Diamond Tools and Equipment
for Construction and Infrastructure

Abrasive Chainsaws Found to Decrease Kickback Risk When Cutting Pipe in a Trench

Study Indicates That Abrasive Chainsaws Are Safer Than Circular Cutoff Saws

Saw operators who have experienced a kickback event with a circular cutoff saw will say that they didn't do anything out of the ordinary but experienced an unexpected phenomenon. This type of event takes place in just 20 milliseconds – the blink of an eye, flash of a camera or flap of a bee's wing. Because human reaction time is about 250 milliseconds (over 10 times longer than a kickback event), operators don't have the chance to react or get out of the way, oftentimes leaving them to wonder what just happened and what went wrong.

Abrasive saws, like many power tools, carry inherent risk, and many are also regulated to cover their basic and intended use applications. One exception is the lack of regulation around the unique way circular cutoff saws are used for cutting pipe in the trench (e.g., water/sewer/storm pipe), which requires operators to reposition the blade guard to complete the job. As a result, this specific application poses serious risks that are not conveyed or addressed by any published safety standards.

Because construction professionals use circular cutoff saws for many types of cutting jobs, including cutting pipe above the trench on new construction projects, they are very comfortable with the tool and tend to default to using it in the trench as well. However, while circular cutoff saws have many safe and appropriate uses in construction, their inherent design makes them a riskier choice for cutting pipe in a trench.

When operators are working in tight spaces below grade with a circular cutoff saw, they often end up positioning themselves awkwardly and holding the saw differently, which results in less control. Additionally, when nearing the end of the cut, only a small section of material typically remains on the underside or belly of the pipe, and the operator must reposition the blade guard to access it. At this point in the cut, the pipe is the least stable, the guard is completely ineffective, the chances of kickback are the highest and the operator's direct exposure to the blade is the riskiest.

Quantifying the risk and dangers of kickback with any saw has always been a difficult task. ICS Diamond Tools (ICS), a division of Blount International, has long been interested in collecting kickback data to determine if and how much alternative cutting methods could help decrease risk in the trench – and how that information could be used to inform regulation to make conditions safer for operators. To gather data, ICS engaged a world-leading research university in 2017 to conduct an independent study to measure the differences in kickback energy between circular cutoff saws and abrasive chainsaws when cutting pipe in the trench. The results of this research can be found in the peer reviewed article "Investigation of abrasive saw kickback" published in the International Journal of Occupational Safety and Ergonomics in 2020 [2] https://doi.org/10.1080/10803548.2020.1770529.

According to OSHA, kickback is one of the main hazards of using a circular cutoff saw, with injuries primarily to the head and neck area, resulting in lacerations, missing teeth or even fatalities [1].

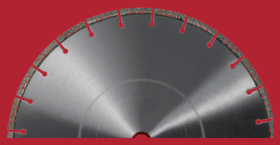
According to published research, an abrasive chainsaw has a significantly smaller kickback zone and generates nearly 50% less kickback energy than a circular cutoff saw, making it a safer choice for operators cutting pipe in the trench.

Common abrasive saws used in pipe cutting

Few professionals associate chainsaws with pipe cutting, and those who consider them an option assume the kickback risk would be greater because they liken it to wood-cutting kickback. Yet, the two types of kickback have distinct differences. This flawed assumption is yet another reason in addition to familiarity that operators default to using the circular cutoff saw in the trench.

Wood-Cutting Chain

Wood-Cutting Blade



Abrasive Blade

Abrasive Chain

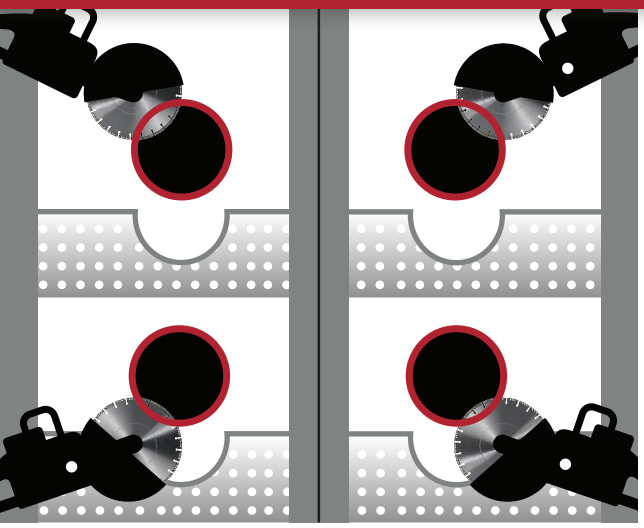
What is kickback?

The Occupational Safety and Health Administration (OSHA) defines kickback as an event "when the blade 'catches' the stock and throws it back toward the operator." Because a kickback event happens faster than the average human reaction time, it's uncontrollable – even for the most skilled operator. Kickback events have nothing to do with the mastery of the tool and everything to do with the saw and specific circumstance, in this case, in a trench. Furthermore, kickback is difficult to measure. Although it has been studied in some settings, the complexities of cutting pipe in a tight trench make this form of kickback one that's not well known or well understood and therefore overlooked as a risk.

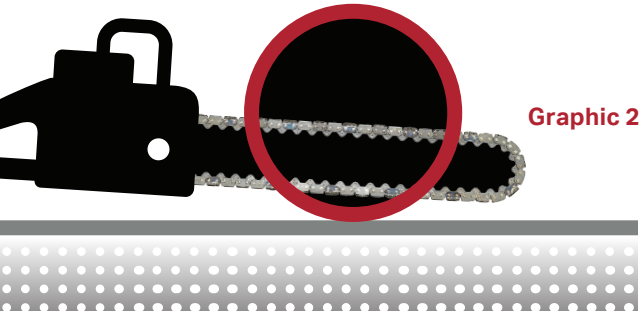
Wood-Cutting vs. Pipe-Cutting Kickback:

Wood-Cutting Kickback: Caused when the sharpened teeth on the wood-cutting chain or blade bore into and grab the wood.

Pipe-Cutting Kickback: Unlike wood-cutting kickback, this kickback doesn't happen from sharpened teeth boring into the work material. Rather, the abrasive chain or blade is made to grind through the material, so kickback happens when it is pinched by the work material.



Graphic 1



Graphic 2

Differences between circular cutoff saw and abrasive chainsaw methodology in the trench

When a circular cutoff saw is used for pipe cutting in a trench, more excavation is required so the operator can move around both sides of the pipe and get beneath the pipe to make an upward cut that removes the last strap of the pipe. To make the final cut, the operator must reposition the guard of the circular cutoff saw, which exposes them to the kickback zone when the pipe is most likely to pinch (see Graphic 1).

When an abrasive chainsaw is used in the trench, less excavation is required because the length of the bar offers increased cutting depth – and also allows the operator to remain stationary and make a top-to-bottom cut with more control. The inherent design of the chainsaw means the kickback energy is lower, the kickback zone is significantly smaller and engagement of the kickback zone is not required to complete the cut (see Graphic 2).

The goal of the independent research was to compare these two types of saws that are most commonly used in the trench, quantify their kickback energy and identify a safer saw solution that would lessen the kickback risk for the operator.

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Why are abrasive saw standards needed?

Kickback is one of the biggest hazards of using a circular cutoff saw and can cause injuries or even fatalities – especially when the guard is repositioned. OSHA mandates that the safety guards must never be repositioned [3], yet this is a common practice when cutting pipe with circular cutoff saws because the operator must cut under the pipe to completely sever it. While there is currently regulation for wood-cutting chainsaws that Blount helped champion with the U.S. Consumer Product Safety Commission in the 1980s, it is lacking for abrasive chainsaws specific to pipe-cutting projects in the trench.

As previously mentioned, circular cutoff saws are not regulated for this specific application because the guard must be repositioned to complete a pipe-cutting job in the trench, which exposes the operators to the kickback zone when the pipe is most likely to pinch (refer to Graphic 1 above). Adding to the inherent risks are the stresses that can build up in underground pipes over time due to natural soil movement. This is partly what causes pipes to break and need repair, and when these same stresses are released at the completion of the cut, this can also cause a pipe to shift unexpectedly and pinch the blade or chain.

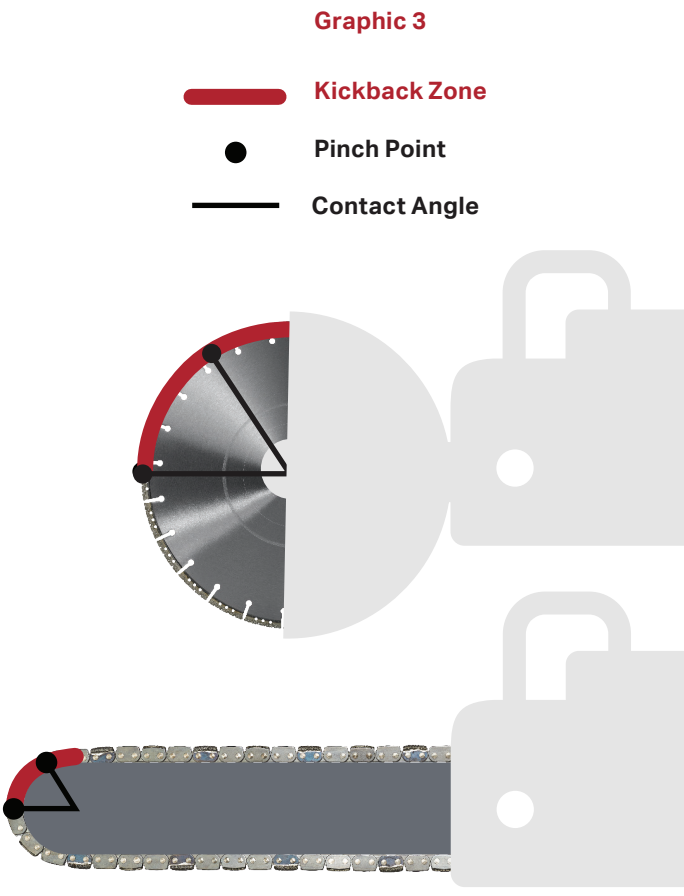
Research findings on kickback

The independent research, outlined in the published article, studied pinch-derived kickback in an effort to predict kickback risk. The lower the kickback energy and smaller the kickback zone, the less likely it is that a kickback phenomenon will occur. To evaluate pinch-based kickback for circular cutoff saws and abrasive chainsaws, a mathematical model was developed and a kickback machine was designed, built and tested. Research and data collection focused primarily on studying the effects or sensitivities of initial contact angle and pinch force on resultant kickback energy.

Contact Angle: In real-life pipe-cutting jobs, contact angles vary according to the operator's positioning, the saw orientation and the cut they're making. The contact angle defines where along the periphery of the kickback zone the pinch occurs (see Graphic 3). The highest kickback energies tend to occur within a very small range of contact angles. Above and below that contact angle of peak energy, kickback energy tends to fall off rapidly. From a risk characterization perspective, researchers identified peak kickback energy for each saw, so data collection focused on these specific contact angles, which were different for the circular cutoff saw and abrasive chainsaw.

- Experimental data aligned with the mathematical model, which predicted more energy across the range of contact angles for the circular cutoff saw and established the initial contact angle at which each saw will exhibit peak energy.
- When a circular cutoff saw is used to cut through the pipe, the blade's orientation and the operator's grip on the saw shift throughout the process (see Graphic 1). This means a variety of contact angles are engaged, including the contact angles that exhibit peak energies.

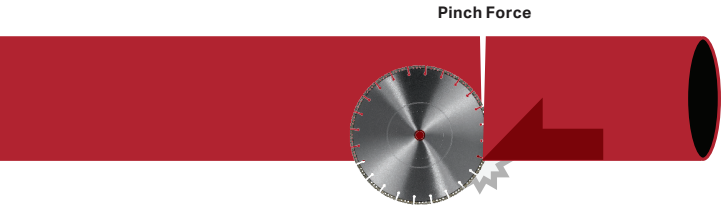
Graphic 3



Research findings continued

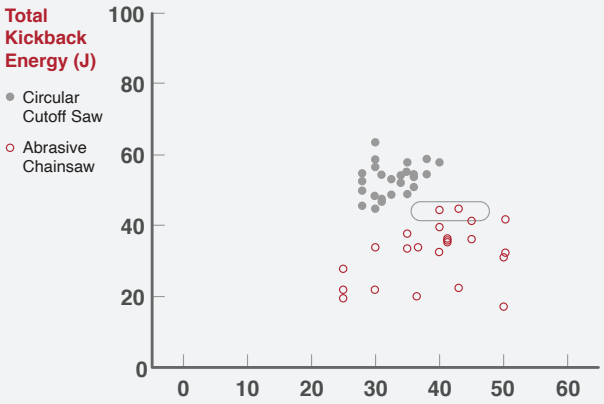
Pinch Force: Pinch force happens when the work material pinches the saw blade, often right before the pipe is completely severed in two pieces.

- When testing at a moderately high pinch force (2,100 newtons), the abrasive chainsaw sometimes caught the nose in the pinch mechanism, stopping the chain entirely. This suggests a limit for the amount of pinch force and represents the highest observed kickback energy of the abrasive chainsaw (~45 joules; see Graph 1).
- Conversely, the circular cutoff saw didn't get caught in the pinch mechanism at 2,100 newtons. To better understand the limit for this type of saw, the pinch force was increased incrementally up to 4,000 newtons before the saw reached its observed peak kickback energy (~80 joules). This was nearly double the kickback energy of the abrasive chainsaw (see Graph 2). To help visualize the energy generated in a kickback event, a fastball thrown by an elite baseball pitcher has about 110 joules of energy.
- At higher pinch forces, the abrasive chainsaw exhibited more variation in the data than the circular cutoff saw. This is likely attributed to the non-uniformity of the abrasive chain. However, the data still match fairly closely to the predictions of the mathematical model and are still valid for comparing kickback energy and risk.



Graph 1

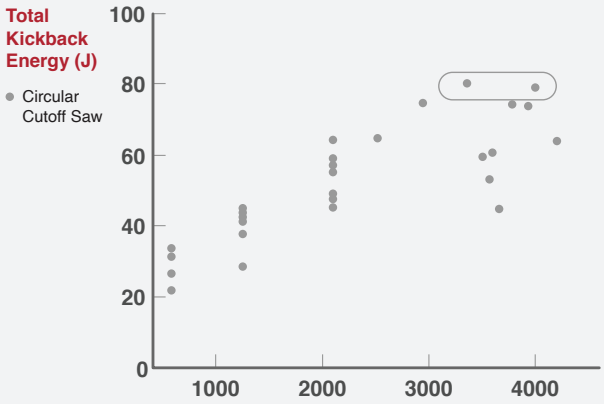
Total Kickback Energy at Constant Pinch Force - Circular Cutoff Saw Versus Abrasive Chainsaw



Constant Pinch Force = 2100 N

Graph 2

Total Kickback Energy at Constant Initial Contact Angle - Circular Cutoff Saw



Constant Initial Contact Angle = 31°

Linear and rotational data components of the kickback energy were removed from these graphs. Please view published article to see this information.

Key takeaways

The research study was able to compare and quantify the kickback energies of a circular cutoff saw and an abrasive chainsaw. Results found the kickback energy of the circular cutoff saw to be nearly twice that of the abrasive chainsaw given the same environmental conditions. This data indicates that using an abrasive chainsaw is the safer option for cutting pipe in the trench compared to a circular cutoff saw.

How to decrease risk in the trench

While not included in this research, other alternative cutting tools that reduce risk in the trench include guillotine saws, universal pipe cutters, snap cutters and the like.

Visit https://icsdiamondtools.com/kickback-study to view the full independent research study, connect with an expert to learn more about safer alternative cutting methods or request a free demo.

[1] https://www.osha.gov/SLTC/etools/woodworking/kickbacks.html#Common%20Hazards / https://www.osha.gov/SLTC/etools/machineguarding/saws/tablesaws.html#Kickbacks

[2] Steven Burcat[a], Brian Yue[a], Alexander Slocum[a] & Tal Cohen[b] (2020) Investigation of abrasive saw kickback, International Journal of Occupational Safety and Ergonomics, DOI: https://doi.org/10.1080/10803548.2020.1770529 [a]Dept. of Mechanical Engineering, [b]Dept. of Civil Engineering, Massachusetts Institute of Technology, Cambridge, MA USA

[3] https://www.osha.gov/Publications/osha3080.html