Updated: 27/06/18

Low-Energy X-ray inspection: Pouches seal inspection

1. Pet food packages (100 g)

This report covers 24 samples of pet food packaging. The packages are both defect free and with various deviations in conformity. All samples are taken from the production line. The samples are about 130 mm long, 85 mm wide and 10-25 mm thick. Scanning was accomplished at about 15 m/min, with a maximum possible speed of 27 m/mi, using an InnospeXion standard HYMCIS low-energy X-ray system.

Fig. 1. Example on the two varieties of pet food packages considered

Test Images

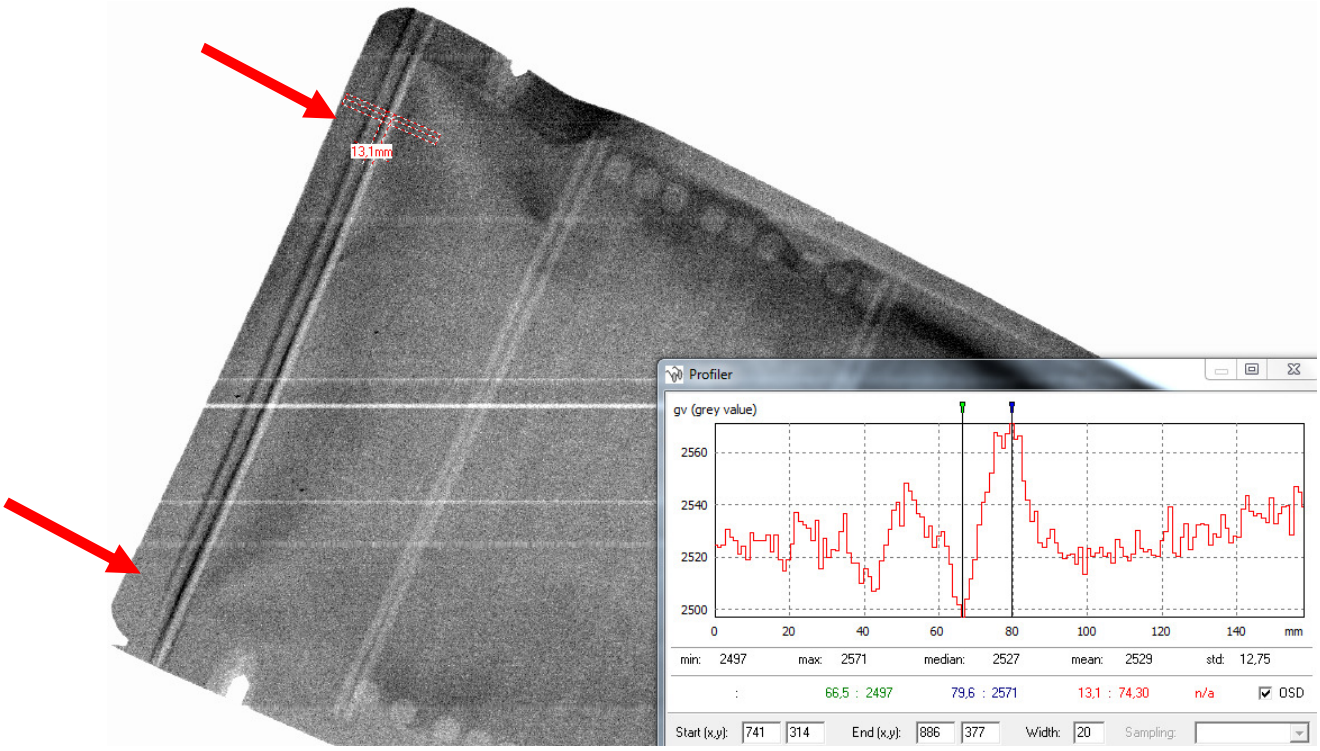

Fig. 2. The seal is tilted and there are density variations. E.g., at the lower arrow, the outer (dark) seal line is missing, while it at the arrow at the upper part is well defined. The grey level density curve shows the seal definition by a clearly identifiable dark line, followed by a bright line. This conforms to the structure made by the sealing machine.

Fig. 3. A similar example for another pouch: the seal is ill-defined at the bottom compared to the top.

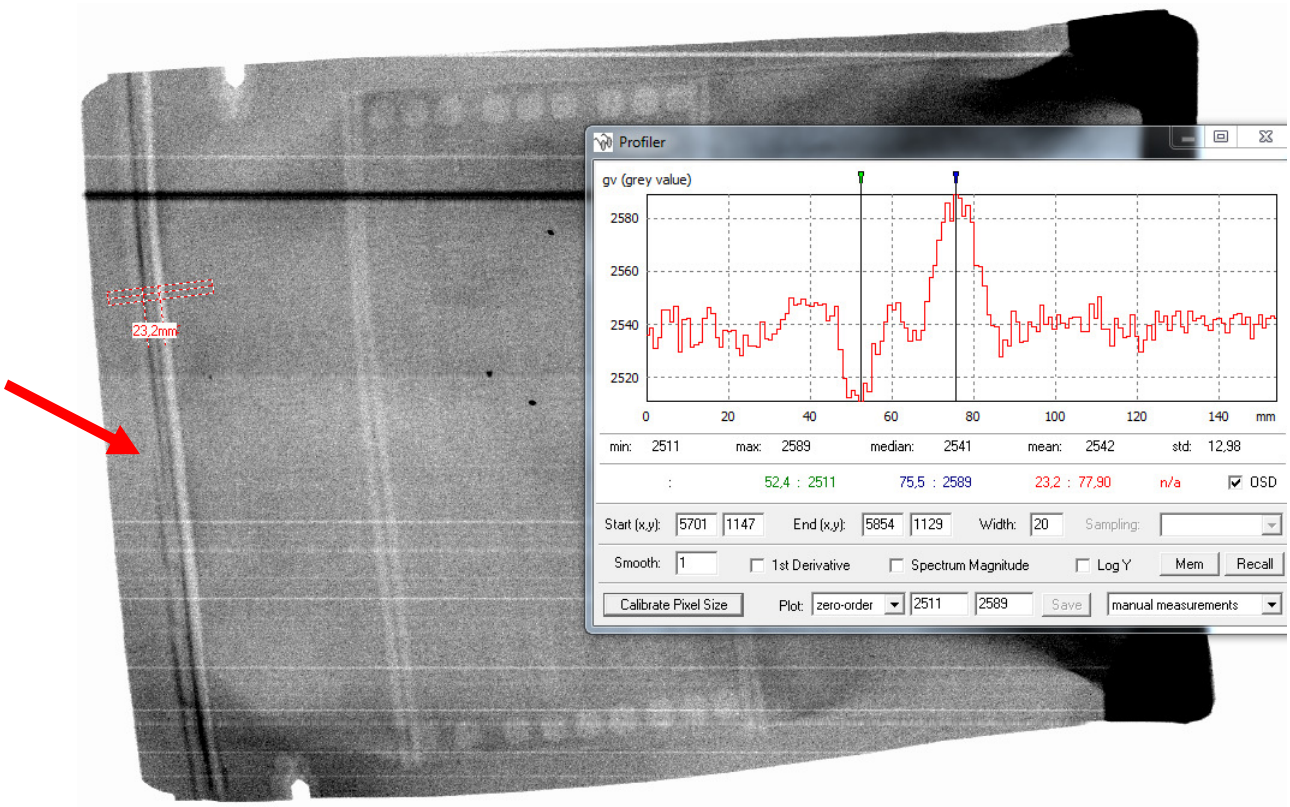

Fig. 4. This pouch unveils a weak seal which is interrupted midway (arrow). The pouch is likely to leak.

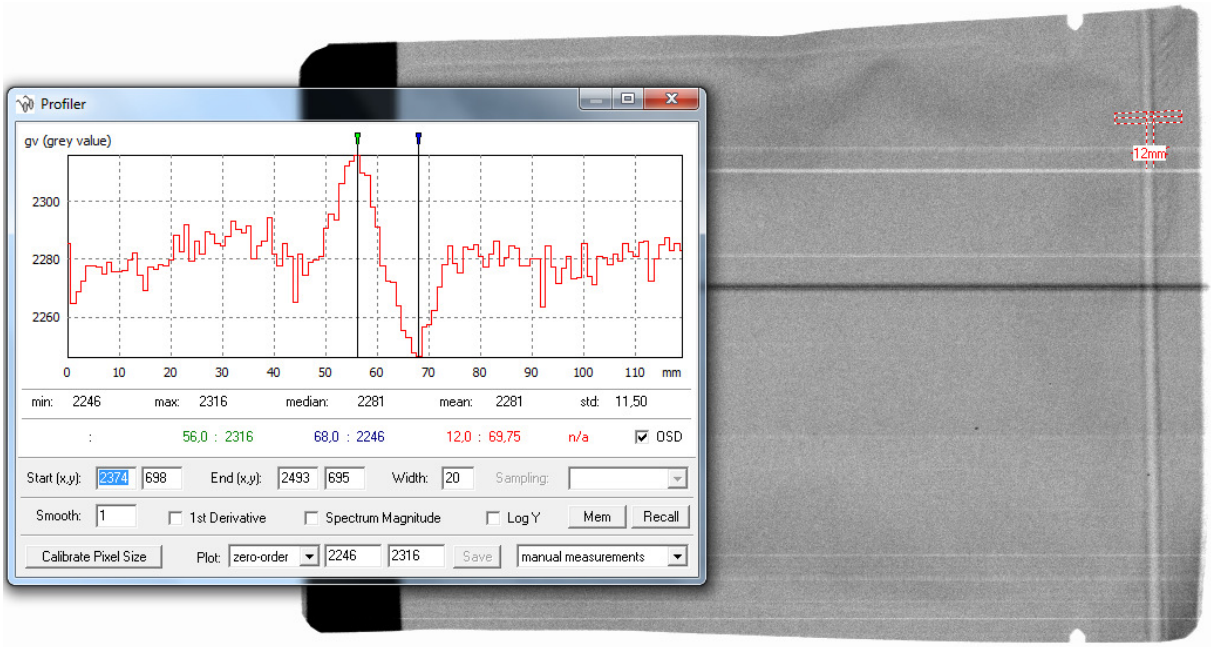

Fig. 5. The seal width varies by approximately 0.2 mm from top to bottom (wider). Note that the seal line is very pronounced relative to the samples above.

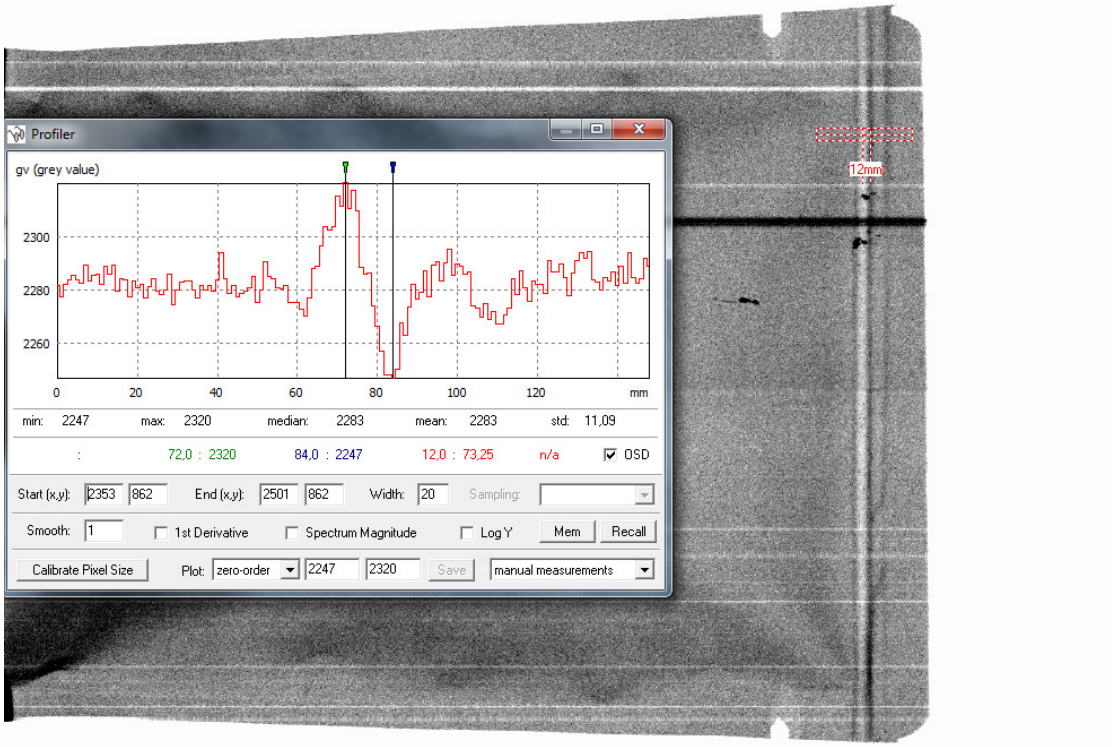

Fig. 6. Sample with a couple of wrinkles in the seal. There is a distinct higher density of the seal at the lower right (distinct black area).

2. Food Pouch inspection 400 g.

The results below summarizes the functionality for a HYMCIS solution for the on-line inspection of medium-sized food pouches. The pouches are conveyed through the system on the system built in conveyor, featuring a thin special conveyor tape. The speed is maximum 2 pouches per second at a belt speed maximum of 27 m/min. The pouches are fed into the system with the sealing PARALLEL to the conveyor motion direction.

The pouches considered are presented in Fig. 7.

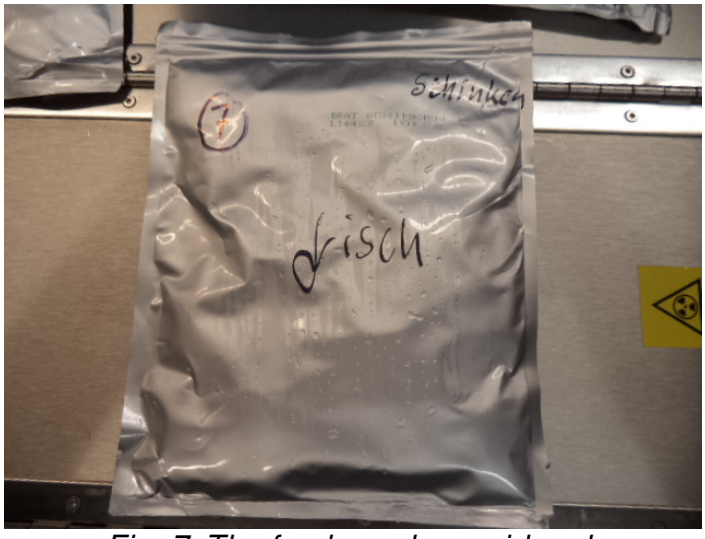

Fig. 7. The food pouch considered.

The system will automatically inspect and classify the pouches according to the following:

1. Misaligned seal (out of tolerance – tolerances defined by Xx);
2. Fold or other defect in seal
3. Missing sealing (minimum dimension/width of the missing seal is likely > 5 mm)
4. Product in seal
5. Foreign object in product
6. Product mass out of tolerance

The system will categorize as follows for pouches that cannot be correctly classified:

- Irregularly conveyed pouch (misaligned)
- Dirt (water etc) on pouch
- Dirt (water etc) on conveying belt or in other parts of the imaging "chain"
- Highly irregular pouches (out of shape)

Please note in particular, that the system is very sensitive and will detect even very thin contaminations in the seal. Therefore, water droplets etc will give false rejects.
Typical performance is as follows:

- (Seal) False positives: < 1 %
- (Seal) False negatives: < 3 of 100
- (Foreign object) False positives: < 0.5%
- (Foreign object) False negatives: < 3 of 100

Precision of tolerance for mass determination to be agreed upon.
Note that the ratio between false positives and false negatives depends on the dimensions of the defect.
For a proper classification, a table with the established probability of detection relative to the defect dimensions is established.

Product in-feeding

In order to ensure safe detection of defects and a low false reject rate, the samples must be imaged without obvious defects such as strong misalignment, package curvature etc.

As it is well known that the pouch seal area may fold or bend, the X-ray system may include a feature so that the seal is presented straight during the imaging, e.g. as described in Fig. 10, straightening out by a set of rollers that carry/conveys the seal across the X-ray imaging area.

The system imaging capability

Below is described typical defects in packages, and how the software automatically detect these defects.

The image below in figure 8 shows a package without any defect (except a small fold in the middle). The welding in the sealing are seen in the X-ray image as 2 bright lines and the distance between these welding zones are expected to be about the same for all packages. The image shows the distance to be 7.7 mm and it is measured using a profile and finding the points for the two highest GLV (Gray Level Value). The welding zone is about 2450 in GLV and about 2490 for the area in rest of the sealing.

If there are defects in the product it will be shown in the X-ray image as dark zones. This will be shown later in this report. For the package from the image below the edge is wrinkled which is also shown as a dark zone in the X-ray image. When packages are wrinkled like this, the wrinkled area will not be possible to inspect, since a real defect will look quite similar on an X-ray image.

To avoid the packages are winkled, when scanning, a set of rollers may be used, just before scanning, which will flatten out the sealing. Figure 9 shows a package with wrinkled seal, which might be rejected, because it looks like contamination in seal. The sealing in this package will be flatten out with a roller, and a false reject will be avoided. In figure 9 we also see that the distance between the welded zones are too small, which indicates wrinkled sealing.

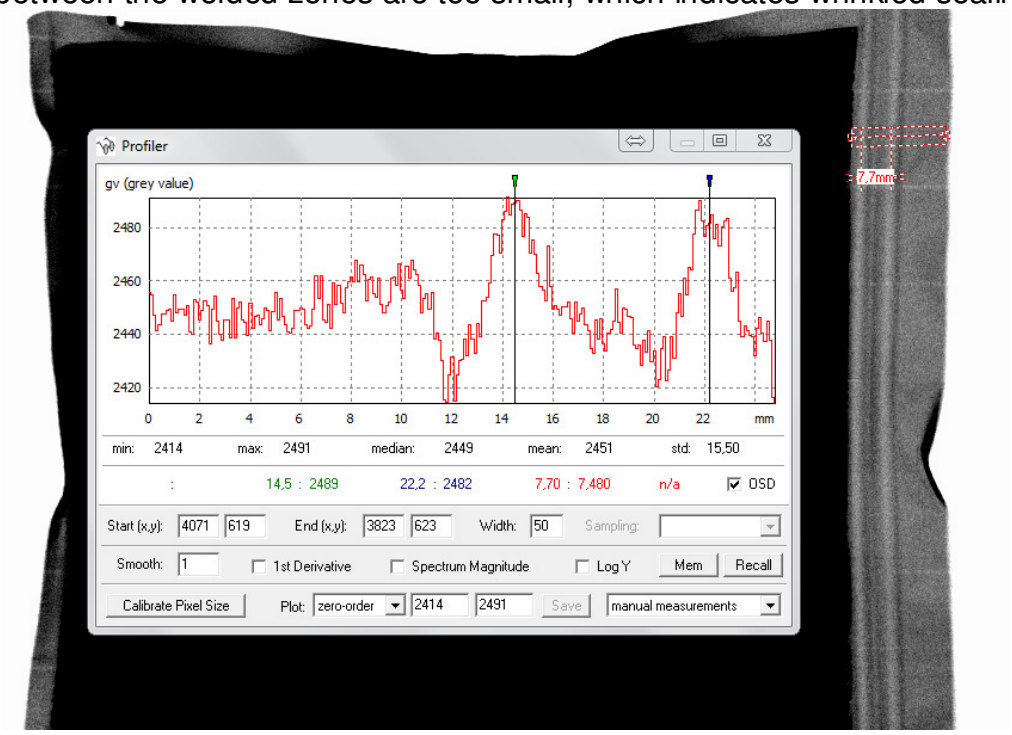

Figure 8

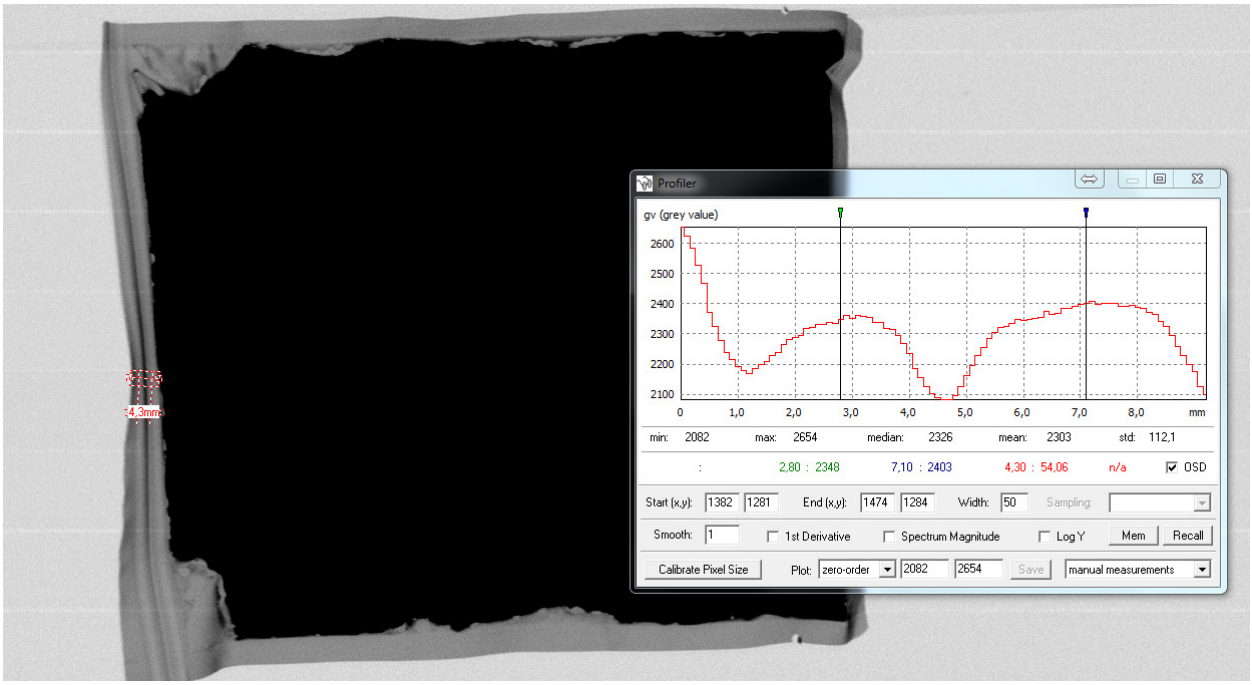

Figure 9 Wrinkled seal

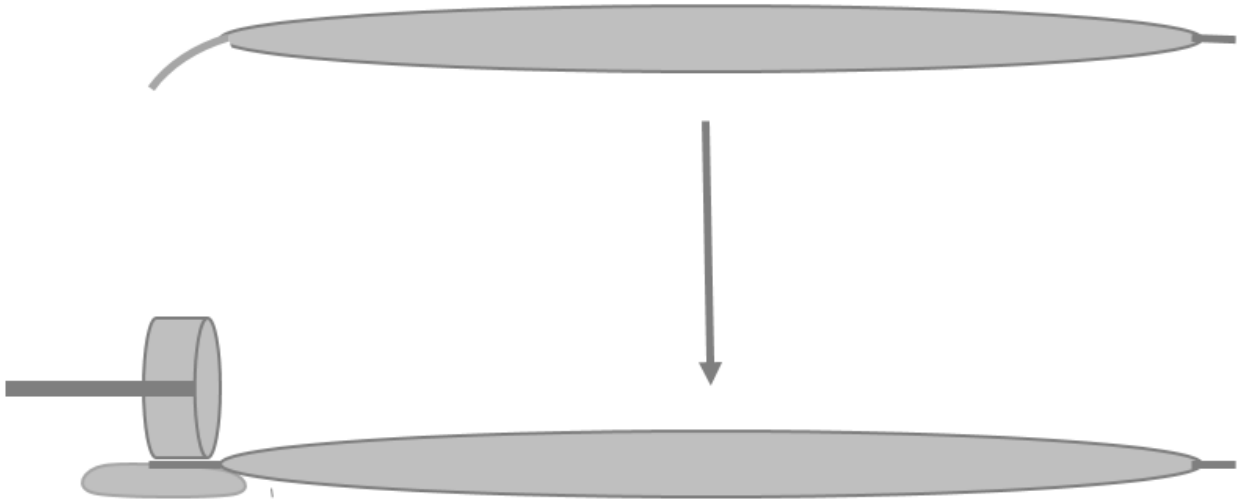

Figure 10 drawing of a roller arrangement for straightening out possible folds in the seal area

Defects

1. **Product in seal (vapor)**
   Using same profile lines in the sealing as mentioned above, we find the two welding zones and when inspecting between these zones, we will find dark areas (Low GLV - 2225), compared to rest of the sealing. That means there is contamination in beetween the welding zones and can easily be detected.

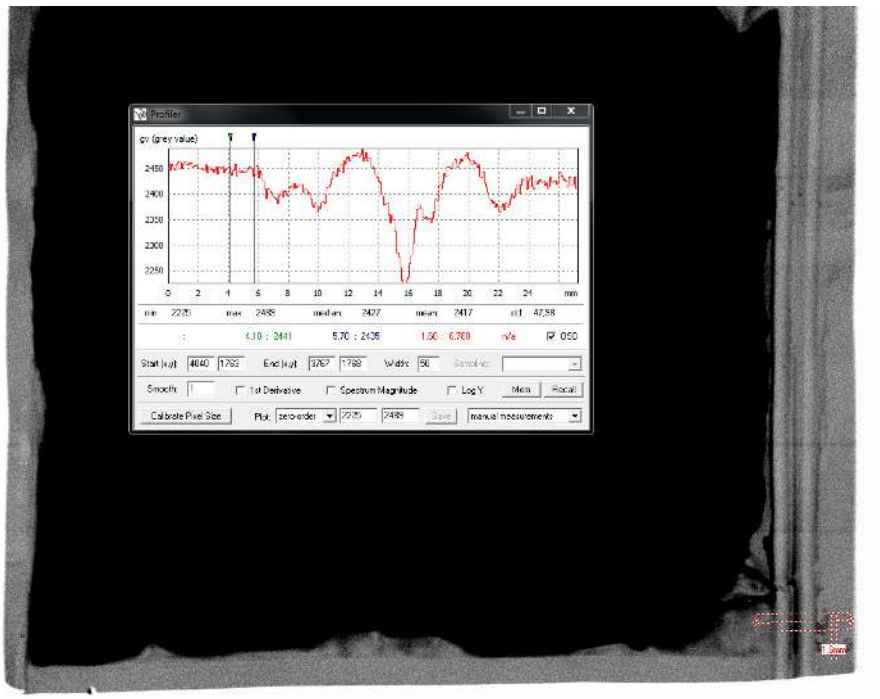

Figure 11 Minor seal contamination by product, lower right.

2. **Missing seal**

Welding zone (crest/bead of the weld) are missing in the middle of the sealing (outer seal missing). This defect can easily be detected, since in that area, only one welding zone (the inner, defined by the crest/bead of the weld) can be detected. In the area with missing weld zone, the GLV is the same as outside of the weld sealing, which also can be seen from the profile plot.

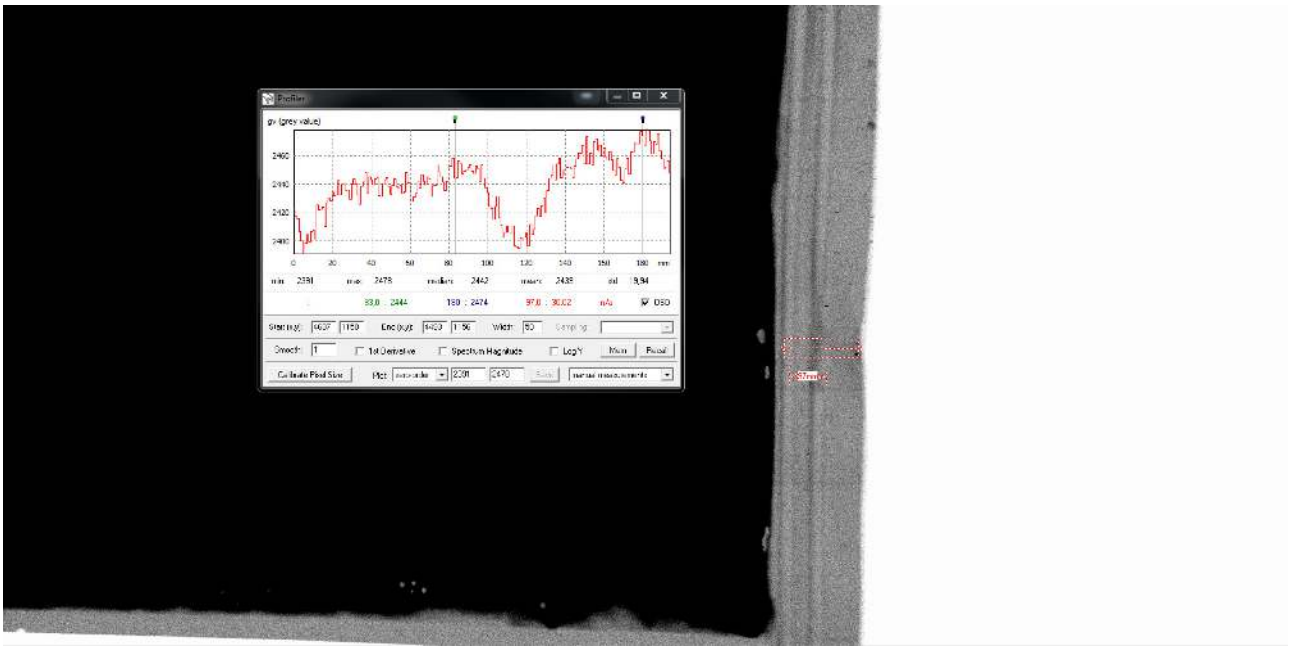

Figure 12. Missing outer seal

3. Folds in sealing

In this image (Fig. 13), the folds in the packages are very clear. Also by analysing the sealing area with vertical profile lines, the folds shows up with very low GLVs compared to rest of the sealing. This can be seen in figure 14.

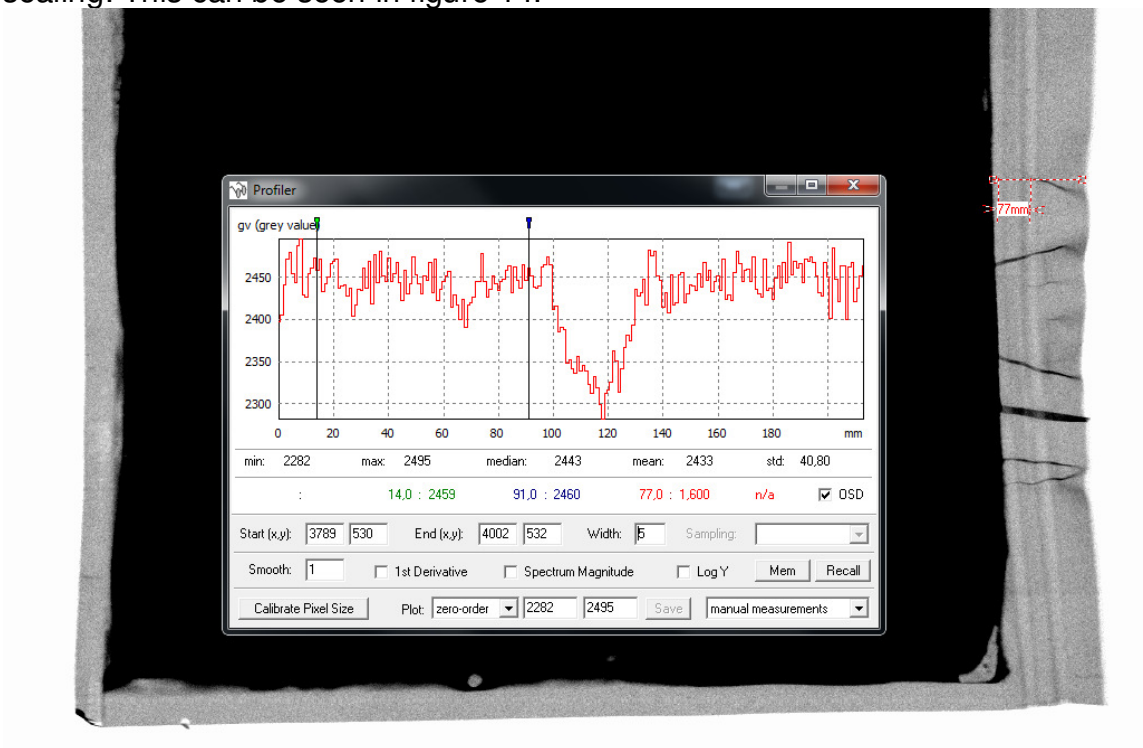

Figure 13. Folds in seal

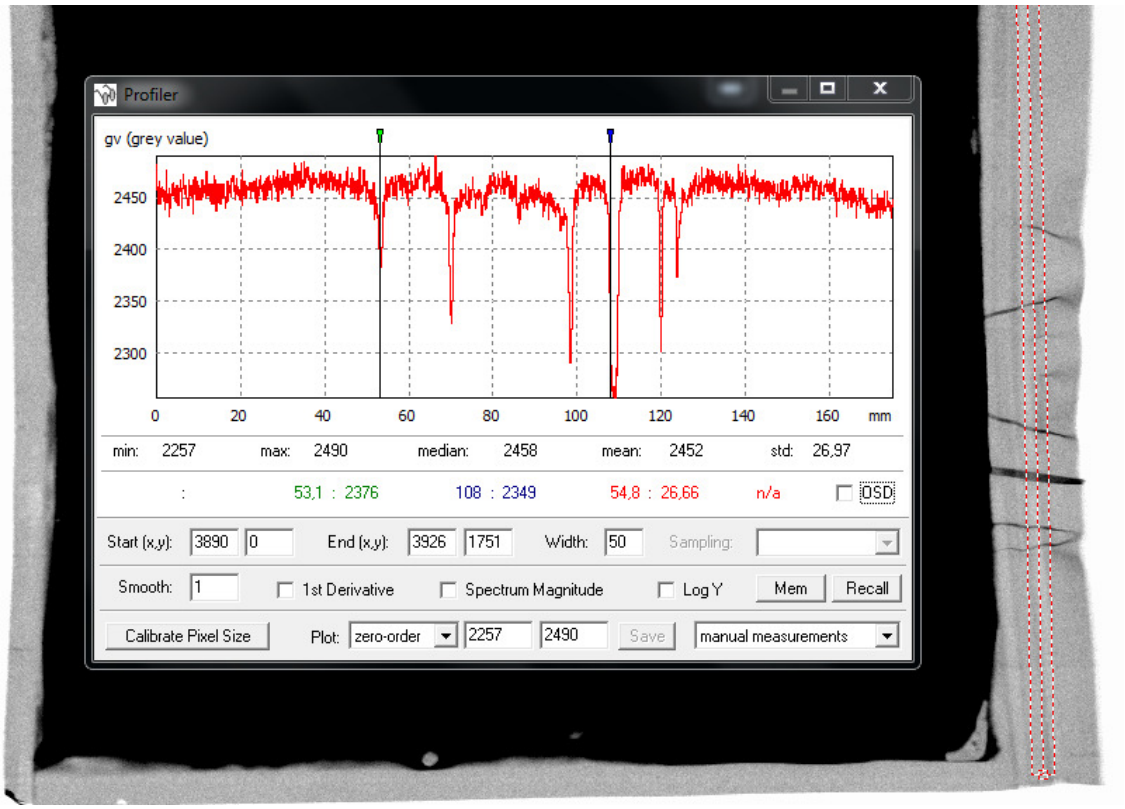

Figure 14 Folds in seal, vertical profile across these shows distinct "dips" coinciding with the folds.

4. **Product in seal (vapor)**

Analyzing and detection is similar to #1, above.

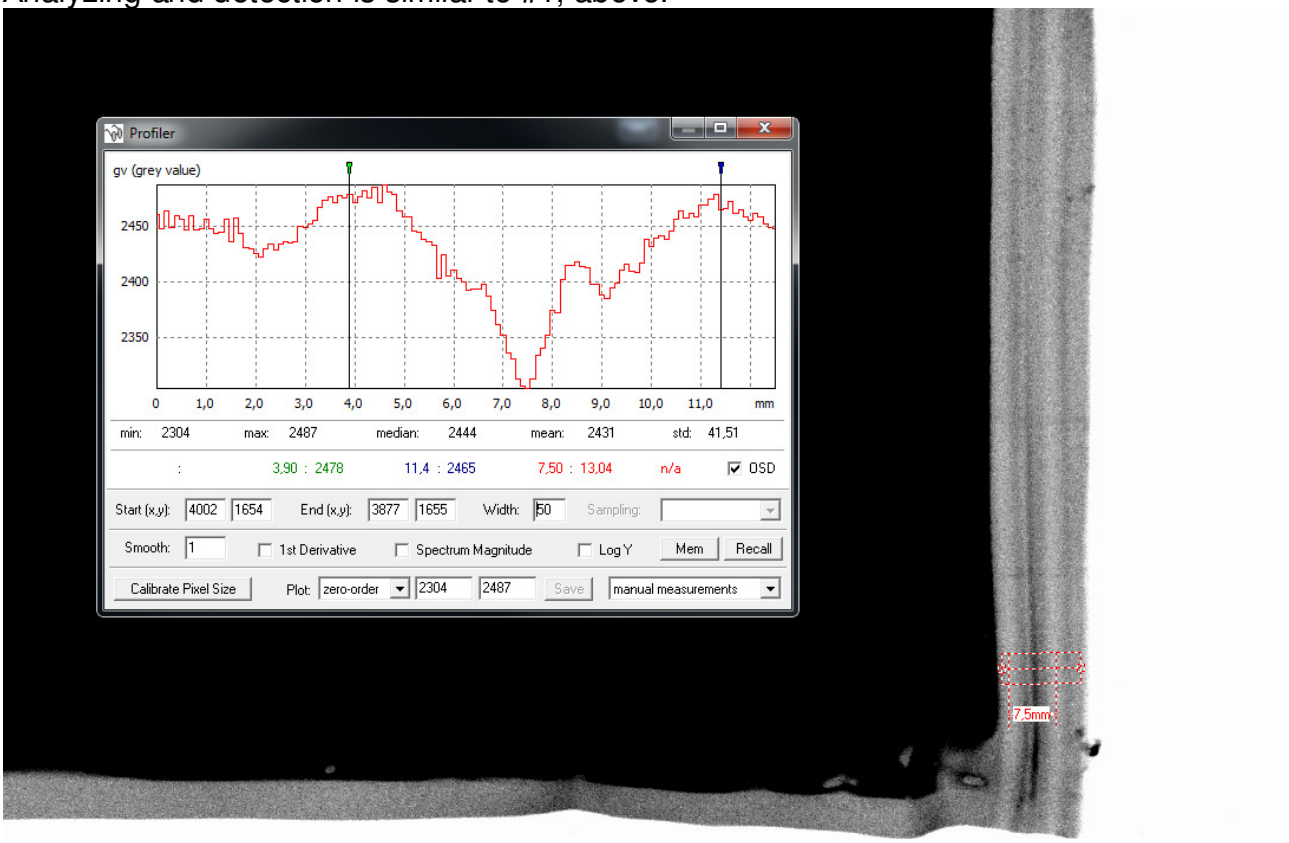

Figure 15 Product (water/vapor) in lower right of the seal

6. Meat entrapped in seal

Meat has a very high density (high attenuation) compared to the seal area and is easily detected both with horizontal and vertical profile lines. GLV for the meat is below 2100.

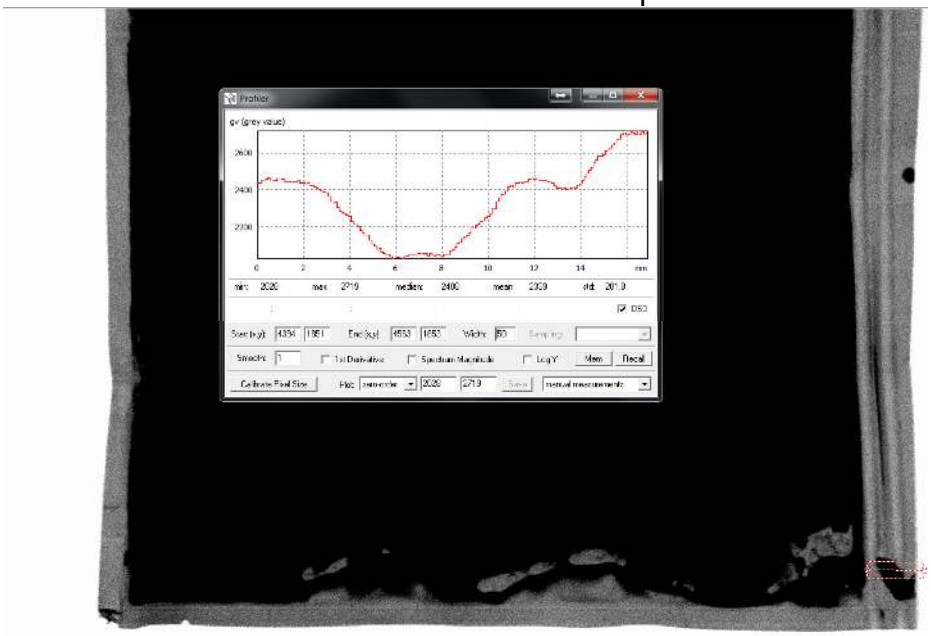

Figure 16 Product (meat) entrapped in seal

7. Ham entrapped in seal

Analyze and detection is similar to #6

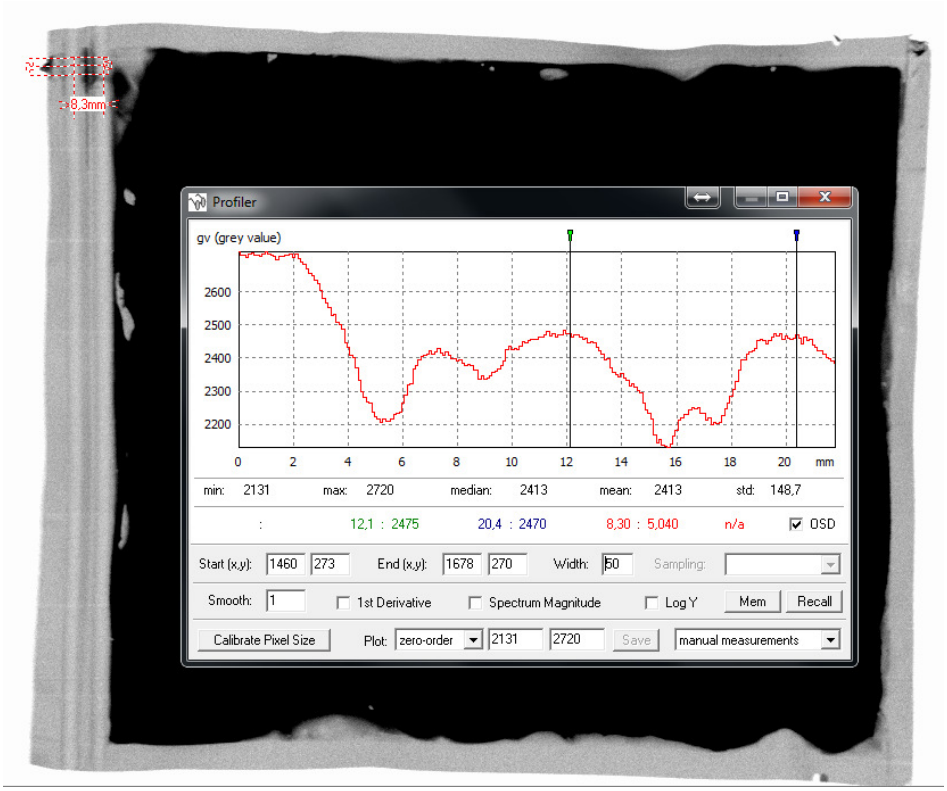

Figure 17 Ham entrapped in seal

8. Onion in seal

Analyze and detection is similar to #6

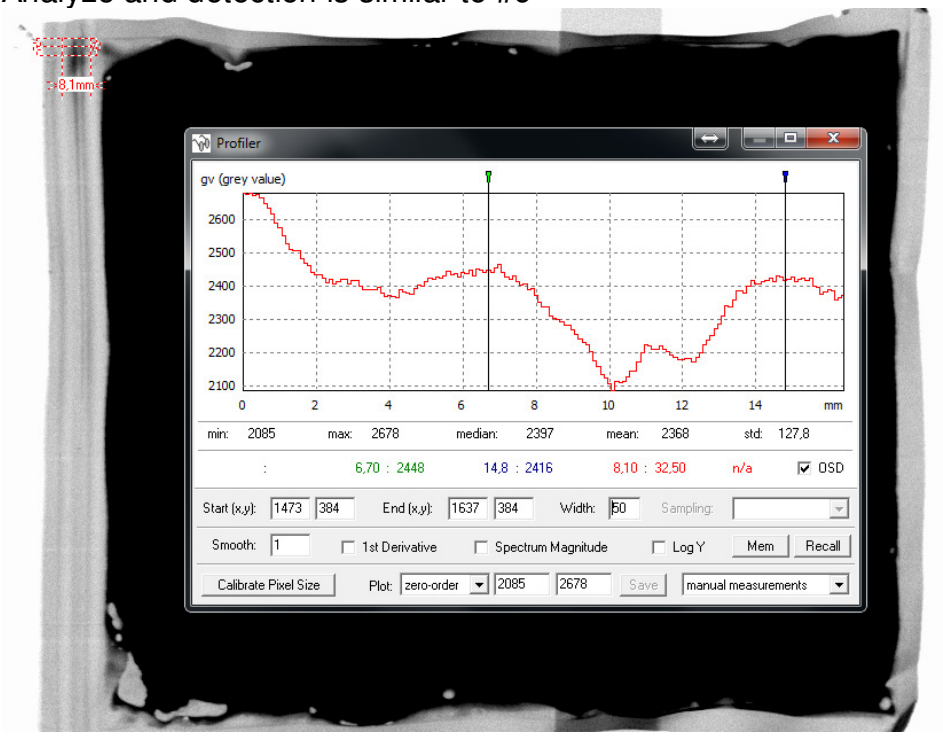

Figure 18 Onion entrapped in seal, upper left

9. Missing seal (2)

Analysis and detection for missing seal is similar to #2, but it is more well expressed in this sample. The width across the seal varies in this package with 66 pixels ≈ 6,6mm.This is detected using horizontal profiles and measuring the length in top and bottom of the package. See figures 19 and 20.

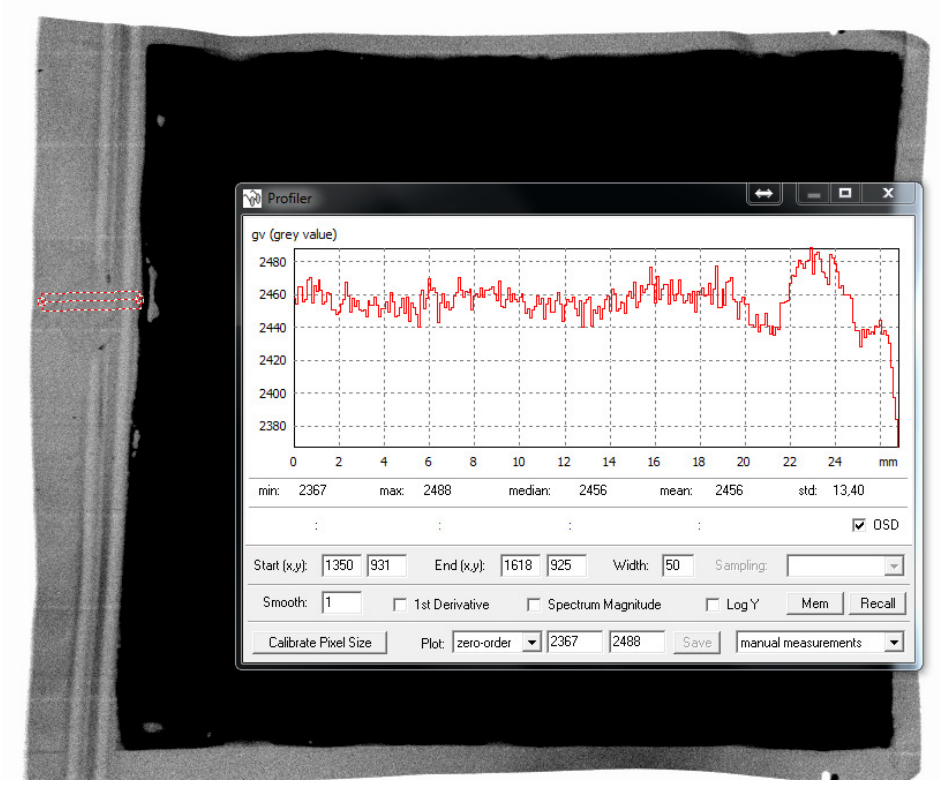

Figure 19. Missing (outer) seal

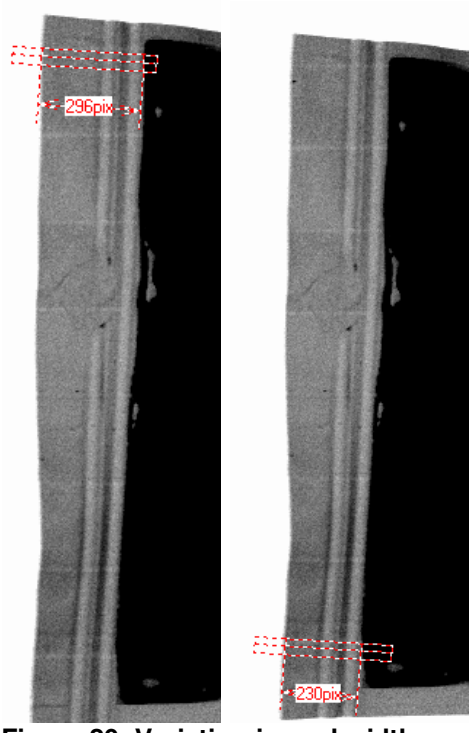

Figure 20. Variation in seal width

10. **Fold in mid part of the seal**

Analysis and detection is similar to #3, but the defect is not as critical.

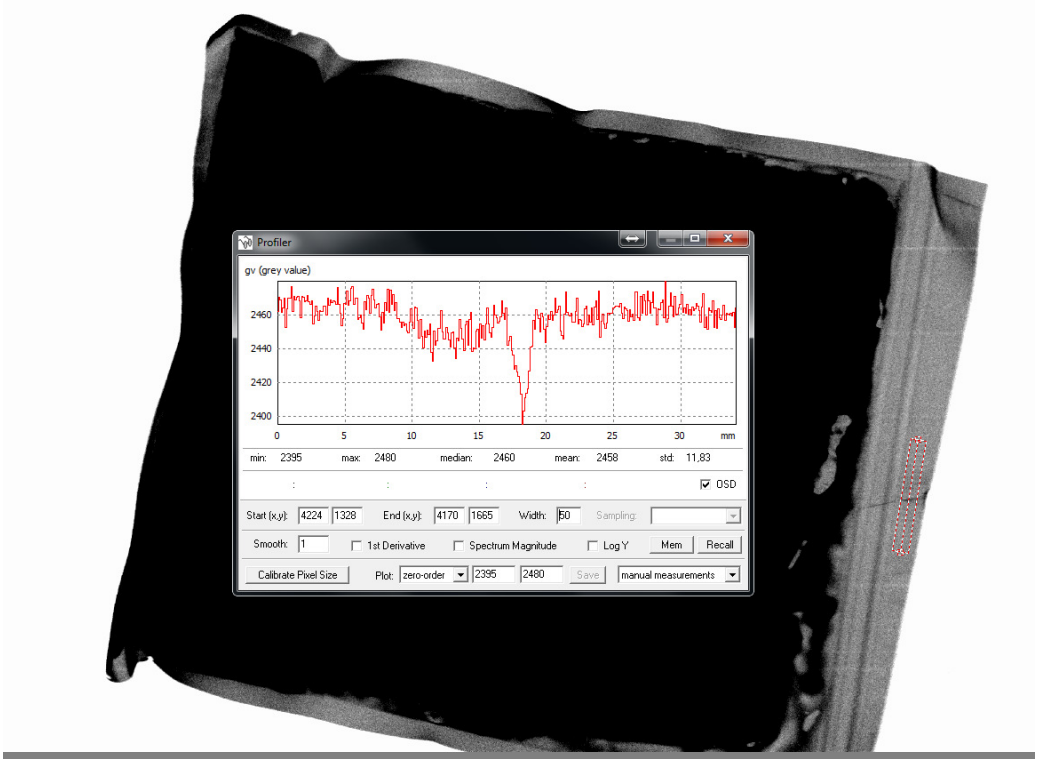

Figure 21 Fold in the mid part of the seal

13. Small metal piece inside the product

Metal and foreign objects in general will appear very clear on an X-ray image, since they attenuates the X-rays much more than the product inside packages. This is seen in the profile, showing distinct dip coinciding with the position of the small metal piece (figure 22).

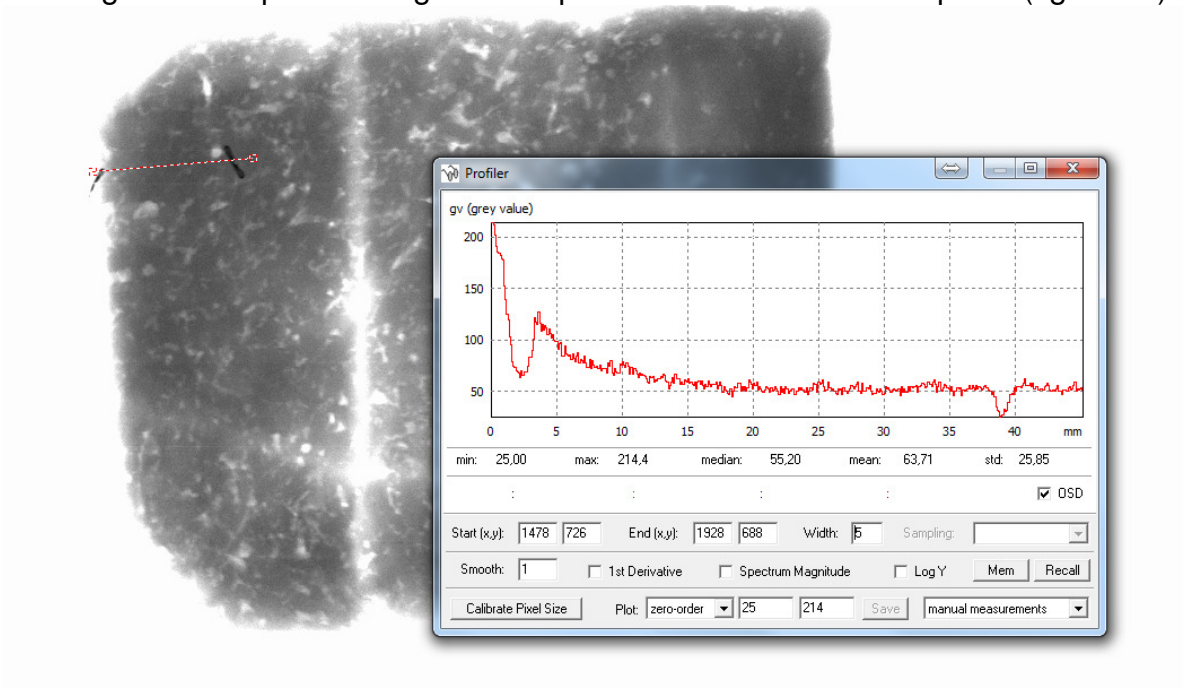

Figure 22 Small metal piece inside product

Concluding remarks

The presentation above has shown the various types of defects in the seal of (food) pouches and described the methods for revelation/automatic detection of these.
In general, the seal defects (contamination) are clear and consistent, but of course there is a lower detection capability when the contamination is very small.

Seal imperfections are clearly seen in the examples above, however the automatic correct classification is not considered likely if the seal imperfection is less than 5 mm in length.

Tolerances for the detection of misaligned seal must be provided on a case by case basis. The same is true for other defects – such as the determination of the mass of the product. The system capability is a tolerance measurement better than 1 mm.

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