Issue: HDPE seam defects we cannot see – Panel discussion presentation given by R. Thiel

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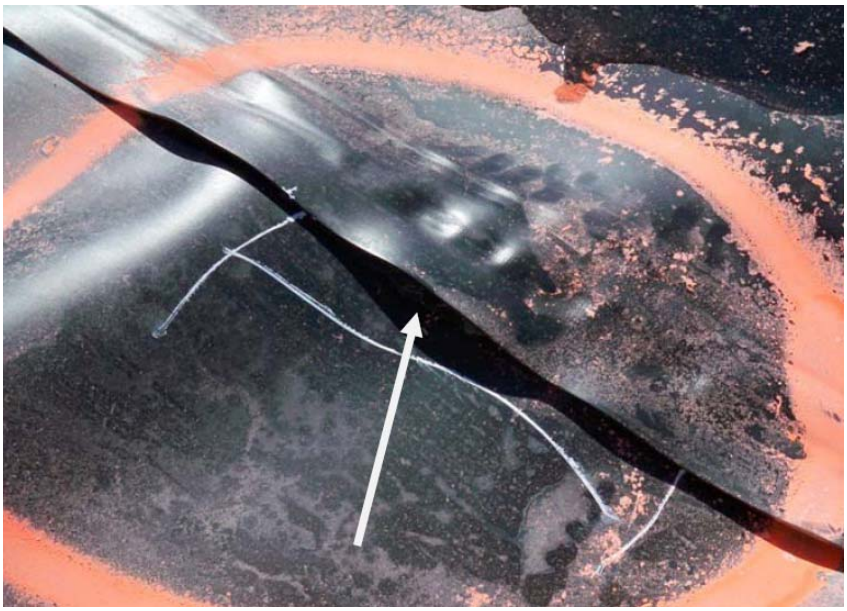
1. Rip in fusion seam on lower sheet, adjacent to the outside weld track, under the flap due to (?)
2. Cuts under the fusion seam weld flap caused by ?
3. Overheated extrusion welds that fail after a few days or weeks of expansion contraction, or the application of a light load

General observation: all of the above welds appear to be perfectly constructed based on visual appearance; and all pass the "standard" non-destructive tests (air channel for fusion; vacuum box for extrusion).

Type of non-visible weld defect	**Suspected causes**	**Possible detection measures**
Rip in fusion seam on lower sheet, adjacent to the outside weld track, under the flap	a) Re-alignment of welding machine, often with a jerking motion, as it is running, especially on hot days	1. Vigilant observation of every weld operation and marking of any alignment adjustments 2. Hand probe or air lance all flaps 3. Water-puddle/lance ELL survey (NEED TO GO SLOW AND GET WATER UNDER THE FLAP)
Cuts under the outer flap of fusion seam	a) Trimming the upper sheet b) sharp material (e.g. rock) caught on the machine plate	1. Vigilant observation of every single cutting procedure and allowing only hook blades 2. Vigilant cleaning of debris 3. Water-puddle/lance ELL survey (NEED TO GO SLOW AND GET WATER UNDER THE FLAP)
Incipient tear in lower sheet of extrusion welds that fail after a few days or weeks	a) Excessive thermal input causing large deformations, thinning of sheet, and stress-concentrating crimps under the weld bead b) Excessive grinding of lower sheet outside the weld zone	1. Vigilant observation of every single extrusion weld for both preparation and execution 2. Moderate field stress (e.g. "kick") all extrusion welds after one week of exposure 3. Other? (e.g. IR)



View from above – perfect looking fusion seam.

Dramatic example of rip under the flap.

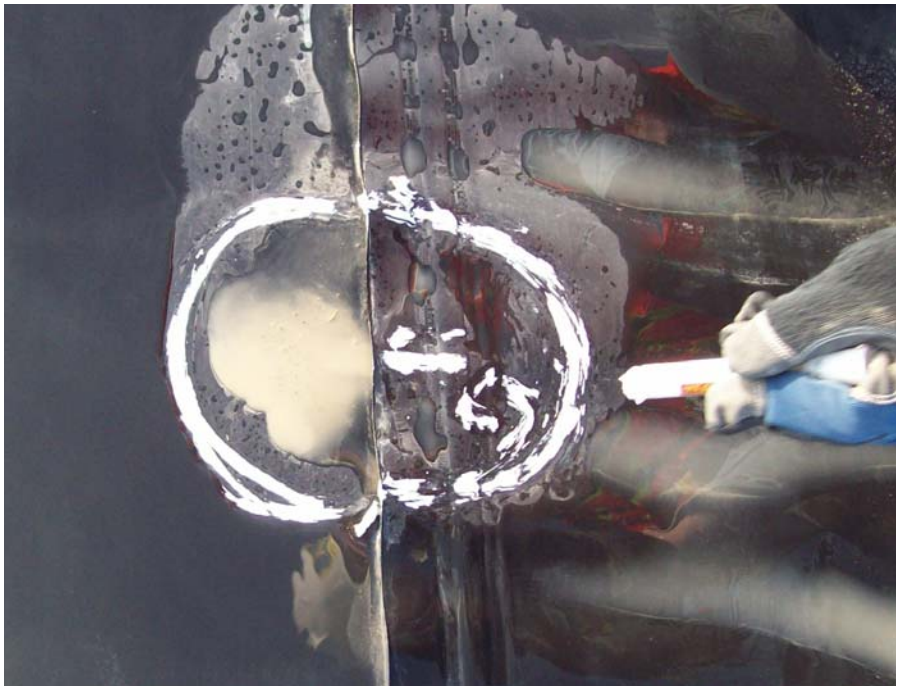
Another close up view of the tear under the flap in 1.5 mm HDPE. Destructive seam tests immediately before and after this location indicated perfect results, and inspection of the seam cross section looked perfectly good.

Another location with the lower sheet torn under the flap at the edge of the seam, where the seam looks perfect from above, and destructive tests immediately before and after the problem areas indicate good quality seam.

Tear under the flat that would never have been found without water lance survey.

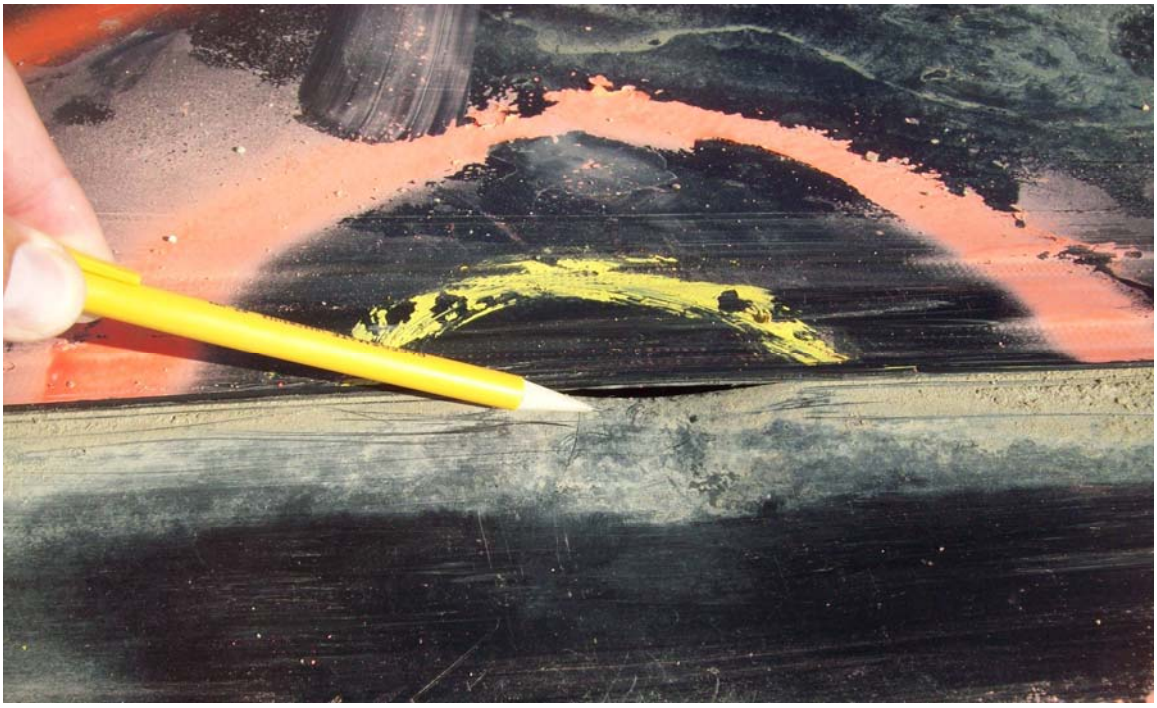
Stepping on the weld just behind the machine, while weld is still hot, to preserve alignment and work with wrinkles

Re-aligning maching during welding



Leak under flap: Seam appears perfect from above.

Seam separation appears when flap is lifted, although air channel is intact.



Seam separation is clearly visible after the flap has been completely cut away.

Extrusion weld cracks open after a week of exposure – it is a tear in the lower sheet that has been severely thinned.

Same story as above – two separate tears in lower sheet. Note QC sign-off on the patch.

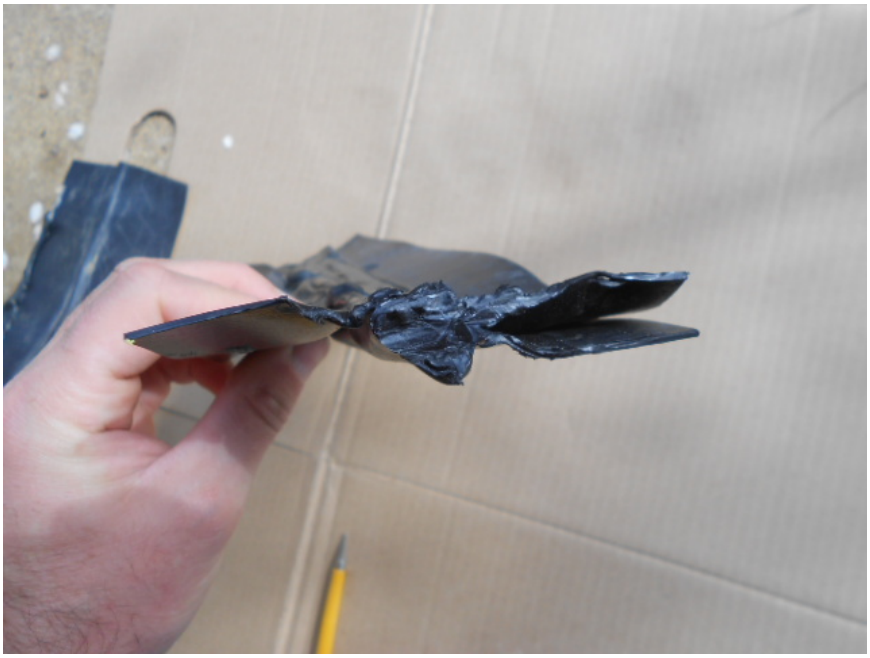
Tear in lower sheet that propagated months later.

View of cracked extrusion weld.

View of severely overheated extrusion weld from below.

Bottom side of overheated extrusion weld.

View from top, and…



…view from side showing extreme overheating.

How did we find these defects? Some were by good visual inspection and poking arounds. Others were by water lance surveys. In fact, not only these problems, but many other problems have been found by ELL surveys that would never have been located any other way, and this is even with good installers and good CQA.