The Importance of Weld Stringer Beads

Welding procedure specifications (WPSs) often specify stringer weld beads, and may even prohibit weave beads. Weld stringer beads look different from weave beads, and more importantly, they may have significantly different mechanical properties.

When a WPS is created, a qualification weld is made according to that WPS. The qualification weld is tested for strength and ductility, usually at room temperature, and sometimes for toughness (impact resistance), usually at lower than room temperature. The WPS will specify if stringer beads are required, based on how the test weld was made. If the test weld was made with stringer beads, then it will specify that production welds also be made with stringer beads. This is especially important for welds that will be used at low temperatures.

At low temperatures, usually lower than room temperature, ferritic steels become increasingly brittle, and less resistant to cracking. A WPS that was made with stringer bead welds and proven by testing to be adequate for a particular application, may not meet the same test requirements when made with weave bead welds. The finished weld may be too weak, too brittle, or lack the toughness to meet the same rigor as that of the test weld on which the WPS is qualified.

Welding technique, the motion of the welding electrode or welding torch during the welding process, determines whether a weld bead will be stringer or weave.

So how can an engineer or an inspector tell if a finished weld meets the requirements of a WPS for stringer beads? This article is intended to show the visual differences so that even a casual observer can easily identify Stringer Bead welds from Weave Bead welds in finished welds.

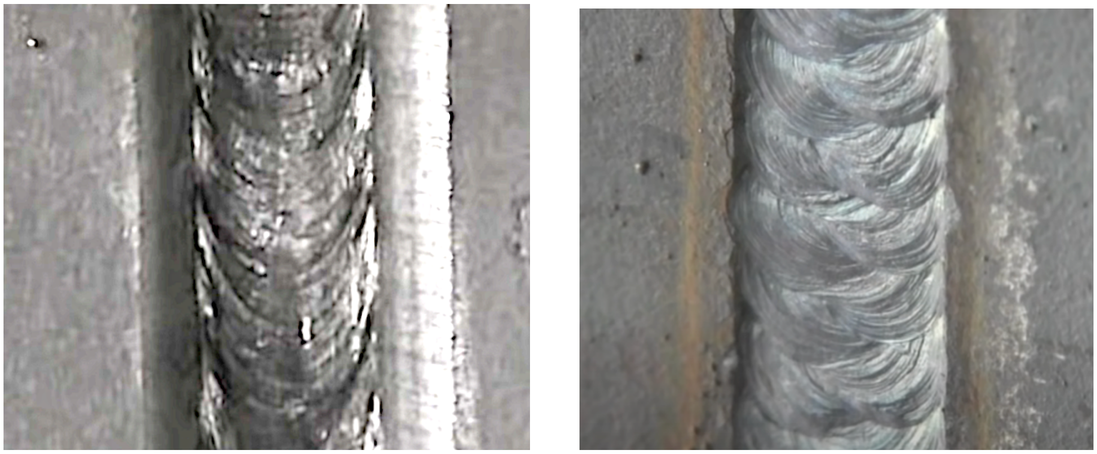
Identifying Stringer Beads and Weave Beads in Finished Welds

When inspecting welds for WPS compliance, it is important to be able to identify the two types of weld beads: stringer beads and weave beads.

AWS D1.1 (2020) definitions of Stringer Beads and Weave beads do little to clarify how these weld beads look:

> stringer bead. A type of weld bead made without appreciable weaving motion.
> weave bead. A type of weld bead made with transverse oscillation.

Better descriptions, with pictures, can help identify stringer beads and weave beads in finished welds. See Figure 1.



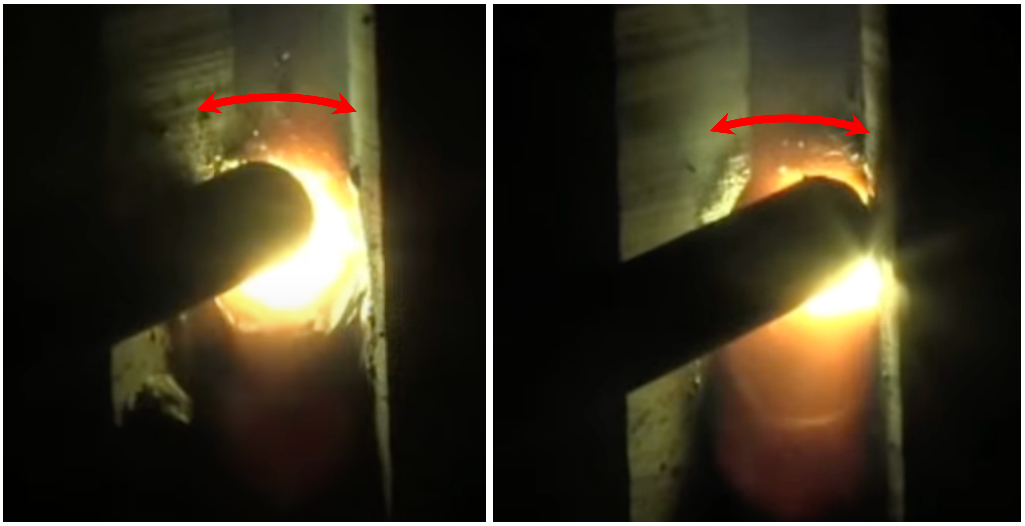
A B

Figure 1: (A) a Stringer Bead Weld showing ripple patterns that appear as a single row of crescents, sometimes called stack of dimes (Collier, 2015, 2:24)[1]. (B) a Weave Bead Weld showing ripple patterns that appear as a parallel (side by side) row of overlapping crescents: side by side crescents overlapping within the single weld bead (Collier, 2015, 4:10)[1].

As shown in Figure 1, the distinct difference in the appearance of stringer beads from weave beads is that stringer beads display a single row of crescent-shaped ripples within each weld bead, whereas weave beads display parallel, overlapping crescent-shaped ripples within each weld bead.

Stringer Beads

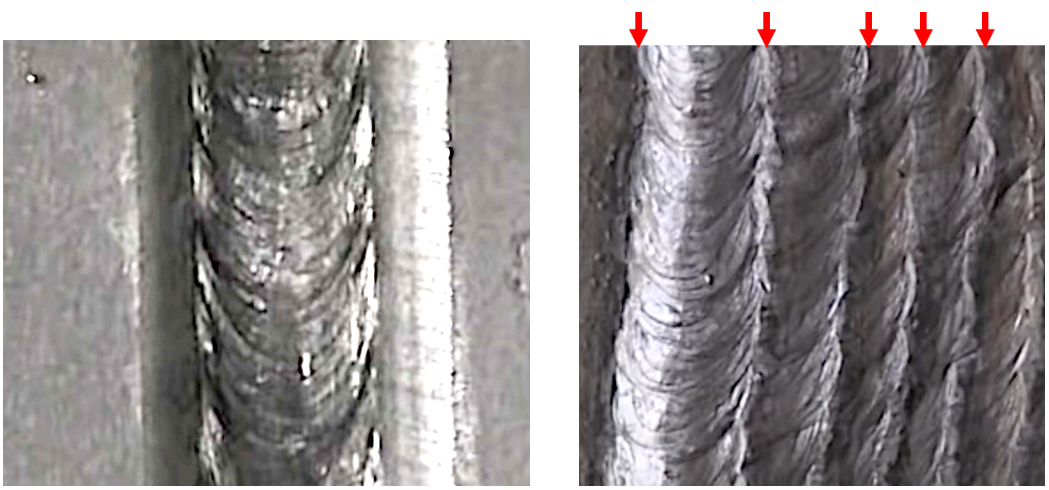
As stated in the AWS definition, stringer beads are made "without appreciable welding motion." Collier (2015, 1:08, 4:27) demonstrates sideways motion that is limited to about the width of the welding electrode, which is 1/8-inch diameter (not including the flux coating). See Figure 2.



A B

Figure 2. (Collier, 2015 1:06). A and B showing welding electrode movement from side to side (red arrows). The gap between plates is ¼ inch and the welding electrode is 1/8-inch diameter. Electrode motion is about 1/8 inch from side to side to ensure side wall tie in.

Limited rod motion, or *stirring the puddle*, by about the width of the welding electrode is acceptable for making stringer beads, and may be necessary to properly tie the weld pass into the base metals and into previous weld passes. The final weld beads will look like those in Figure 3, showing a single row of crescent patterns (ripples) within each weld pass.



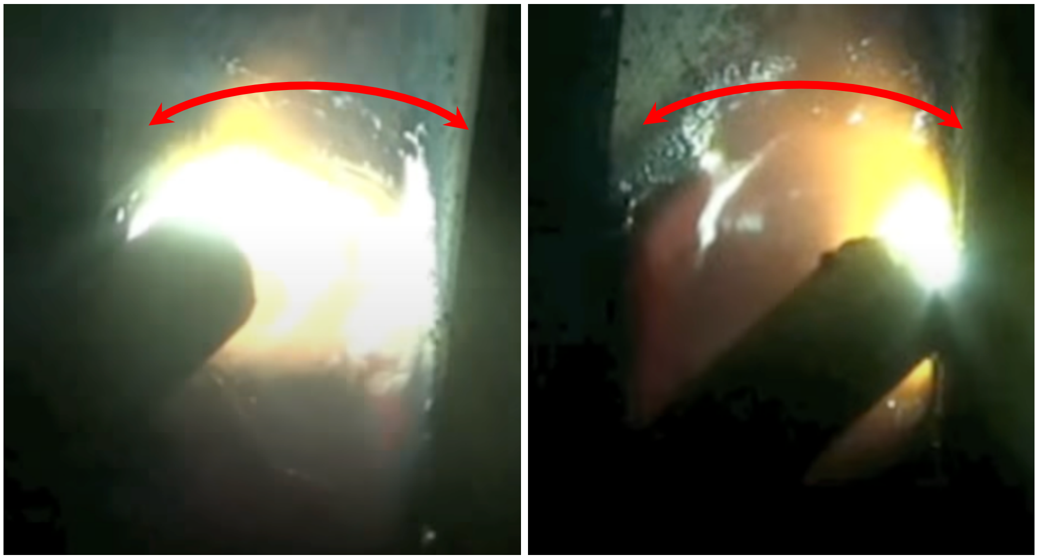
A B

Figure 3. (A) A single stringer bead (Collier, 2015, 2:24) shows a single row of crescent shaped beads. (B) Multiple stringer beads (Collier, 2015, 11:18) show single crescent shaped beads each of which stop at the fusion zone (indicated by red arrows) of each weld pass. Crescents do not overlap between the fusion zones.

As Figure 3 shows, stringer beads display a single row of crescent-shaped ripples that terminate at the weld bead fusion zone.

Weave Beads

Weave beads are made by oscillating the welding electrode from side to side, relative to the direction of weld travel. The oscillation swings from side to side considerably wider than the width (diameter) of the welding electrode, and wider than that which produces stringer beads. See Figure 4.



A B

Figure 4. A and B (Collier, 2015, 4:00) showing welding electrode movement from side to side (red arrows). The gap between plates is ¼ inch and the welding electrode is 1/8-inch diameter. Electrode sideways motion is sufficient to allow the weld puddle to freeze on each side of the weld bead.

Figure 5. The weld bead produced by the weave bead technique shown in Figure 4 (Collier, 2015, 4:10). The side by side, overlapping crescent-shaped ripples result from weld puddles freezing on each side of the weld bead.

Weave beads display overlapping, parallel crescent-shaped ripples that may be likened to basket or hair weave patterns.

Vertical Up Welds

Vertical-up welds are sometimes made with a weave bead technique because of a mistaken belief that weave beads keep the molten weld pool from sagging due to the effects of gravity. However, Collier (2015)[1] demonstrates SMAW vertical up welding with both stringer and weave beads. Collier (2022)[2] also demonstrates GTAW vertical up welding with stinger beads.

Both videos dispel the idea that weave beads are needed to keep weld beads from sagging when welding vertical up. In actuality, maintaining proper heat input allows the weld puddle to freeze before it has time to sag. Weaving the weld bead does not help, and can actually cause sagging of the weld beads because of the excess heat input of the weave technique.

Importance of complying with the WPS

A WPS is a written instruction to the welder. It specifies a range of welding variables so that a weld that is made within those variables can be expected to have the strength, toughness, and crack resistance as that of the qualification test weld, which is the basis for qualifying the WPS for a particular application.

The American Welding Society (AWS) welding code recognizes that welds made with stringer beads have different toughness than welds made with weave beads.[3] Welds are required to be qualified by testing for stringer bead welds and also for weave bead welds, whenever toughness is a criterion of the production weld. Weave bead welds are not qualified with stringer bead welds.

Welds that do not meet the requirements of the qualification test weld violate the AWS Welding Code, and also cannot be expected to meet whatever toughness may be required for a particular application. Welds that do not meet the requirements of the WPS should be rejected or corrected.

Conclusions

Recognizing stringer bead welds and weave bead welds in finished welds is often easily done by comparing finished welds with those shown in Figure 1. Weave bead welds cannot be expected to meet the same mechanical strength, toughness, or cold weather fracture resistance as that of stringer bead welds. For that reason, it is important that engineers, inspectors, and welders are capable of recognizing welds that meet the requirements of the applicable WPS, and recognizing those that do not.

References

1. Collier, J. (2015, March 24). *Stick Welding Tips Vertical 7018* [video]. YouTube. https://www.youtube.com/watch?v=1QxT7JUjs94. [Images are used with permission of the video creator.]
2. Collier, J (2022, July 27). *Tips for Passing a 3G Aerospace Weld Test AWS D17.1* [video]. YouTube. https://www.youtube.com/watch?v=h84Y5Ydbhcs
3. American Welding Society, Structural Welding Code - Steel, AWS D1 .1/D1 .1 M:2020, 24th edition. Table 6.7 (11).