. Vacuum excavation equipment is used to dig down to access the buried infrastructure, and the repairs are performed from the surface using long handled tools. Once the work or inspections are finished, the hole is backfilled and compacted to the base of the pavement, and the original core of pavement is put back into the opening using a specially formulated bonding compound **Utilibond™** which creates a permanent, waterproof, mechanical joint with the existing roadway.

Thirty minutes later, the road will have regained its pre-excavation load bearing capacity and can once again be safely reopened to traffic. No temporary patches. No sunken potholes. No unsightly scaring of the roadway sidewalks.

Just a perfectly clean, neat and almost invisible permanent repair to the road or sidewalk.

The benefits from utilizing keyhole technology are almost too numerous to mention - and applications are growing every year. It is a true win-win-win technology. Not only is it better for the community in which it is used, it is a better process for those using it, the crew and, perhaps most importantly, for the planet on which we all live. It is a green technology that results in a dramatically smaller carbon footprint when compared to traditional construction techniques. It saves tax payers and utility companies millions of dollars when compared to traditional methods of utility cut repair.

Benefits for the utility company, their contractors, and the municipality:

- **Saves Money:** Dramatically reduces repaving budgets. Saves up to $1,000 or more per hole or millions of dollars or more per year vs. traditional cut & repair methods.
- **Positive Community Relations:** Faster less intrusive process. Fewer complaints from municipalities about traffic disruption, unsightly road cuts, sunken patches or weakened or failed roads.
- **100% Performance Index:** Field-proven process with ZERO reported failures in more than 20 years and over 500,000 successful core reinstatements in tough urban climates.
- **Improved Logistics:** Single crew, one-stop, same-day coring and pavement reinstatement means simplified scheduling, no temporary patching or repaving and no repeat visits.
- **Faster & Efficient:** The speed with which the Utilibond™ gains strength - 50,000 lbs. in 30 minutes @ 70° F, (can support 5 transit buses) is unique and not seen in other pavement restoration processes. Time is money. Instead of waiting around an hour or more until other products gain sufficient strength to reopen the road, with Utilibond™, after just 30 minutes the road can be safely reopened to traffic, allowing the crew to move on to another job.

Benefits for the Crew:

- **Easy to Operate:** No extensive training required to operate the coring unit.
- **Easy on the Back:** Coring and reinstatement is physically less demanding on the crew. It eliminates the need for jack-hammers, shovels and backhoes and reduces potential for workplace injury.
- **Easy to Use:** Utilibond™ permanent pavement repair compound is packaged in easy-carry, easy-open, pre-measured pails. No awkward measuring and mixing from fragile paper bags and no guesswork. Just add the appropriate amount of water, mix and pour into the hole.
- **Safe:** Work-safe engineered equipment and non-hazardous bonding materials.
- **Reliable:** Utilicor coring units are the only Heavy Duty, purpose-built, coring equipment capable of quickly and accurately cutting through asphalt, asphalt-concrete and reinforced concrete road systems and sidewalks with a minimum of effort.

Benefits for the Community:

- **Reduced Traffic Disruption:** Faster, one-step, permanent pavement repair means reduced traffic disruption with fewer and shorter road closings and no repeat visits. The road can be reopened to traffic just 30 minutes after the repair.
- **Saves Tax Dollars:** Less intrusive, more precise, pavement coring and reinstatement process means less structural damage to road system, longer pavement life and reduced maintenance. Saves millions of tax dollars.
- **Environmentally Friendly with Reduced Carbon Footprint:** This is a one-stop road closure that uses the same materials to repair the road that were used to build it in the first place. No road-cut spoil needs to be trucked away and disposed of and no temporary patching materials with volatile organic compounds (VOC's) that escape into the atmosphere are used in the process. As a result, keyhole coring and reinstatement emits less than ONE-TWELFTH of the amount of green house gases (GHG) than an equivalent repair using conventional methods.
- **Cleaner, Safer, Less Intrusive Worksite:** Neat, almost invisible, 18-inch diameter circular, keyhole core (area: 1.75 ft^2) vs. 2 ft. x 4 ft. conventional rectangular road cut (area: 8 ft^2.) means a perfectly matching repair and reduced 'scarring' of the community landscape. No jackhammers or large excavation equipment means less noise and mess during and after the excavation and reduced disruption for neighbors.

Utilibond™ Approvals and Testing

The coring and reinstatement process was developed and field proven in the City of Toronto, where it was ultimately accepted and approved as a permanent pavement repair after monitoring the performance of thousands of reinstated cores in city streets from 1988 to 2003. To date, more than 500,000 cores have been cut and reinstated in North America, with zero reported failures.

As part of the proof, Golder Associates, an internationally respected science and engineering firm was retained to monitor the development of the pavement coring and reinstatement process and to evaluate a broad range of potential bonding products. Among the evaluation criteria for the selection of the appropriate bonding material were:

- fast setting and rapid strength gain to minimise traffic disruption;
- high bond strength to exceed AASHTO standards (safety factor) and to create a long-lasting, mechanical joint with the remainder of the pavement;
- low shrinkage to ensure the waterproof integrity of repair;
- high flowability to ensure complete coverage with no voids;
- convenient mixing and use characteristics to ensure uniform and consistent application;
- performance capability in a wide range of operating temperatures to extend use of the process;
- non-hazardous impact on crews and public; and
- adhesive bonding performance needed to achieve an effective coupling or 'structural bonding' between the core and the pavement in such a manner that the road would regain its design ability to share and transfer the effect of traffic loading from one section to another.

The Golder Report

https://www.utilicor.ca/utilibond-testing-and-approvals

The initial Golder Study spanned the period 1992–1996 and encompassed a series of field trials and laboratory tests on more than 20 potential bonding materials. It resulted in the selection of a single-process, cementitious bonding compound (now Utilibond™), which has been specially designed for the process. Golder continued to monitor the effectiveness of the process for a period of ten years and in April 2003 reported that:

'The lab trials and previous demonstrations on the rotary cutting method have shown that the pavement coupon has been bonded into the slab in such a manner that the loads of traffic are effectively transmitted to the remaining intact slab. Based on trials carried out at our testing laboratory in Whitby and our in-field performance observations, we are satisfied that the equipment, procedures and materials [including Utilibond™] developed and used by Enbridge Gas Distribution over the last 10 years will ensure satisfactory long term performance of pavement reinstatement.'

The Golder Report is the only ten-year longitudinal study to evaluate the effectiveness of a road reinstatement process by monitoring the degree of coupling between the undisturbed road structure and the newly restored utility cut.

Above: To test the effectiveness of the bond, Golder cut satellite core samples through the kerf of previously reinstated cores. These samples (right) showed perfect and complete bonding or adhesion of the Utilibond™ to both the surface of the core or coupon and the surface of the remaining pavement, as well as excellent 'cohesion' through the joint itself. The light grey line in the photograph is Utilibond™, showing excellent bonding of the asphalt–concrete core (central area) to the undisturbed pavement (outer layer) with complete infilling of voids in pea gravel (bottom). The core, which is directly in the wheel path of a transit lane of this arterial road, showed no deflection from the time it was first reinstated in September 1995 (left) to December 2002 (centre) notwithstanding the fact that, during the seven-year interval, more than 145,000 transit buses and 13 million commercial and other vehicles have passed directly over the keyhole with no apparent weakening or other degradation of the reinstated core or the adjacent road system or paved surface.

Utility Road Cut Study
National Research Council Canada & U.S. Army Corps of Engineers, April 2004
https://www.utilicor.ca/utilibond-testing-and-approvals

These impressive results were independently confirmed in testing by the Joint Utility Cut Study conducted by the **National Research Council of Canada** and the **United States Army Corps of Engineers** on behalf of seven Canadian municipalities, thirteen American municipalities and state DOTs, seven natural gas, electric and communications utilities, the American Gas Association (AGA) and the Gas Technology Institute (GTI).

A report on the results of a Field Investigation conducted in Toronto, Ontario, between October 2001 and April 2003 which monitored and compared the performance of the excavation and restoration procedures involved in a conventional trench excavation and a cored and reinstated keyhole, found that the keyhole repair outperformed the conventional rectangular utility cut by a substantial margin.

Surface and subsurface data collected from sensors embedded in both excavations and visual observations over the 18-month test period revealed that the restored keyhole performed better and caused less damage to the road system than the conventional rectangular utility cut performed with a road saw and backhoe and restored in a conventional manner with newly poured concrete and newly laid asphalt. Specifically, settlement and deflection had occurred along the wheel path in the conventional repair, and the material used to seal the linear joints had been lost through the action of traffic shortly after its application. These failures allowed the joint between the road and the repaired section to open and was considered to be the most likely cause of higher than normal levels of moisture at the bottom of the conventional cut compared with the keyhole cut. By comparison, the keyhole repair showed no distress, remained level with the road profile, and performed well throughout the life of the experiment, with no signs of cracking or separation in the bonding compound surrounding the core.

The smaller footprint of the keyhole was also credited with reducing the level of wheel-load stress transmitted to the underlying sections of the roadway compared with the standard cut, and the circular shape minimized the potential for the propagation of pressure or stress cracks in the corners of the repair.

Based on these findings, the Report on the Toronto Field Investigation concluded that:

"the keyhole coring and reinstatement process was an effective restoration technique that should be encouraged whenever feasible to minimize the need for opening large trenches in the future. The keyhole cutting and restoration technique that was evaluated in the Toronto Field Experiment indicates that the process is practical and effective in reducing the potential for damaging the road. It is recommended that the keyhole application be encouraged whenever proven feasible."

Newmark Civil Engineering Laboratory of the University of Illinois at Urbana Champaign
Bond Strength and Performance Testing of Utilibond™ and Other Products, June 2003
https://www.utilicor.ca/utilibond-testing-and-approvals

The fast strength gain and overall bond strength performance of Utilibond™ was independently confirmed in 2003 by testing at the **Newmark Civil Engineering Laboratory of the University of Illinois at Urbana Champaign (UIUC).**

The comparative testing of three commercially available bonding materials concluded that:

'The Utilibond™ material was the only bonding material that demonstrated satisfactory performance in the 30 minute tests where it gained sufficient strength to support a single wheel load of more than 50,000 lb (22,680 kg). Since all three materials ultimately achieved high safety factors against core punch out, it is reasonable to emphasize attributes of performance such as rapid set time and workability. Rapid set time and workability are meaningful attributes in the field application, and effectively differentiate the performance of bonding materials for reinstatement of cores.'

"Only Utilibond™ met these challenges."

Utilibond™ Strength and Performance Testing by Construction Technology Laboratories (2009)
https://www.utilicor.ca/utilibond-testing-and-approvals

In May 2009, the bond strength of Utilibond™ was tested by **Construction Technology Laboratories (CTL)**, an American Association of State Highway and Transportation Officials (AASHTO) approved testing facility, as part of the certification process for the **Illinois Department of Transport**. In their test of Bond Strength using the Slant Shear Method (ASTM C 882), CTL reported that the fracture pattern that was revealed in the tests indicated that the bond formed by Utilibond™ was actually stronger than the pavement itself.

'Samples had fractures occurring through the bonding and substrate material. The fracture pattern resulted in a well-formed cone on one end, vertical cracks running through the caps, and no well-defined cone on the other end. This fracture pattern for this test indicates that the bond material is stronger than the substrate'

Municipal Approval and Standard, City of Toronto, November 2007
https://www.utilicor.ca/municipal-keyhole-approvals-1

The UIUC findings, together with the results of the Joint Utility Cut Study form the basis of the approval of the process by the **City of Toronto** and its promulgation in November 2007 of **TS 4.70: Construction Specification for Keyhole Excavation and Permanent Reinstatement of Keyhole Cores,** the first comprehensive set of acceptance and performance standards for the keyhole coring and reinstatement process in North America. The Standard is far reaching and comprehensive.

The maximum diameter of the core is specified to be 460mm or 18-inches, but, with prior approval of the city larger cores up to 610mm or 24-inches in diameter, or overlapping cores, may also be cut. This is important, because some locates may be a little off or a larger opening may be required to perform the underground repair work (see below). The minimum depth of asphalt or flexible pavements in which the process may be employed is fixed at 100mm or 4-inches. There is no thickness limitation on any other types of pavement or sidewalks. The Standard also requires that the core be cut with equipment that is capable of accurate vertical adjustment, to ensure that the core is cut in an alignment perpendicular to the horizon to eliminate the effects of gravity in the reinstatement of the core.

A central part of the Standard establishes minimum performance criteria for the high-strength bonding material to be used to bond the keyhole core or coupon back into the pavement. To be approved, the bonding material must be capable of generating a waterproof bond that, within 30 minutes of application at 70°F (21°C), achieves an equivalent traffic loadable condition at least two times greater than the AASHTO H-25 standard or 30,000 lb (13,600kg).

NOTE: At 70°F (21°C) Utilibond™ achieves an equivalent traffic loadable condition of more than 50,000 lb.

Two 18" diameter cores are cut to allow for greater access to buried facility

Adhesion and Cohesion

Adhesion: When surfaces are held together by interfacial forces, they are said to show good "adhesion". Good adhesion requires very close contact. In the case of adhesive bonding this is achieved by flow of the bonding agent into the surface of the substrate. Adhesion strength is the force required to pull the adhesive clearly from the surface.

Cohesion: Cured adhesives or bonding agents, like other materials, can also be characterized by their internal strength, or the force required to cause permanent deformation, i.e. to break the bond. To differentiate from adhesion, "cohesive strength" of adhesives and substrates is used for this internal strength as shown.

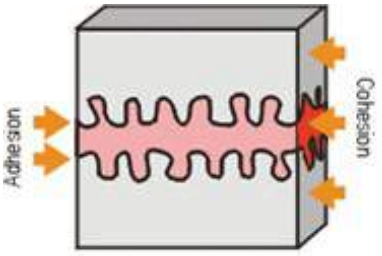


Figure 1: The types of forces in an adhesive joint. Good adhesion and cohesion are required to achieve high performance joints. Adhesives and bonding agents typically have a flow phase when they are applied, building up adhesion, followed by a hardening phase during which the cohesive strength builds up.

Structural Bonding

Structural bonding is the name given to a bond where it forms a joint that performs a load bearing function as in a paved road. This means that forces in a structure can be transmitted from one member to another through the joint. This force would be taken up by the bonding agent and spread or transmitted to the next member. This is the type of bonding that is important in a pavement repair where the end result is to reinstate the capacity of the pavement to perform as a load bearing system.

Golder Associates Study (1992-2002)

Golder Associates is an international engineering firm that provides science and engineering consulting services in support of environmental, industrial, natural resources, health and civil engineering projects. Golder monitored the development of the Enbridge rotary coring and pavement reinstatement system for ten years between 1992 and 2002. According to Golder, to be effective in the long term reinstatement of pavements, the bonding agent needed to achieve an effective coupling or "structural bonding" between the core and the pavement in such a manner as the road would again share the effect of traffic loading as it did before the excavation.

The Golder study encompassed a series of field trials and laboratory tests on a broad cross section of potential bonding materials undertaken over the period 1992 to 1996 and resulted in the selection of a proprietary bonding compound specially designed for the process. The result of this testing and selection was the predecessor of Utilibond™.

Ten years later, in October of 2002, a follow up study was commissioned to confirm previous results over a longer "in ground" period and to update performance data on the current version of Utilibond™ which is the third generation of the compound originally selected for the process. (See: Golder Associates Ltd., Report on Laboratory Testing of New and Improved Bonding Compound (Utilibond™) and Investigation of Previously Repaired Pavement Keyhole Restoration Techniques, Toronto, Ontario, April 21, 2003.)

Figure 2. *Satellite core samples taken through bonded area of rein-stated core. Light gray line, Utilibond™ shows excellent bonding of asphalt-concrete core (central area) and undisturbed pavement (outer layer) with complete infilling of voids in pea gravel (bottom). (See: Golder Report).*

To test the effectiveness of the bond, Golder cut satellite core samples through the kerf of previously reinstated cores as shown in Figure 2. These samples showed perfect and complete bonding or adhesion of the Utilibond™ to both the surface of the core or coupon and to the surface of the remaining pavement, as well as excellent "cohesion" through the joint itself. The Golder study is the only ten-year longitudinal study to evaluate the effectiveness of a road reinstatement process by monitoring the degree of coupling between the undisturbed road structure and the newly restored utility cut. It concluded that:

"The lab trials and previous demonstrations on the rotary cutting method have shown that the pavement coupon has been bonded into the slab in such a manner that the loads of traffic are effectively transmitted to the remaining intact slab. Based on trials carried out at our testing laboratory in Whitby and our in-field performance observations, we are satisfied that the equipment, procedures and materials [including Utilibond™] developed and used by Enbridge Gas Distribution over the last 10 years will ensure satisfactory long term performance of pavement reinstatement."

Multiresistant Bonding

Not all adhesively bonded joints are solely structural. Multiresistant bonding is the use of adhesives where the joint is also required to withstand other environmental forces such as temperature cycling and vibration and resist the infiltration of water.

In the context of pavement repairs, to prevent infiltration of ground water through the perimeter of the cut that can washout the subgrade and result in premature degradation or failure of the pavement, the bond must not only be strong, but it must be waterproof.

Restoration of Utility Cuts Study (2000-2005)

In this study conducted by the National Research Council of Canada (NRCC) and the U.S. Army Corps of Engineers (USACE) the effectiveness of Utilibond™, as a bonding agent, was demonstrated during independently monitored field tests . (See: National Research Council of Canada, Road Utility Cuts: Report of Field Investigation, Toronto Site, April 2004).

The "Restoration of Utility Cuts" project was a joint effort involving a number of North American cities, utility compa-nies and U.S. state departments of transportation. The objective of the project was to develop a guide for best restoration practices based on sound engineering principles. As part of this study an experiment was conducted in the City of Toronto using two cut sections -- a conventional transverse trench and a keyhole.

An Interim Report on this experiment, released in April 2004, discussed the results of the Toronto Field Experiment that included in-situ testing and data collected from sensors installed in both the conventional and keyhole restored cuts that covered a wide range of engineering parameters and environmental conditions including quality control tests included in City of Toronto specifications. Sensor data was collected in four visits to the site where a test truck and the Falling Weight Deflectometer (FWD) device were used to load the test sections.

Both the conventional cut and the keyhole were instrumented to monitor traffic-induced stresses and moisture conditions in the lower layer of the subbase and pavement associated with this restoration procedure. After placement of sensors in the sand layer, unshrinkable fill was poured directly from the agitator truck into the excavation and brought up to the level just below the base of the pavement in both trench and keyhole restorations.

Road condition data collected prior to construction was used to establish a reference for tracing changes associated with cutting (trench and keyhole) and quality of construction. After the reinstatements, damage survey visits and inspections were conducted on three occasions: (1) October 2001, after completion of temporary restoration; (2) May 2002, following the final assessment of the performance of the temporarily restored trench prior to the second restoration stage; and (3) April 2003, when the final assessment of the permanent restoration stage was performed.

Observations made during these site visits noted that:

- There were noticeable failures in the conventional cut. The conventionally repaired joint between the road and the cut opened. The location of this joint separation coincided with visible settlement in the trench along the wheel path. The material used to seal the joint was lost under the action of traffic as a result of shear-flow or pullout of the sealant, and there are indications that the sand cover and surrounding clay in the Toronto restored cut were exposed to higher than normal levels of moisture (compared with the keyhole).

- There were no defects noted in the keyhole cut. The keyhole section established on October 2001 continued to perform well throughout the life of the experiment. The surface of the restored keyhole remained at level with the road profile. The grout [Utilibond™] surrounding the AC/PCC plug remained intact (no cracking or separation).

The report observed that keyholes are currently being used to access buried facilities to perform the intended utility job reducing the need to cut large openings in road, and that the surface and subsurface data collected from the keyhole established in the Toronto experimental site revealed that the restored keyhole performed well and resulted in no damage to the road. Based on these findings the report concluded:

- "Considering the area of a tire print of heavy trucks in contact with the road surface, the keyhole opening resulting from coring is quite small (18-inches in diameter). As a result, low stresses are transmitted to the underlying sections of the restored keyhole."
- "Based on basic rules of mechanics, a circular cut shape in the Asphalt Concrete (AC) is ideal for preventing propagation of cracks into the surrounding road area."
- "Effective equipment was developed for performing cutting and excavation with no potential for causing damage. Cutting is performed by coring and removal of existing road material is performed by vacuuming material from inside the keyhole."
- "The plug consisting of Portland Cement Concrete (PCC) and AC layers is removed with great care using dedicated equipment and later reinstated at the surface."
- "Research conducted by Enbridge Gas Distribution Inc. resulted in developing an effective grout [the for-runner of Utilibond™] for use in the restoration process. The grout is used to attach the PCC/AC plug to the road and for sealing the joint. In the Toronto keyhole section, the grout performed effectively throughout the life of the experiment (September 2001 to April 2003) with no signs of loss of material or separation of the joint."
- "The combination of keyhole construction technique and unshrinkable fill produced an effective restoration technique that should be encouraged whenever feasible to minimize the need for opening large trenches in the future."

In essence the NRCC/USACE Report confirmed that the keyhole excavation and reinstatement method using Utilibond™ is superior to conventional methods. There is no deflection or settlement of the reinstated core (i.e. effective structural bonding) and no infiltration of ground water (i.e. effective multi-resistant bonding).

The Mechanics of Bonding

According to Dr. David Lange*, the mechanical performance of the bonding material is one of the most important factors in achieving long-term performance in the reinstatement of cores in pavement. It is a well known engineering principle that repair or bonding materials achieve their primary bond through mechanical interlock with the surface or micro-structure of the substrate.

It is important that the bonding material mechanically engage with the surface irregularities or penetrate the pore structure of the concrete.

To be effective, the solid particulate in a dry-base bonding agent needs to be fine enough, when mixed with water, to establish an intimate bond with the surfaces to be bonded. Coarser grouts will not work as well and, while they may exhibit good compressive strength or appear able to fill the kerf and stabilize the core, they will lack the adhesive qualities of a good bonding agent.

Traffic pressure and vibration may cause premature adhesive bond failure in these grouts that will deprive the joint of vertical support and the ability to transfer transverse loading across the joint, as well as permitting the infiltration of water into the sub-grade.

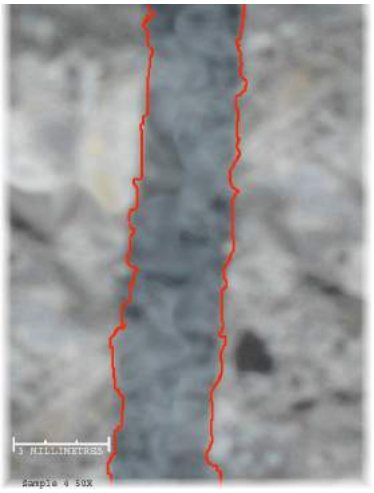
When liquefied by the addition of water, the chemical composition and fine granular structure of Utilibond™ results in a lower surface tension of the bonding material relative to the solid surfaces of the concrete substrate. Surface tension is the force at the surface of a liquid due to adhesive forces of the liquid molecules for the solid walls of a container (in this case the surface of the core and the surrounding pavement) and the attractive forces of the molecules of liquid for each other. When the adhesive forces of the molecules for the solid walls are greater than the attractive forces between the liquid molecules, the liquid will wet the solid surface. In porous solids like cement paste, concrete or asphalt, the liquid will wet the exposed surfaces and will be drawn into intimate proximity with the surface structure (densification) under forces known as capillary tension. The extent of penetration of a liquid into pore structure which contributes to densification is governed by the strength of capillary tension forces and the liquid viscosity. Unlike Utilibond™, which is a bonding agent, in typical grouts these forces are very weak or non-existent.

* David A. Lange, Ph.D., P.E., FACI, is a recognized authority in the area of civil engineering materials, cement microstructure property relationships, fracture mechanics of concrete, fiber reinforced concrete, and interfacial bond in cement-based and masonry materials. He is the Principal Investigator or Co-Principal Investigator for the Illinois Department of Transportation, The National Science Foundation, Master Builders, Inc., Applied Sciences, Inc., Federal Aviation Administration, FAA Center of Excellence, and the NSF Center for Advanced Cement Based Materials. Dr. Lange also serves as the Chairman of the Cements Division of the American Ceramic Society, Chair of ACI Committee on the "Materials Science of Concrete," and is Associate Editor of the ASCE Journal of Materials in Civil Engineering.

The relationship of viscosity with time is one way of understanding the evolution of Utilibond™ from a liquid to a solid. As a liquid with a low viscosity it can wet the concrete surface and be drawn into very close contact with the concrete pore structure by capillary forces. The densification process of Utilibond™ will cease once the material hydrates.

Utilibond™ is a multi-component, super-plasticized, lime cement mortar specifically engineered and designed for bonding cement and asphalt cores back into the original substrate. Unlike typical "grouts" which are moderate strength fillers used for filling cavities, voids and cracks, Utilibond™ contains special additives designed to enhance the bonding performance of Portland cement-based materials.

This unique blend of components results in high cohesive strength through high density and low water absorption and improves the mechanical performance, workability, adhesion and resistance to harsh environmental exposures of the product such as freeze-thaw scaling.



Utilibond™ Micro-structure (illustrated)

Bond Microstructure:

An examination of the microstructure of the interface between Utilibond™ and the concrete substrate of the core and the surrounding pavement shows a very strong and high quality adhesive and cohesive bond. The strength of this bond was demonstrated in the "No Bottom" experiments of the Gas Technology Institute conducted in the Fall of 2003.

GTI "No Bottom" Core Test (2003)

In this test GTI tested the bond strength of Utilibond™ by attempting to restore a cored and excavated hole in an 8-inch section of pavement without any backfill using only Utilibond™.

The original GTI study plan was intended to demonstrate the effectiveness of backfill compaction as a factor in keyhole reinstatement. They planned to use various levels of compaction - good - fair - poor and no backfill at all. They began with the no backfill experiment in which they cored an 8-inch deep hole through asphalt, vacuumed excavated down 10 inches below the base of the pavement. Then they inserted a temporary false bottom consisting of a cardboard plate suspended by cables under the pavement base. On this false bottom they placed pea gravel followed by Utilibond ™ and the pavement core (See below). After the Utilibond™ set they released the supporting cables and began testing the ability of the Utilibond™ to support a core suspended over a void with no backfill under it.

To do test this, they passed a 9,000 lb AASHTO standard test vehicle over the core and to their surprise it sustained 40,000 passes without any movement or deflection.

False bottom hole

Utilibond™ poured into hole

Setting the core

Loading machine 40,000 + passes

Although the test could have been compromised by possible defects in the actual reinstatement procedures, and the actual cause and effect of the failure is speculative, the experiment did prove that the Utilibond™ bond itself did not fail and that Utilibond™ was more than a "grout" that just in-fills the annular space surrounding the core like a typical grout.

Utilibond™ is, as designed and engineered, a Pavement Bonding Compound. The GTI test clearly demonstrated that Utilibond™ had significant adhesive and cohesive bonding strength to support an otherwise unsupported 8-inch asphalt pavement core suspended over an excavated void when exposed to more than 40,000 passes of a 9000 lb. AASHTO standard test vehicle in which the wheel path passed directly over the core. That is equivalent to more than seven years of traffic on a non-arterial road.

This test is also supportive of anecdotal evidence that Utilibond™ reinstated cores were capable of withstanding underground washouts that undermined the entire pavement area resulting in a sinkhole. In these cases notwithstanding the long-term lack of support that resulted in catastrophic sub-surface failure of a large area of the paved surface, the Utilibond™ reinstated cores in that pavement showed no deflection from the surrounding pavement layer whatsoever.

Results of Testing and Conclusions

The superior adhesive and cohesive bonding performance of Utilibond™ demonstrated in these tests is due in part to the granular fineness or High Blaine of the cementitious material of which it is composed and to the proprietary additives that help to lower surface tension when in liquid form to enable it to penetrate the surface structure of the materials to be bonded and to form a strong, interlocking, mechanical, waterproof joint when it hydrates.

When initially mixed, Utilibond™ has a low viscosity and a low surface tension that allows capillary forces to draw it very close and into the surface structure of the concrete or asphalt where its very high density and super-fast strength gain can result in a very strong bond capable of supporting 52,600 lbs in less than 30 minutes at 70 degrees Fahrenheit.

When used for reinstatement of cores, these properties result in a waterproof joint that reintegrates the core with the original pavement slab to restore the structural performance of the roadway as a load bearing system to its pre-excavation levels.

Importance of Center Pilot hole

The central pilot bit and related pilot hole, which are unique to the Utilicor process, perform four important functions in Rotary Coring and Reinstatement.

1. Accuracy: The 2 3/8”diameter central pilot bit, which is integral to the Utilicor coring process, acts as a concentric guide for the coring drum, centering and stabilizing it to ensure a fast and accurate cut. It is the same type of robust, high-performance bit that is used in the drilling industry to quickly and accurately cut through rock and other tough materials.
2. Access and Handling: The central pilot hole, created by the pilot bit, provides a convenient full-depth access for the core-lifter by which the core or pavement coupon is removed from the pavement and by which it is repositioned back into the pavement during reinstatement after completion of the underground work. Full depth access enables the removal of the entire core, even when multiple pavement layers may have become delaminated. Other coring processes that do not employ an integrated central pilot bit must either core or drill a separate bar hole in the core, insert separate lifting rings or lag-bolts into the core or use some other form of clamping mechanism or other device to lift the core out of the hole after cutting or to accurately refit the core back into the hole after the repair. This involves an extra step and adds more complexity to the coring and reinstatement process especially in older pavements where delaminated pavement layers are commonly encountered.
3. Strength and Stability: The central pilot hole, when filled with Utilibond™ increases the bonding surface of a typical 12” deep 18” diameter core by almost 100 square inches (a 13% increase in bonding surface area) and adds strength to the reinstatement process. In addition to increased surface bond strength, this central column of Utilibond™ acts as a continuous stabilizing link between the replaced core and the Utilibond™ impregnated bed of pea gravel at the base of the hole, thus increasing the vertical stability of the core as well as adding to the overall strength of the reinstatement process.
4. Guidance: Because the pilot bit cuts slightly deeper than the coring drum it can provide the coring operator with an audible and sensory cue as to when the coring drum is about to core through the bottom of the pavement. When the pilot bit breaks-through the pavement into the sub-grade there is a noticeable change in the sound and the feel of the coring process, which alerts the operator to the fact that the coring drum is about to cut through the full pavement depth.

Infrastructure, like highways, streets, rail, transit, airports, seaports, waterways, waste management, power grids, communications equipment, gas distribution and other pipelines is the backbone of every economy and supports the quality of life of its people. As different as all of these public infrastructure systems are, they have one common denominator: Over time, and with use, they will all wear out and will need to be replaced.

Because much of this infrastructure is buried underground it is "out of site and out of mind" and its maintenance and replacement has been accorded a very low priority. This pattern of neglect has gone on for decades and only reaches the point of public concern when bridges collapse, water-pipes burst and gas mains explode. Today, most of the developed world finds itself at a point where the cost to close this huge investment gap needed to upgrade decaying and failing infrastructure of is trillions of dollars. The Organization for Economic Co-operation and Development (OECD) has estimated that total worldwide requirement for new infrastructure thorough 2030 could be as high as $71 trillion to simply maintain the current levels of global GDP growth.

At the same time, competing for these public funds, are concerns about Climate Change. Whether or not you believe in it, or agree with its cause, it does appear that some form of climate change is occurring. The best scientific minds today suggest that rising temperatures are very likely caused by the emission of greenhouse gases from human activities and pose significant risks for a range of human and natural systems.

While international agreements like Kyoto and Paris can set the moral context, most experts agree that it will be in the cities that the climate battle will be waged. Because cities and other urban areas consume over two-thirds of global energy and emit more than 80 percent of the world's total greenhouse gases, they are both the cause and effect of global warming and will suffer the greatest consequences of its impact, logic suggests that is cities and local municipalities, that appear to be the most appropriate vehicle by which to attack climate change.

And they appear willing to accept the challenge.

The fact that thousands of cities worldwide are already active and involved in the climate change issue, stems from the simple reality that, not only do they house the majority of the world's population, consume two-thirds of the world energy, generate over 80 percent of global emissions, but they accommodate within their borders the greatest concentration of vital energy, water, waste water, and communications, infrastructure and own the vast majority of the paved roads under which most of it is buried.

Cities are already responsible for decisions and actions related to the delivery of a wide range of services that ensure the well-being of their citizens. These include economic development and expanding access to basic services, like health care, education, public transportation, housing, electricity, water and sanitation, and appear better able to meet the challenge of global warming and climate change more efficiently, cost effectively, and with less environmental damage, than any other form of government.

Today, cities also exercise the legislative and fiscal levers that daily affect almost 60% of the world's population and more than 85% of the population of the United States, and they often have closer relationships with their businesses, residents and institutions than state and national governments, allowing new programs to be implemented more quickly and decisively.

Cities and local governments have also ecognized that individual or local action is not capable of resolving these global issues and have banded together in national and international organizations like C40 Cities, ICLEI-Local Governments for Sustainability, the Covenant of Mayors for Climate & Energy, the U.S. Conference of Mayors, the Compact of Mayors, EUROCITIES, Asian Cities Climate Change Resilience Network and others have already begun to implement climate action to reduce GHG emissions at the same time that they are preparing for greater climate impacts with a range of major programs.

These major programs include reducing reliance on fossil fuels in public transportation, investing in and encouraging next generation mobility options like expanded public transit, zero-emission buses and electric vehicles, optimizing energy efficient buildings restricting transit and taxi licenses to electric vehicles, optimizing energy efficient buildings by implementing ultra-high efficiency building codes, decarbonizing the electrical grid by placing more reliance on renewable energy sources like solar, wind and hydro, and developing enhanced waste management systems.

All of these ambitious options have merit. But they also have very significant costs measured in billions of dollars. Moreover, in most cases, cities themselves lack the wherewithal or authority to do it alone and will need to align themselves with others. These actions will require a huge shift in public opinion and the cooperation of those affected like landlords and residents of those buildings,

Cities cannot independently decarbonize the grid. Privately owned, regulated utilities that own and operate the vast majority of this generation capacity and their Public Utility regulators will need to play a significant role in managing the billions of dollars in investment needed to build-out renewables at the system or regional level to replace carbon-based generation.

In addition, these major programs will also take years to plan and implement. But while we a working to reduce reliance on fossil fuels in public transportation, or to convert public transit and taxis to electric vehicles or optimizing energy efficient buildings, there are actions that cities can undertake on their own at little or no cost.

Because cities are also where most utility companies operate, and it is the cities that own and control the public Right of Way – the sidewalks and streets -- under which most of utility infrastructure is buried, with no additional investment or cost, cities can, "with a wave of the pen" reduce GHG emissions by modifying the way public works and infrastructure projects are conducted and pavement excavation and repair is performed in their streets and encouraging the use of keyhole coring and reinstatement.

And this is something that a city can implement on its own, at no cost, without any additional taxes, grants or environmental incentives, by simply revising its city Ordinance dealing with performing and restoring utility cuts in pavement.

The first such Ordinance was issued by the City of Toronto in November 2007 when it promulgated TS 4.70: Standard Construction Specification for Keyhole Excavation and Permanent Reinstatement of Keyhole Cores. This standard recognized Keyhole Coring and Reinstatement as a permanent repair that requires no further restoration procedure such as cut-backs, chip-seals or milling-and-overlay if the process is performed in accordance with the standard. Since then, the keyhole process has been formally recognized by the FHWA and several State DOTs (e.g. Penn DOT, Illinois DOT and Utah DOT) and has been implemented by a number of major municipal agencies including: Phoenix AZ, Las Vegas NV, Montgomery County MD, Overland Park KS, Lincoln NE and Chicago IL, with informal municipal approvals in Dallas-Fort Worth TX, New York City NY, Boston MA, Denver CO, Colorado Springs CO, Washington DC, Spokane WA, Oakland CA, and hundreds more municipalities across the nation.

Admittedly these are small steps but these small steps taken now can help reduce the need to take larger and potentially more expensive actions later on.

MONTGOMERY COUNTY SPECIFICATIONS FOR UTILITY CONSTRUCTION PERMIT

DEPARTMENT OF PERMITTING SERVICES
DIVISION OF LAND DEVELOPMENT SERVICES
RIGHT-OF-WAY PERMITTING AND PLAN REVIEW SECTION
255 ROCKVILLE PIKE, 2nd FLOOR
ROCKVILLE, MARYLAND 20850

240-777-6300

http://www.montgomerycountymd.gov/permittingservices

AUGUST 2009

15. KEYHOLE" EXCAVATION AND RESTORATION

"Keyhole" excavation and pavement restoration consists of coring the existing pavement to excavate and perform the required utility operation and then restoring the pavement. The "keyhole" technique minimizes pavement excavation by coring small excavation openings of 12 to 18 inches in diameter through existing pavement. Typically, the operation consists of two vehicles; a truck mounted coring machine and a vacuum truck. The need for other conventional equipment such as backhoes and dump trucks is eliminated. Once the pavement has been cored, high-pressure air tools are used to cut the soil in the excavation below the pavement allowing the vacuum truck to remove the soil. Once the excavation and the work is complete and backfill placed, the removed pavement core is grouted back in place with an approved bonding agent (grout).

"Keyhole" pavement coring shall be performed with equipment designed for this purpose.

Once the pavement has been cored, and prior to excavation, a metal template shall be placed over the cored hole to minimize damage to the pavement edge of the cored hole.

"Keyhole" soil excavation shall be performed using vacuum excavator tools and equipment through the cored pavement opening. Backfill material shall be select borrow meeting the requirements of in paragraph 3 of these specifications. Compaction of the backfill material shall be in accordance with paragraphs 3 and 14, as applicable, of these specifications.

Pneumatic compaction equipment (pneumatic rammers or equivalent) shall be used for compaction of the backfill material. The size of the compactor shall not exceed half the diameter of the cored keyhole.

Once backfill and compaction of the excavation has been completed, the intact cored pavement section (plug) shall be reset and grouted in the keyhole from which it came and the surface of the reset pavement section shall be restored to the grade of the adjacent road surface. The keyhole section may be marked before coring in order to restore the core to its original position.

Grout used to secure the pavement core shall comply with the definition for grout as listed on page 21 of these Specifications.

The cored pavement section shall be set centered in hole, plumb and flush with the adjacent the road surface. The grout used in core replacement shall be placed under the core to insure proper leveling of the core. During core installation, the grout should flow upward to the road surface through the core side (saw kerf) and pilot hole to insure proper grouting around the core. Bonding agent should flow uniformly around the core. Excess grout shall be removed and the street surface cleaned after grouting in accordance with the requirements of Specification 8.

The grout shall be allowed to set per manufacturer's instructions prior to opening the street to traffic. Traffic control will be maintained per Specification 4.

DEFINITIONS: (Page 21)

GROUT: Grout utilized in keyhole excavation techniques shall be "UTILIBOND" manufactured by Utilicor Technologies, Inc. or an approved equal.

KEYHOLE EXCAVATION: An excavation made through existing pavement utilizing specialized drilling and coring equipment.

SPECIFICATIONS REVISIONS
EFFECTIVE 01/01/11

SECTION TITLE AND REVISION SUMMARY 215 “Keyhole Pothole Excavation and Backfill" - To allow for keyhole type pothole excavation and repair.

VOLUME I
UNIFORM STANDARD DRAWINGS REVISIONS
EFFECTIVE 01/01/11

506 "Utility Pothole Repair" – New standard drawing to allow for keyhole type pothole excavation and repair

SECTION 215 KEYHOLE POTHOLE EXCAVATION AND BACKFILL
DESCRIPTION

215.01.01 GENERAL

A. This specification covers the requirements for keyhole coring, vacuum excavation, backfilling, and reinstatement of the keyhole core in asphalt or concrete pavements to allow for underground utility repairs and underground exploratory potholing.
B. Quality control field inspection and testing requirements including frequency shall be in accordance with Contracting Agency requirements.

215.01.02 DEFINITIONS

A. Keyhole coring: The operation of coring a circular hole through the roadway pavement using diamond core drilling equipment.

MATERIALS

215.02.01 GENERAL

A. The material and placement requirements in the pipe zone and final backfill area shall be in accordance with Section 208, “Trench Excavation and Backfill.”
B. Pavement keyhole cores removed shall either be removed from the work site or stored in a safe and secure on-site location. The cores shall be made readily available for restoring the pavement after backfilling is complete and approved.
C. **Bonding Agent:** The bonding agent shall be a single component cementitious, rapid hardening, high strength, waterproof bonding agent conforming to the physical properties shown in Table 1.
    1. The bonding material shall be impervious to water penetration at the joint after application.
    2. The bonding material shall securely bond the undamaged keyhole core to the pavement and shall completely fill the annular space at the joint.
    3. The bonding material shall, within 30 minutes at an ambient temperature of 70 degrees Fahrenheit, allow the core to support an equivalent traffic load condition of at least three (3) times the AASHTO H-25 standard.
    4. The bonding material shall be Utilibond™ , manufactured by Utilicor Technologies, Inc., or an Engineer approved equal.

Table 1:

Bonding Material Properties

Property	ASTM Test Method	Requirements
Bond Strength (Slant Shear), psi (70° F,30 minute cure)	C882	200 min.
Compressive Strength, psi (70° F., 60 minute cure)	C109	1500 min.

CONSTRUCTION

215.03.01 POTHOLE EXCAVATION, GENERAL

A. The vertical alignment of the keyhole coring shall be perpendicular to the horizon, and the cutting shall extend to the full depth of the existing pavement section.
B. Unless otherwise approved by the Engineer, keyhole cores shall not be greater than 24-inches in diameter. Adjacent cores shall not be closer than 3 feet from each other (edge to edge), shall not contain a joint or any pavement cracks greater than 1/8-inch wide, and shall not be performed in pavements where the section is less than 4-inches thick.
C. Coring shall be performed with a keyhole coring saw.
D. The Contractor shall place a temporary mark on the keyhole core prior to cutting to insure that the removed section is replaced in the same orientation as originally found in the pavement.
E. Soils within potholes shall be removed by air/vacuum extraction methods to expose utilities. The zone of soil removal shall remain essentially within a vertical plane extending below the edges of the removed pavement.
F. The Contractor shall remove all materials excavated from the site.

215.03.02 POTHOLE BACKFILL AND COMPACTION

A. The backfilling of each zone shall be completed in accordance with Section 208, “Trench Excavation and Backfill.” Unless otherwise approved by the Engineer, the backfill material shall be placed in maximum 10-inch loose lifts.
B. Backfill compaction quality shall be determined by use of a compression wave amplitude monitoring device manufactured specifically for the purpose of measuring soil compaction. This device shall measure the compression wave amplitude as compaction progresses using below-grade disposable piezoelectric transducer wave sensors and an above-grade electronic monitor. The device shall signal the operator of successful compaction when the compaction wave amplitude becomes asymptotic to continued compaction effort for each lift.
C. Backfill soil shall be placed with a moisture content within three percent of optimum moisture content. Moisture content shall be determined in accordance with AASHTO T217.
D. Place a disposable compaction sensor at the bottom of the first loose lift. A new sensor shall be placed for every 48-inches of compacted fill depth. Remove backfill soil and sensor if the disposable sensor fails during compaction and repeat repairs with a new sensor.
E. Mechanical compaction on each lift shall be continued until the electronic monitor signals that compaction is complete. A new lift shall not be placed until a positive signal has been received. Remove backfill soil and sensor if the monitor does not give a positive compaction signal after repeated compaction work.

215.03.03 PAVEMENT RESTORATION

A. The surface cut by keyhole coring restored to its original condition with the reinstated core flush with and in the original orientation as the existing surface, matching existing pavement surface appearance.
B. Excess bonding material shall be removed from the restored surface. A patched appearance shall be avoided in surface restoration wherever possible.
C. Unless otherwise approved by the Engineer, the Contractor shall reinstate the bonded keyhole core within 24 hours of cutting the pavement. Openings allowed to be left open greater than 24 hours shall be covered with an approved steel road plate capable of supporting traffic loads, and in accordance with Subsection 208.03.21, “Cutting and Restoring Street Surfacing.”
D. Surface Tolerances: The reinstated core shall be flush and level with the adjacent pavement. Gaps attributable to the positioning of the core shall be less than 1/16-inch between the bottom of a minimum 3-foot long straightedge and the surface of the pavement in any direction on the surface of the keyhole core.

215.03.04 DEFICIENCIES

A. Where the keyhole core is found to be fractured or defective upon removal, or becomes damaged after removal and prior to reinstatement, the core shall not be used to restore the pavement. The pavement at damaged keyhole core locations shall be cut and a permanent patch shall be installed in accordance with Subsection 208.03.21, “Cutting and Restoring Street Surfacing.”
B. A keyhole core shall be considered unacceptable when one of the following conditions exist:
   1. The keyhole core contains any vertical cracks wider than 1/8-inch extending full depth through the core; or
   2. Any deteriorated piece of the keyhole core is larger than ten percent of the overall area of the core; or
   3. Two or more successive layers of pavement in the keyhole core become horizontally delaminated and cannot be re-bonded to each other with the bonding material.
C. All keyhole cores that are damaged or do not meet the surface tolerances shall be removed, and the Contractor shall cut and install a permanent patch in accordance with Subsection 208.03.21, “Cutting and Restoring Street Surfacing.”

METHOD OF MEASUREMENT

215.04.01 MEASUREMENT

A. Unless otherwise specified, the quantity of Keyhole Core repair will not be measured for payment, but shall be considered incidental to other items of work.

BASIS OF PAYMENT

215.05.01 PAYMENT

A. Payment for Keyhole Core Repair will be made only when required in the Special Provisions.

NOTE: The report of the Regional Transportation Committee for Southern Nevada creating this Standard suggests that they would like to have had at least two products that meet the specification. But subsequent inquiry by Officials indicated that only Utilibond™ met the requirements of overall strength and the strength gain time frame. The Standard provides for the substitution of an Engineer approved equivalent.

“Mr. Paul Judd, Regional Transportation Commission of Southern Nevada (RTC), explained that this item was a follow up to the prior agenda item. He went on to say that this particular item concerned the criteria for the materials and methods. He shared that the Utility Coordination Committee had made their approval conditional upon RTC staff members' attempts to find two sources of Utilibond™ to bond the keyhole back into the holes. He related that the RTC had conducted an industry-wide search and could not find a product with sheer strength equal to that of Utilibond™ . He further noted that certain other products could achieve compressive strength equal to Utilibond™ , but not in the same time as Utilibond™ . Mr. Judd concluded his statement by stating that the RTC had listed Utilibond™ as the sole source and noting that the California Department of Trans-portation had a sole source for this particular keyhole application.” RTC Report dated: 9/12/2010

SPECIFICATION REFERENCE	

UNIFORM STANDARD DRAWINGS
CLARK COUNTY AREA

UTILITY POTHOLE REPAIR

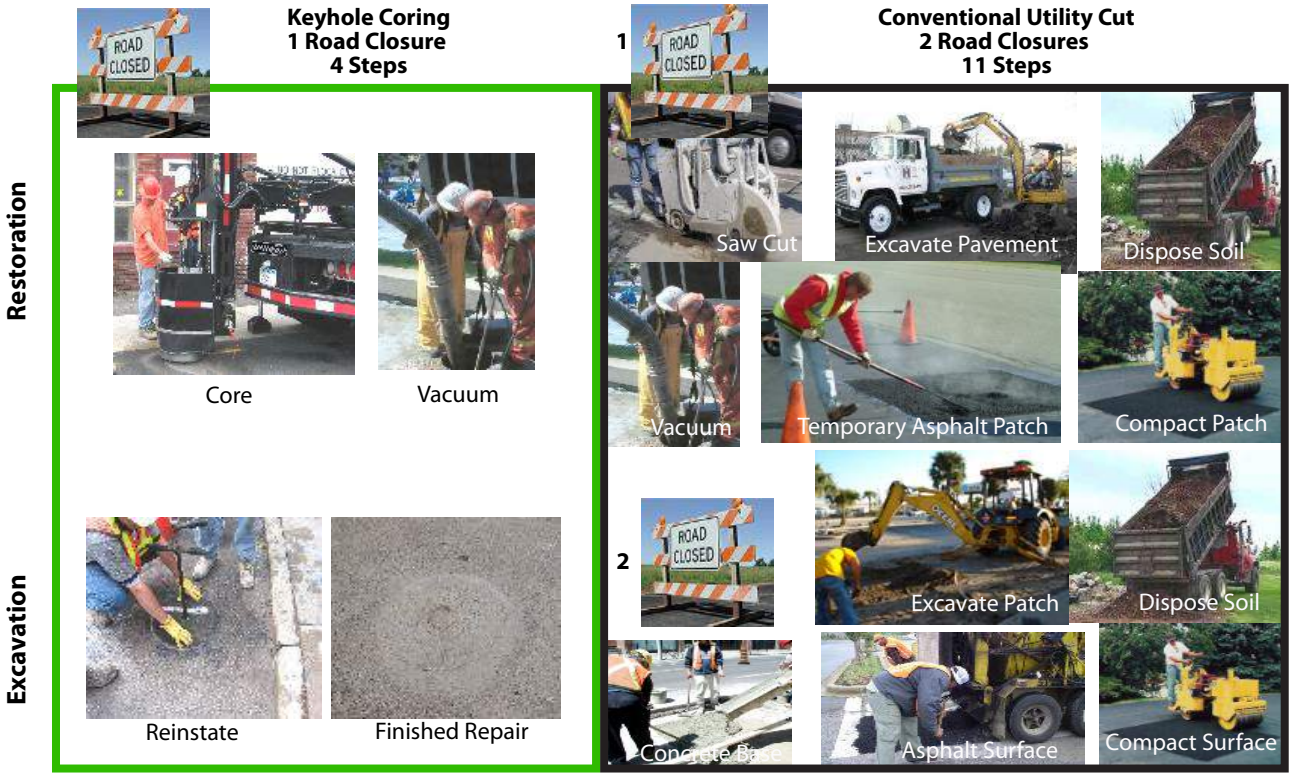
DATE 12-09-10	DWG. NO. 506	

Reduced Carbon Footprint

The keyhole coring and reinstatement process also has a very positive environmental impact on utility construction and highway maintenance operations. The coring and reinstatement process significantly reduces the carbon footprint of utility cuts and pavement repair. It minimizes the atmospheric emissions of greenhouse gases by simplifying and shortening the maintenance and repair process, and by reducing the consumption of millions of tons of asphalt paving materials and the disposal of millions of cubic feet of asphalt spoil every year.

Keyhole coring and reinstatement, in conjunction with other trenchless technology methods, offer an environmentally sensitive alternative for installing and connecting new gas, water, and communications utilities and rehabilitating existing infrastructure.

Conventional pavement excavation and repair employs many different pieces of construction equipment, including jack-hammers, concrete saws, backhoes, dump trucks, vacuum excavators, asphalt and cement delivery vehicles and pavement compactors that generate more greenhouse gas and other emissions than keyhole methods. Keyhole coring and reinstatement is limited to three pieces of equipment: a coring unit, a vacuum excavator and a hand-held pogo tamper compaction device.



Not only does it use fewer pieces of equipment, but keyhole reuses the same core of pavement to permanently repair the roadway after the underground work has been performed. There is no spoil to be disposed of and no need for additional paving materials.

Moreover, because the core reinstatement is a permanent repair, there is no need to subsequently close the road again to remove and replace a temporary asphalt pavement patch with a permanent repair. This avoids the emission of harmful volatile organic compounds (VOCs) into the atmosphere from newly laid asphalt pavement.

Finally, the keyhole process has a carbon foot print MUCH SMA:LLER than conventional excavations and repair. Using a standard carbon calculator, the energy consumption and carbon emissions from the ten or more pieces of construction and transportation equipment involved in the transportation, excavation and temporary and permanent restoration of a conventional utility cut has been calculated to be 365 lb (165 kg) of CO_2 as compared with only 60 lb (27 kg) of CO_2 from the three pieces of equipment used in the keyhole process.

Looked at in national terms, as can be seen from the following table, if the keyhole process had been used in the approximately 800,000 situations for which it was suited the United States, there would have been an aggregate reduction in CO_2 emissions of approximately 320,000 tons per year.

Activity	Annual Savings of Keyhole Methods Compared with Conventional Excavation and Restoration Methods
Reduction in asphalt pavement used[1] :	2 million tons -- Enough to resurface 650 miles of 4 lane highway
Reduction in spoil disposal:	27 Million cubic feet. -- Enough to fill 200,000 dump trucks
Reduction in work zone delay:	4 Million hours[2] 1.9 Million gallons of fuel[3] $520 Million cost[3]
Restoration cost savings to utilities:	$900 Million (estimate)
Reduction in VOC and GHG emissions:	60,000 Tons of Volatile Organic Compound (VOC) Emissions 320,000 Tons of GHG Emissions This is equal to CO_2 emissions from an Average Power Plant[4] (2.8 billion tons CO_2 ÷ 8000 power plants)

1. *Assumes: 800,000 small hole 2ft x 4ft excavation of 12in deep composite pavement comprising 4in asphalt over 8in concrete with 1ft cutback on permanent restoration.*
2. *Average 5 hours shorter road closings x 800,000 excavations*
3. *TTI Urban Mobility Report 2012*
4. *8000 Power Plants in USA annually generate 2.8 billion tons CO_2 Average: 350,000 tons CO_2.*

That is almost equivalent to the average CO_2 emissions (338,000 tons) from each of the 8,000 power plants in the United States. It follows that use of the keyhole process nationwide would be almost like closing one of those power plants.

And given the prediction by the OECD that, over the next decade, action needed to meet the worldwide challenge of decaying infrastructure would inevitably increase the current levels of work to be performed in city streets by two or three times. It logically follows that this would also increase opportunities for keyhole coring and reinstatement, in which case those savings illustrated in the Table above it can be expected to double or triple as well, and increase the environmental and other benefits of the keyhole coring and reinstatement process.

Coring and Reinstatement Benefits

Southwest Gas Corporation uses the keyhole coring and reinstatement process throughout its operating areas in Arizona, California and Nevada. According to Byron Elkins, Manager of Operations Planning & Analysis:

"The keyhole process is cost-effective, results in a better pavement repair, is safer for the employees because they do not have to go down into the excavation, and is environmentally friendly. For us at Southwest Gas there are four key environmental benefits to the Utilicor keyhole coring and reinstatement process. First, it eliminates the massive amounts of energy that are normally required to produce, heat and transport new asphalt to the worksite. Second, because the process actually reuses the existing material to repair the road, it also eliminates the need to dispose of any pavement debris. Third, it prevents the release of toxic VOC emissions that would otherwise occur during the asphalt curing.

34. "*Concrete CO_2 Fact Sheet", (2008), National Ready Mixed Concrete Association, p.6*

1. The first step is to **ensure that the top of the backfill is 1 to 2 inches below the level of the base of the pavement layer.** Using a pointed trowel undercut the bottom of the existing pavement all around the circumference of the hole to a depth of an inch or so. This will allow the pea gravel (the next step) to extend into that space under the pavement.

2. Line the bottom of the hole with a one to two inch layer of ¼ to ½ inch pea gravel and work it into the space that you just carved out. Amounts will vary depending on the irregularities on the bottom of the core.

3. Using the core puller, lower the core back into the hole following the orientation marks to check the level of the surface of the core with the existing pavement. **Adjust the pea gravel until the surface of the core is level all around with the surrounding pavement and approximately ½ inch below the surface.** This process is referred to as "dry fitting" the core. This is an essential step for a proper core reinstatement. Once the Utilibond has been added to the hole and the core has been reinserted it will be too late to adjust its position. Make sure it's done right the first time.

4. Next, because Utilibond will not bond to dirty surfaces, **clean the outside vertical surface of the core and the walls of the cored hole with a clean, damp sponge** to remove all loose cutting debris or backfill particulate. Proper bonding depends on achieving a clean surface for the bonding agent to adhere to. Now you are ready to mix the Utilibond.

5. Open the Utilibond pail and remove the contents. Regular pails will contain one bag and Twin Packs two bags of Utilibond as well as a one liter measuring container. For Regular pails add clean water to the level of the bottom of the line on the outside of the pail (2 liters). **Do not exceed or reduce the amount of water. Exact proportions of water to Utilibond are critical for effective performance**. Add one liter of water for each bag of Twin Pack Utilibond being mixed.

6. Carefully open the bag(s) of Utilibond, creating a clean opening though which to pour the Utilibond powder into the pail. Use a handheld drill (Minimum: 1/2" chuck, 7amps) with a 4-arm mixing blade. Engage the drill and insert the mixing blade to the bottom of the pail while slowly pouring the Utilibond powder into the water in the pail. **At the start the mix may appear to be lumpy and dry BUT do not add more water.** Keep mixing and the Utilibond compound will "turn" after about one minute and begin to smooth out.

7. Move the mixing blade continuously up and down to the bottom and around, scraping the sides of the pail, to make sure that everything is blended together. Continue until the mixture is smooth and flowing. **After about 2- 3 minutes of mixing the Utilibond will appear smooth and creamy** with a flow characteristic similar to that of pancake batter. The Utilibond is now ready to use.

8. Carefully pour the blended Utilibond into the hole so as not to disturb the layer of pea gravel at the bottom of the hole. For shallow cores it may not be necessary to pour the entire pail into the hole but it is always better to have more Utilibond in the hole, to ensure that the reinstated core is completely surrounded by Utilibond.

9. Using the core-puller align the core with the orientation marks on the surface and slowly lower it down into the hole on top of the Utilibond. **Gently work the core downward using a swivelling back and forth motion to allow the bonding compound to flow up through the cut spaces all around the core (the kerf)**. Remove the excess Utilibond with a trowel as it flows up and onto the surface. When the entire kerf is filled and the core completely surrounded by Utilibond, remove the core puller to allow the rest of the Utilibond to flow up through the center pilot hole. **Apply gentle pressure (or tapping) to the top of the core to bring it level and flush with the rest of the pavement.** Holding the trowel perpendicular to the core slide the flat bottom edge across the surface of the core to the outer edges to check that the core is flush and level with the rest of the roadway all around the circumference. Use gentle taps from a pry-bar on the high points to bring it level. Use the flat trowels to continuously clean up the excess Utilibond.

10. **Because the effectiveness of a reinstatement is judged by the appearance of the surface, thoroughly clean off any excess Utilibond from the surrounding pavement before it dries** carefully using a wet grouting sponge to "scrub-off" excess Utilibond from the top of the core and surrounding area. The Utilibond will begin to set up within 15 minutes or so at 70° F. Keep the exposed Utilibond surfaces in the kerf and pilot hole "damp" by periodically shaking drops of water from a whitewash brush on the Utilibond until the surface is firm to the touch. Thoroughly clean all mixing tools before the Utilibond has a chance to set.

11. Once the core has gained strength (about 30 minutes at 70° F), use water (high pressure is recommended) to wash-off any excess debris, carefully avoiding the Utilibond in the kerf and pilot hole, and thoroughly sweep the area before leaving. Properly dispose of all excess Utilibond material and reuse or recycle the Utilibond pail.

Hot Weather Core Reinstatement Procedure

Utilibond™ is specially formulated for permanently replacing excavated cores in asphalt, asphalt and concrete and concrete road systems and sidewalks and other paved surfaces. The rapid hydration and fast strength gain of this product allows the roadway to be reopened within 30 minutes at 70°F/21°C.

However, sometimes cores will need to be reinstated when the ambient temperatures are well above 70° F.

Utilicor deems hot weather to be temperatures when the day time highs exceed 80 °F and extreme hot weather to be above 100 °F. When reinstating cores in these hot or extreme hot weather temperatures certain procedures will help the crews attain a proper core reinstatement. Failure to follow these instructions may result in improper or poor reinstatements.

Utilibond™ permanent pavement bonding compound is designed to be mixed with a precise amount of water to the proportion of Utilibond™ powder. This ratio must be maintained even in extreme hot weather conditions. The precise amount of water required is one liter of water for one 22 lb. bag of Utilibond™ powder. For a 44 lb. bag of Utilibond™ powder, mix with 2 liters of water. Do not alter this ratio the ultimate strength gain and performance of the Utilibond™ ™ will be reduced.

In the case of hot weather and extreme hot weather conditions the following tips will allow for additional working time during the process of reinstating the core:

- **Start with cold water to mix the Utilibond™ and keep the Utilibond™ in a cool place.** As only two liters of water are required for an entire 44 lbs. pail of ***Utilibond***™, filling a potable water container with cold tap water before leaving the yard and storing it in the air conditioned cab of a work truck on site until mixing is needed will help to slow down the set up time of the ***Utilibond***™ . Make sure the ***Utilibond***™ powder is as cool as possible before mixing.
- **Reduce overall mixing time.** Utilicor suggests a full three minute mix time of ***Utilibond***™ at 70°F. At this temperature this with help to accelerate the setting times for the product. However, in hot weather conditions we recommend reducing this time to 1½ minutes. Once the ***Utilibond***™ is mixed through and is lump free, with a flow consistency of pancake batter, it is fine to stop the mixing process and start the core reinstatement.
- **Keep everything wet.** This would include the cored portion of the roadway and the core itself before reinstatement occurs. Dampen all portions of the cored roadway and core with a sponge just prior to reinstatement.
- **Once the core has been reinstated keep the kerf and pilot hole portions wet.** By using a wet soft bristled brush or the sponge you can "paint" the top of the reinstated core with cold water – this will help the ***Utilibond***™ to set a little slower and reduce any premature or rapid hydration of the ***Utilibond***™ . Make sure you keep the kerf and the pilot hole damp. In extreme weather spraying the kerf and pilot hole with *Utilicure™* is highly recommended.
- **Keep the cores cool.** In extreme hot and sunny days the asphalt cores can literally "melt" if left unprotected at the side of the road with the sun beating down on them. An asphalt core will also have the tendency to expand, or "mushroom" due to excessive heat when left in the sun. We recommend storage of cores for short durations in the shade and if possible covered with wet burlap. For longer durations they should be carefully moved to a cooler inside warehouse location.
- **Do not leave the core puller in the core for extended periods of time.** Once the core has been removed from the roadway it is imperative that the Utilicor puller be extracted from the center of the cut core. If it is left in the core in tightened position it could possibly cause the core to split. During reinstatement on a hot day only tighten the puller to the point that one can securely move the core.

With ambient temperatures of 70°F Utilibond™ has an initial set in 15 minutes, a final set at 20 minutes and is load bearing at 30 minutes, at which time the roadway can be safely reopened to traffic.

At correspondingly higher temperatures set times will be reduced.

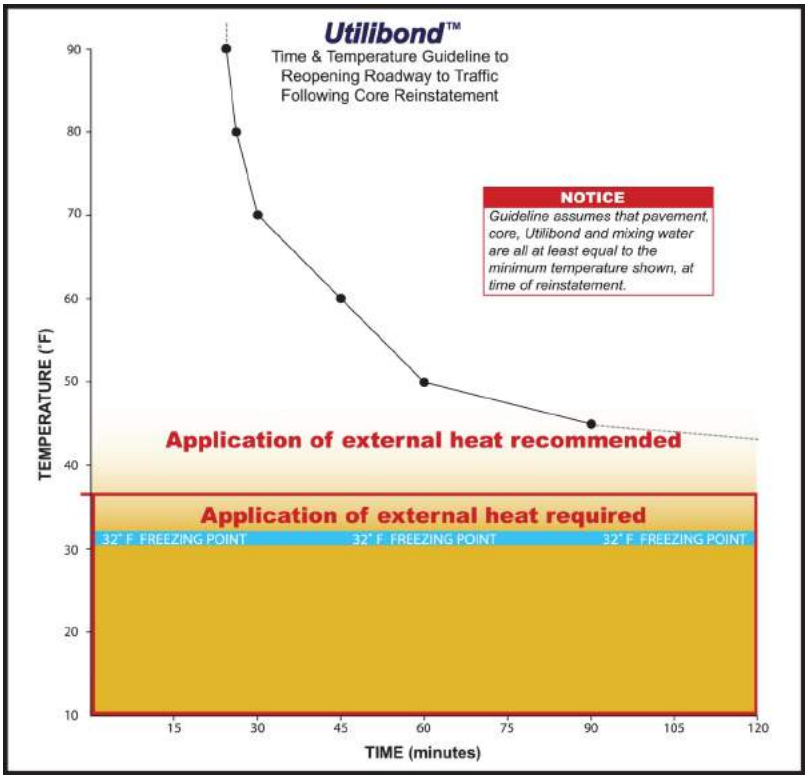
Time and Temperature Guide to Reopen Roadway to Traffic Using Utilibond™ Core Bonding Compound

Reinstatement at 70°F (21°C) - 30 Minutes to safely reopen the roadway to traffic
Cores may be safely reinstated with Utilibond™ and the roadway safely reopened to traffic in 30 minutes when the temperature of the pavement slab, core and bonding materials, including mixing water immediately before placement, are at a minimum of 70°F (21°C). At that temperature the bond strength of a typical 18-inch diameter core, 8-inches deep will be capable of supporting a wheel load of at least 30,000 lb or 3 times the AASHTO H-25 Standard, in 30 minutes after application, and the roadway can be safely reopened to traffic at that time.

Reinstatement at 50°F (10°C) - One hour to safely reopen the roadway to traffic
Cores may be safely reinstated with Utilibond™ and the roadway safely reopened to traffic in 60 minutes when the temperature of the pavement slab, core and bonding materials, including mixing water immediately before placement, are at a minimum of 50°F (10°C). At that temperature the bond strength of a typical 18-inch diameter core, 8-inches deep will be capable of supporting a wheel load of at least 30,000 lb or 3 times the AASHTO H-25 Standard, in one hour after application, and the roadway can be safely reopened to traffic at that time.

Reinstatement at temperatures BELOW 50°F (10°C)
While reinstatement of cores can be performed with Utilibond™ at temperatures as low as 40°F (5°C) because of the proximity to freezing temperatures and the danger of frost crystals forming at the bonding interface, it is recommended that a source of external heat, such as a Utilicor Core Heater, be employed to raise the surface temperatures of both the core and the surrounding pavement to 70°F (21°C) at which temperature the bond strength of a typical 18-inch diameter core, 8-inches deep will be capable of supporting a wheel load of at least 30,000 lb or 3 times the AASHTO H-25 Standard, in 30 minutes after application, and the roadway can be safely reopened to traffic at that time.

Reinstatement at temperatures BELOW FREEZING 32°F (0°C)
The Core Heating procedure can also be successfully employed to facilitate core reinstatement with Utilibond™ at temperatures below freezing, providing that the duration and application of external heat from an approved Core Heater is sufficient to raise the surface temperature of both the core and hole in the surrounding pavement to approximately 70°F (21°C) and the bonding materials, including water, immediately before placement, are at the same minimum temperature of 70°F (21°C)



As might be anticipated, the duration of heating required to achieve these results at below freezing temperatures, using an approved core heater, will vary inversely with the ambient temperature of the pavement but should not exceed 15-20 minutes in normal circumstances at a temperature down to 10°F (-21°C).

Once the surface temperature of the core and the pavement reach a sustainable 70°F (21°C), normal core reinstatement procedures can be employed and the bond strength of a typical 18-inch diameter core, 8-inches deep will be capable of supporting a wheel load of at least 30,000 lb or 3 times the AASHTO H-25 Standard, in **30 minutes** after application, and the roadway can be safely reopened to traffic at that time.

Cold Weather Core Heater Reinstatement Procedure

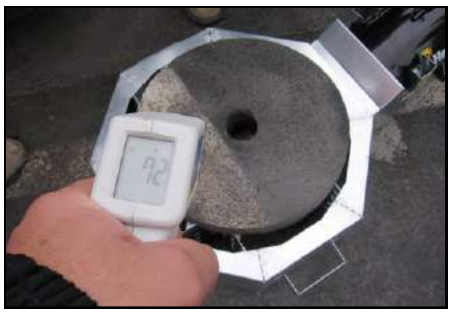
The Utilicor Core Heater should be used when ambient temperature drop below 50°F. as set up times will exceed the 30 minute target. The Core heater must be used when ambient temperatures are below 32° F.

1. Before you begin, make sure the core is dry fitted properly, as per warm weather reinstatement.

2. Place the core heater base in the hole and connect heater-blower to unit and place core on the base.

3. Place core cover on top of the Base, and open vents on top of core cover - ignite blower and position into the intake baffle.

4. Check the temperature occasionally with a non-contact infrared temperature sensor.



5. When the core reaches at least 70° F, the core reinstatement process can begin.

Note: Make sure the Utilibond™ powder is stored in a warm location, and use warm water to mix with.

6. Remove the core heater and place the core in the opening, which will keep the core warm while mixing the Utilibond™ . Once ready, remove core, pour in mixed Utilibond™ , and reinstate the core as per normal procedure.

7. The reinstated core will begin to set up within 15-20 minutes. Take intermittent temperature readings to better gauge set time.

8. At 70° F ambient temperatures Utilibond™ will reach final strength gain in 30 minutes.

9. Final core reinstated.

1. Core hole through pavement around existing valve box or location of test station.

2. Clean up area. Remove core with core puller or sunken valve box by hand.

3. After test wire is installed and hole is back filled clean the sides of the cored hole.

4. Add 1-2 inches of pea stone and install test box or new valve box

5. Using a straight edge, make sure the top of the valve box is flush with the surrounding pavement.

6. Test box or valve box is flush and ready for reinstatement.

7. Supplies required: Utilibond, water, pea stone, trowels, sponge, whitewash brush, power drill and Utilibond mixing blade.

8. Add one liter of water to the pail. (For larger areas mix both bags of Utilibond™)

9. Add bag of Utilibond™ powder to pail while mixing blade is engaged.

10. Mix for 2 minutes or until Utilibond™ is smooth and flowing.

11. Add 3 liters (3 full cups) of ¼ to ½ inch pea stone to the Utilibond™ , mix until blended together. (⅔ Utilibond to⅓ pea stone)

12. Spray outside of cored hole and test box with Utilicure™ Carefully pour Utilibond™ mixture into the hole around the valve box.

13. Consolidate the mixture into the hole to make sure there are no voids.

14. Smooth and remove excess Utilibond™. Trowel smooth.

15. Keep surface wet with whitewash brush to ensure proper hydration. Spray top liberally with Utilicure™ while setting.

16. Spray top portion liberally with Utilicure™. After 30 minutes @70°F the roadway may be safely reopened to traffic.

Delaminated Cores

Once a core has been cut, and depending on the condition of the road from which it was cut , it is not uncommon to find the core has come apart horizontally in layers… or delaminated.

This occurs most often when the top portion of the core is asphalt and the bottom section is concrete. However,often a road which has been milled and overlaid with a new layer of asphalt rolled over the older roadway, the binder used to glue the new with the old will not have adhered properly, and once the core is cut and extracted the two layers will delaminate.

By inserting the core puller all the way to the bottom of the core it is possible to remove both delaminated layers. It is also possible to use Utilibond™ to bond the delaminated layers together when reinstating the core.

The Core shown above has been removed from the roadway. The layers of the core have separated. This is a delaminated core.

How to reinstate horizontally delaminated cores:

1. Dry fit the core 1/2" lower than normal.
2. Make sure the orientation of the top portion matches the bottom portion.
3. Mark with paint if required.
4. Reinstate the bottom portion first, allowing the Utilibond™ to flow up and on to the top of the lower core - pour more Utilibond™ on top of bottom core.
5. Slowly lower the top portion onto the bottom portion and push down to level with surrounding roadway.
6. Clean up remaining ***Utilibond***™ off top of roadway and core and trowel smooth.

Core Farms

It is also not uncommon to see a core that has been cut and extracted from the road completely fall apart, and not be suitable for reinstatement.

In these cases it is possible to import a core from either another piece of roadway which is destined to be a trench or an area where a larger excavation is to be performed. In this case simply have the coring equipment cut, remove and store spare cores before actual trench or the excavation performed.

In some instances an actual "core farm" can be built where the coring crews can precut cores that match the optimal core composition and thickness. Typically these "core farms" are constructed with the same asphalt specifications that the municipality requires in their new road construction specifications and is of a similar depth profile.

A Core Farm where cores can be harvested year around as needed to replace defective cores from the field.

Overlapping Cores

The industry standard size for keyhole is 18" in diameter. However often larger or smaller cored openings are required due to differing applications. While spot locates for direction drilling facility verification can be as small as 12", it is important to remember that when the core will be reinstated there really is little to be gained by making the hole smaller than is practical for the work to be preformed.

Often there is a need to core a larger diameter hole than the standard 18" diameter. All Utilicor equipment can accommodate coring drum diameters up to 24", and a combination of these larger cored openings may even be capable of serving as a launch pits for HDD.

While not the norm, and usually due to a missed locate, it is possible to core and properly reinstate overlapping cores.

Two 18" diameter cores are cut to allow for greater access to buried facility

Two cores that have been simultaneously reinstated

A triple core cut, extracted, and reinstated as one repair

Utilibond™ is available in two colors - Aged Asphalt and Natural Concrete.

Aged Asphalt Utilibond™ is identical in composition to Natural Concrete Utilibond™ with the exception of a carbon black additive, which once cured will dry to a darker color than Natural Concrete Utilibond™. The Natural Concrete colored Utilibond™ once dried will closely match that of a typical concrete sidewalk or concrete topped roadway.

Older roadways, which are asphalt topped, have a faded appearance of being lightened in color when compared to that of a newly constructed asphalt roadway. In these cases Aged Asphalt Utilibond™ will closely match that of a asphalt roadway which has been in use for some years. However, on newly constructed asphalt topped roadways Utilibond™ can be mixed to appear even darker with the addition of carbon black - which is provided in the form of UtiliBlack™. This is especially important when working on Moratorium roads.

The 2 oz. container of UtiliBlack™ can be added to either the Aged Asphalt formulation or the Natural Concrete. Add the contents of the bottle to the supplied measuring cup then fill the cup to the 1 liter mark.

Utilibond XL™ is available to speed up the set times in colder climates.

Mix Utilibond™ as per normal.
After one minute add one or two bottles of Utilibond XL™ to the mixture and continue to mix for another 2 minutes.
For pavement temperatures:

1°C to 7°C (34°F to 45°F) add two bottles per 10 KG/22lb bag of Utilibond™.
8°C to 13°C (46°F to 55°F) add one bottle per 10 KG/22lb bag of Utilibond™.

**Set times will vary depending on conditions.

Utilicure™ is available to slow down Utilibond's rate of hydration and prevent surface cracking in hot climates.
Mix Utilibond as per normal, and reinstate the core. When you are finished the reinstatement and have cleaned up the area, spray the surface liberally with the Utilicure™.

Utilicure™ is also recommended to be used when installing valve boxes and test stations.

Core Drum Rotation Speed
The rule of thumb here is the smaller the drum diameter the faster the rotation, and the larger the drum diameter the slower the rotation. If a drum rotates too fast for its diameter, the diamond segments will be "glazed", or polished, and new diamonds will cease to be exposed. As a result the cut will take too long. Running at too slow a speed will result in premature erosion of the diamond segments and will reduce the cutting life of the segments, and result in a higher cost per cut.

Recommended Core Drum Speeds.:

• 8" Drum: 230 - 250 rpm • 12" drum: 210 -230 rpm • 18" drum: 190 - 210 rpm • 24" drum: 170 - 190 rpm

Coring Drum Segments
Coring drum segments are composed of synthetic diamonds impregnated in a specially formulated matrix. As the bit is driven into the substrate the diamonds grind away the material being cut. In the keyhole environment we are generally cutting through two very different materials: asphalt and concrete. The asphalt cutting creates slurry that is very abrasive, and contrary to conventional wisdom, even though asphalt is a softer material than concrete, it is more abrasive on the segments than when cutting through concrete.

Utilicor, through years of in-field testing, has developed a segment that provides its end users with the best of both worlds. Our ProCor™ coring drums are equipped to handle both asphalt and concrete and will provide quick and efficient core cutting action with extended drum life. This means more cuts per drum and reduced cost per core cut.

Feed and Speed
Feed and speed are the two variables the core cutter has to keep in mind when cutting a core. The correct down pressure feed rate will depend on what you are cutting through. With this in mind, all of Utilicor's equipment comes with a feed gauge and a rotational pressure gauge. We recommend a down pressure of 300 to 500 psi and a rotational pressure of 500 - 750 psi. This should result in a penetration rate of approximately one inch per minute, through asphalt, concrete or composite roadways and sidewalks. If you are taking longer than this, one or more parts of your cutting equation need to be adjusted.

Water for drum cooling slurry removal
While there are core drums designed to "cut dry", in the keyhole process we recommend always using water to cool and lubricate the drum and to carry away the slurry away that is created in coring. Water also keeps the dust down. How much water is proper amount? We recommend a ratio of approximately one gallon per one inch of core cutting. Too much water will clear away all the slurry too quickly, and it's that slurry that helps to expose the new diamonds in the segment during the coring process. Too little water will result in a thick slurry that might cause the core to get stuck inside the core barrel. You should adjust your water flow to keep the kerf area clear, but not so much that you flood the street. As a rule of thumb, for a 10" deep core, you should normally use about 10 gallons of water.

Coring Completion
When you are coring it is impossible to "see" when you are through the roadway or sidewalk. But there are a number of ways that will help you to determine when to stop cutting. If you core too far below the paved surface there is a danger that the loose dirt will work its way up into the drum and cause the core to become stuck. We have five senses, and when you use them they will tell you when it's time to stop coring and time to check to see if your core is ready to be extracted.

Sound
The Utilicor core cutting process incorporates a center pilot bit which simultaneously cuts a center pilot hole through the center of the core. This pilot bit extends an inch or two beyond the bottom of the core barrel so it will actually cut through the pavement before the rest of the drum. When that occurs, you can usually hear a change in the coring sound, and you will know that the bottom of the coring drum needs only to cut another inch or so.

Sight
Watch the color of the slurry. The slurry from the cutting of asphalt or concrete is a distinct and consistent color. As soon as the core drum cuts through the bottom of the roadway or sidewalk, the slurry coming up to the surface will look different. Watch for the change in color of the slurry, and it will help you tell when you are through. Also, watch the Hydraulic gauge that measures pressure on the coring drum. It will often spike just as the core drum cuts through the last portion of the core. When you see this spike in PSI you will know you are through and the core can be extracted.

Feel
All Utilicor coring equipment is equipped with a proportional orbital feed system connected to the steering wheel that gives the operator real time feedback from the coring operation. As you cut through different materials you will notice a different feel. Once the drum penetrates through the asphalt or concrete and into the soil beneath the pavement, the steering wheel will become easier to turn, and you will know that you are through. To check that the core is ready for extraction, stop coring, lift the drum, and stick a pry bar down the center pilot hole in the middle of the core and gently try to rock it back and forth. If it moves easily you will know that the cut is all the way through. This action will also help to break the suction between the bottom of the core and the base of the roadway.

Extracting the Core
Cores are heavy. And larger diameter and deeper cores are very heavy. Always use caution when extracting these from the roadway. Utilicor's specially designed core puller is the safest way in the industry to extract a core. The rubber stopper at the bottom will expand inside the pilot hole and the friction will create a solid hold on the core. A 4 to 5 foot pry bar can be inserted through the eye-bolt mounted on the top of the core puller and with a crew member on either side of the core the two of you can share the load and safely lift the core out of the hole. Make sure you lift with your legs - and never with your back. For cores too heavy for two crew members to lift, use the core hoist on the unit or hook the core puller to a small skid steer or backhoe and lift.

Storing and Moving the Core
Cores are circular, and when turned on their side they roll. This helps when you need to move one from the middle of the road to the side of the road. Gently tip it on its side, and roll it away. If you need to store the core for an extended period of time, and it is a hot day, store it upside down on a flat surface. Because of the way it is poured in the first place, the bottom of the core is usually uneven. On a hot day, if you rest the core on this uneven bottom, the asphalt is likely to soften allowing the core to sag or deform.

Delaminated Cores
Not every core cut will be perfect. Many older roadways have been overlaid (resurfaced) with new layers of asphalt. Sometimes entire new roadways are laid over old roadways. Every time you core it's a bit of a mystery as to what you will find. Sometimes a core will have separated between its different layers of asphalt or between the asphalt the concrete. Make sure that you insert the core puller all the way down to the bottom so that you can pull the core (and all of its layers) out in one piece. When you seek to reinstate this delaminated core, the bond strength of Utilibond™ will effectively bond the layers together.

Marking Cores for Reinstatement
Because you will be saving the core to be reinstated at a later time, it is important to mark its orientation in the roadway before you core cut and extract it. We recommend using white marking paint with two intersecting lines that will extend across the cutline of the kerf of the core. The letter V works best, as there is only one way to put it back to make the lines match up. This is preferable to an X, which due to being symmetrical can result in misinterpretation of its original orientation.

In areas when you will be cutting multiple cores, paint a number on the top of the core and mark the roadway with the same number. Reinstatement is simplified when you know which core goes in which location.

Keyhole Uses For Smart Construction

1. Daylighting for Damage Prevention

"Daylighting" can be used everywhere but is most commonly found in advance of horizontal directional drilling work. These small access holes are opened through hard surfaces to allow for visual confirmation of buried utilities in the bore line to reduce the chance of inadvertent hits to existing buried infrastructure. Not only does this process prevent damage, but a precisely cored and reinstated keyhole is better for the roadway, earier on the worker, causes less inconvi-enence to the public and saves thousands of dollars in paving restoration costs.

2. Cathodic Protection

Anode installation through a keyhole, using long handled tools is an easy keyhole application, and one every gas or water utility should adopt. Using keyhole coring and vacuum excatation to access pipes buried under pavement and long handled tools to clean the pipe and weld on the connection is simple, safe and reliable. The process is fast and efficient and the comparative pavement restoration costs are a fraction of conventional methods and can save more that $1,000 per hole..

3. Cast-iron Joint Leak Repair

Some cast iron gas pipes have been in the ground for 100 years or more and.are prone to leaks between the bell and spigot. These leaky joints can be repaired by encapsulating the joint with a boot or sealing it with an anaerobic sealant using long handled tools through a cored keyhole. The process has been used for more that 15 years and the reinstatement of the core can save entire streets from being ripped up and repaved.

4. Subsurface Utility Engineering (SUE)

Visually identifying and measuring the exact location of buried infrastructure is an essential element of the mapping of buried infrastructure before final engineering drawings are completed. SUE can save more that four dollars for every dollar invested. Using keyhole coring and reinstatement allows SUE companies to get in and out without damaging the roadway, while still obtaining the exact utility depth and location measurements required for "A" level SUE work.

5. Service Cut-offs

Cutting off a service from the main, or sectionalizing the pipe for safety reasons after a main has been abandoned, is a perfect application of the keyhole process as many gas utilities look to reduce the punitive costs of pavement rehabilitation and large cut-backs imposed by municipalities for these small openings. Tooling for these applications is readily available, and processes have been well developed over the years to cover a multitude of different types of service cut-offs using the keyhole process.

6. Valve Box Installation, Repair / Replacement.

Valve box or test station install, repair or replacement using the keyhole process results in a precise, circular-cored opening and a perfectly flush finish with the surrounding roadway. There are no overcuts one typically finds when using a road saw and a jack hammer, and the smaller cored openings can be sized to exactly fit the new valve box. This application works for both gas and water utilities. For valve boxes that have sunk, or that have been paved-over, the coring and reinstatement process is also a perfect solution when these need to be reset level with the surrounding pavement.

7. Connecting Service Laterals

Connecting a new service lateral through a keyhole to a main that had been trenchlessly installed or rehabilitated is a key element in helping to keep, what was supposed to be a "no-dig" or "trenchless" process "trenchless"… or at least as close to "trenchless" as possible. After a new main is directionally drilled and the new pipe pulled through, the service laterals can be reconnected through a keyhole using bolt-on or electrofusion saddles.

DESCRIPTION

Utilibond™ is a ready-to-use, fast setting, high strength waterproof bonding agent. It is non-metallic, non-staining, and non-toxic. Utilibond™ is specially formulated to be used for permanently reinstating pavement cores. It comes in two colors: Aged Asphalt and Natural Concrete.

WHERE TO USE

Utilibond™ is specially formulated for permanently replacing excavated cores in asphalt, asphalt and concrete, and concrete road systems and sidewalks and other paved surfaces. The rapid hydration and fast strength gain of this product allows the roadway to be reopened within 30 minutes at 70°F/21°C.

BENEFITS

Fast setting • High strength • Forms waterproof bond • Excellent freeze-thaw resistance • Very low permeability • High resistance to sulphate attack • Non-toxic • Chloride free •

MIXTURE CONSISTENCY

0.265 US gal water/22 lb (1 L water/10 kg bag)
Mix for 3 minutes until you have a smooth consistent mixture with no lumps.

PROPERTIES

Compressive Strength @ 70°F (21°C) ASTM C109

1 hour..... 1,640 psi (11.3 Mpa)
2 hour..... 2,459 psi (17.0 Mpa)
24 hours..... 6,344 psi (43.8 Mpa)
7 days..... 8,600 psi (59.3 Mpa)

Slant Shear Bond Strength @ 70°F (21°C) ASTM C882

30 minutes..... 231 psi (1.6 Mpa)
45 minutes..... 422 psi (2.9 Mpa)
1 hours..... 670 psi (4.6 Mpa)
2 hours..... 836 psi (5.8 Mpa)
4 hours..... 1182 psi (8.2 Mpa)

Punch Through Bond Strength @ 70°F/21°C

30 minutes..... 137.0 psi (0.9 Mpa)
45 minutes..... 186.9 psi (1.3 Mpa)
1 hour..... 281.5 psi (1.9 Mpa)
2 hours..... 288.3 psi (2.0 Mpa)
4 hours..... 322.0 psi (2.2 Mpa)
28 days..... 9,500 psi (65.5 Mpa)

Punch Through Bond Strength @ 70°F/21°C

Compared to AASHTO H-25 Highway Load
Factor of Safety 10,000 lbs (4536 kg) per tire
30 minutes..... 5.2 Times
45 minutes..... 6.6 Times
1 hour..... 9.9 Times
2 hours..... 10.2 Times
4 hours..... 11.4 Times

Punch Through Bond Strength @ 70°F/21°C

Compared to AASHTO H-25 Highway Load
Factor of Safety 10,000 lbs (4536 kg) per tire
0.265 US gal water/44 lb (1 L water/20 kg bag)
30 minutes..... 5.2 Times
45 minutes..... 6.6 Times
1 hour..... 9.9 Times
2 hours..... 10.2 Times
4 hours..... 11.4 Times

Length Change (Shrinkage)

(ASTM C157-91) % Shrinkage
1 day..... 0.04%
3 day..... 0.05%
28 days..... 0.06%

Chloride Permeability @ 73°F (23°C)

(AASHTO T-277-831)
0.265 US gal water/44 lb (1 L water/20 kg bag)
.....208 Coulombs

Water Absorption

(M1-67-92) % Weight Gain
0.265 US gal water/44 lb (1 L water/20 kg bag)
..... 3.67%

Salt Scaling

(MTC Method 1315)
50 cycles..... 0.467 kg/m²

The above information is representative of actual production runs. Independent test results may vary from the above by approximately ± 10 %.

PREPARATION
Remove all loose dirt and particulate from the cut surface. Wipe the cut surface of the core and substrate with a clean damp cloth or grout sponge. To help achieve maximum bridging strenth and to level the core; the core should be bedded on a 1" layer of clean ¼" pea gravel.

MIXING
Each 22 lb (10 kg) bag of Utilibond™ should be mixed with .265 US gallon (1 L) of clean water. Open the Utilibond™ pail. Remove the bags of Utilibond™ from the pail. Determine how many bags of Utilibond™ are required. (See Usage Chart) For each bag to be consumed add .265 US gallon (1 L) of clean water to the pail. Add the Utilibond™ mixture to the water in the pail while mixing. Mix for 3 minutes until you have a smooth consistent mixture with no lumps. Use Utilibond mixing blade.

CURING
Utilibond™ will begin to cure in less than 15 minutes @ 70°F/21°C. Be sure all surface areas are properly prepared before mixing.

LIMITATIONS
Not recommended for use on substrates below 32°F (0°C) (see cold weather procedures).
Not recommended for structural bonding applications.
Not suitable for acid exposure.
Maximum service temperature 350°F (176°C).
Minimum kerf thickness ¼" 6.5 mm.

COVERAGE
See Usage Chart

STANDARDS
Approved for use in reinstatement of pavement cores.

PACKAGING
Utilibond™ is packaged in 22lb (10 kg) multi-wall bags. 2 bags are packed in a 5 US gallon (18.9 L) along with a 1L measuring cup and sealed polyethylene pail.

CLEAN UP
Clean all mixers and tools with water before product hardens.

STORAGE
May be stored short term anywhere as long as the product is sheltered from UV light. Dry, heated warehouse storage is recommended for extended storage.

SHELF LIFE
Two year shelf life when stored in original packaging. If stored outside, polyethylene pails should be covered or protected from extensive exposure to sunlight or UV rays.

SAFETY PRECAUTIONS
Consult Safety Data Sheet (S.D.S.) for specific in-structions.

WARRANTY
The recommendations made and the information herein are based on our own laboratory and field experience, and are be-lieved to be accurate under controlled conditions. However, no warranty or guarantee of accuracy is made because we cannot cover, nor anticipate, every variation encountered in weather and job-conditions, methods used and types of substrates to which the product is applied. The users should make their own tests to determine the suitability of this product for their pur-poses Utilicor™ makes no other warranty, express or implied, and hereby expressly disclaims a warranty of merchantability or fitness for a particular purpose.

The liability of Utilicor™ shall be limited in all events to supplying sufficient product to re-treat and/or repair the specific reinstate-ment for which Utilibond™ product has been used. Utilicor™ reserves the right to have the true cause of any difficulty or failure determined by accepted test methods. Utilicor™ shall have no other liability, including liability for incidental, consequential or resultant damages, however caused, whether due to breach of warranty, negligence, or strict liability.

THIS WARRANTY MAY NOT BE MODIFIED OR EXTENDED BY REPRESENTATIVES OF Utilicor™, IT'S DISTRIBUTORS OR DEALERS.

Core Diameter (inches)

Core Depth (inches)	24"	22"	20"	18"	16"	14"	12"	10"	8"	6"
20"	3	3	3	3	2	2	2	2	2	1
19"	3	3	3	3	2	2	2	2	2	1
18"	3	3	3	2	2	2	2	2	1	1
17"	3	3	3	2	2	2	2	2	1	1
16"	3	3	2	2	2	2	2	2	1	1
15"	3	3	2	2	2	2	2	2	1	1
14"	3	3	2	2	2	2	2	1	1	1
13"	3	3	2	2	2	2	2	1	1	1
12"	3	3	2	2	2	2	1	1	1	1
11"	3	2	2	2	2	2	1	1	1	1
10"	3	2	2	2	2	1	1	1	1	1
9"	2	2	2	2	2	1	1	1	1	1
8"	2	2	2	2	1	1	1	1	1	1
7"	2	2	2	2	1	1	1	1	1	1
6"	2	2	2	2	1	1	1	1	1	1
5"	2	2	1	1	1	1	1	1	1	1
4"	1	1	1	1	1	1	1	1	1	1

1 1 TP bag 2 2 TP bags 3 3 TP bags

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